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SBGK Szabadalmi Ügyvivői Iroda, Budapest(54) **Többpólusú szinkron villamos gép forgórész kiálló pólussal**

Az európai szabadalom ellen, megadásának az Európai Szabadalmi Közlönyben való meghirdetésétől számított kilenc hónapon belül, felszólalást lehet benyújtani az Európai Szabadalmi Hivatalnál. (Európai Szabadalmi Egyezmény 99. cikk(1))

A fordítást a szabadalmas az 1995. évi XXXIII. törvény 84/H. §-a szerint nyújtotta be. A fordítás tartalmi helyességét a Szellemi Tulajdon Nemzeti Hivatala nem vizsgálta.

Többpólusú szinkron villamos gép forgórész kiálló pólussal

This invention relates to the field of synchronous electric rotating machines comprising a stator assembly and a rotor assembly, the rotor assembly pivoting in relation to the stator assembly about a rotational axis.

More particularly, this invention relates to a rotor for a multipolar synchronous electric machine with salient poles.

Generally-speaking, rotors with salient poles have field poles located at the periphery of a ring of the magnetic circuit.

These rotors are generally used in slow-speed applications up to 1000 rpm with laminated poles and 1500 rpm with solid poles.

In a known manner, the rotor for a synchronous electric machine with salient poles comprises:

- a central portion formed by the ring of the magnetic circuit and by a central shaft; for small-diameter rotors, the central shaft and the ring of the magnetic circuit are formed in one piece only;
- salient poles or poles formed by a central portion known as a pole body or equally as a polar body and a peripheral portion known as a pole shoe; constant induction flows through the central portion of each pole; on the other hand, at the surface of the pole at the level of a pole shoe, induction is pulsed as a result of the rotation in front of the slots of the stator;
- field coils surrounding each pole body formed by a stack of coil turns.

Synchronous machines are electric machines wherein the rotational speed of the output shaft is equal to the rotational speed of the magnetic field. The magnetisation of rotating machines with salient poles is obtained by the field system formed by the field coils surrounding the pole bodies.

The field coils are positioned around the pole bodies in several ways.

According to a first known embodiment of a multipolar rotor with salient poles, each pole comprising a pole body and a pole shoe is mounted on a rim or on a shaft using plugs, dovetails or screws. In this embodiment, the coil is positioned on the pole body before the latter is assembled on the rim or shaft.

According to a second known embodiment of a synchronous rotor with salient poles, a pole body forming an integral part of the rim or shaft is used. Only the solid pole

shoe is mounted and secured to the pole body using numerous screws. The field coil is positioned around the pole body before assembling the pole shoe.

Regardless of the representation taken to date, the energisation of field coils results in the heating of same.

The field coils comprise insulating materials that are sensitive to thermal ageing. For this purpose, the synchronous rotor and more specifically the field coil must be cooled in order to improve the service life of the windings.

In order to cool the field coil during the rotation of the rotor with salient poles, the field coil preferably has an exchange surface with the surrounding air that is as large as possible.

In most known rotors with salient poles, the field coil is naturally cooled by the surface of its periphery during the rotation of the rotor. This type of cooling is generally not very efficient.

Rotors with salient poles are also known to comprise a specific field coil arrangement allowing air to flow between certain layers of the field coil, thus improving the cooling of the field coil. This inter-layer air flow is made possible by the creation of pressed sections produced by the deformation of flat sections of copper comprising the different layers of the field coil.

However, the deformation of the copper of the field coil is a difficult, long and expensive task to accomplish and requires a specific manufacturing process. On the other hand, the depth of the pressed sections producing inter-layer spaces is limited by the mode of producing the field coil by the deformation of flat copper sections, whereby the deformation of flat sections is difficult to control.

Moreover, the configuration of inter-layer spaces is very sensitive to pollution from particulate matter and humidity from the air or from a coolant, and to the consequences thereof on the electric circuits.

The patent US3846651 describes a further example of a field coil arrangement allowing for the improved cooling of the latter.

The patent application JP-A-59041136 proposes another arrangement to improve the cooling of the field coil by fitting inner pipes inside the ring with the aim of generating a natural air flow by the rotation of the rotor, wherein the air flow generated is guided between the different layers of the field coil.

In this context, the invention aims to provide a rotor for a multipolar synchronous electric machine with salient poles, wherein the cooling of the field coil is optimised while allowing for a simple, cost-effective and fast assembly of the rotor that has low sensitivity to pollution.

To this end, the invention proposes a rotor for a multipolar synchronous rotating

machine according to claim 1.

Thanks to the invention, perforated field coils can be easily produced, allowing for the efficient cooling of the field coil while guaranteeing simple assembly on the pole bodies. The design of the coil by layers of coiled wire held spaced apart by spacers guarantees the flow of a coolant between the different layers of the field coil while radially holding it in place during rotation of the rotor.

The rotor of a multipolar synchronous electrical machine with salient poles, according to the invention, can also have one or more of the characteristics described hereafter, considered either on an individual basis or according to any combination technically possible:

- each salient pole of said plurality of salient poles comprises a plurality of removable pole tips facing each other on either side of said pole body;
- each pole tip of said plurality of pole tips is fitted inside said pole body, said pole body comprising two slots arranged on either side of said pole body and having a shape adapted to receive said pole tips facing each other;
- said two slots are made continuously along said pole body;
- each layer of coiled wire of said plurality of layers is formed by means of a flat conducting wire;
- said second spacing is created by each spacer of said plurality of spacers.

This invention further relates to a method of cooling a rotor for a multipolar synchronous rotating machine characterised in that it comprises the following steps:

- cooling said plurality of layers of coiled wire by circulating coolant through said second spacing;
- cooling each layer of coiled wire of said plurality of layers by circulating coolant through said first spacing.

According to another characteristic, the method is such that it comprises a step of circulating heat transfer fluid between the aperture and said second spacing by means of said conduit of said support sheet.

The characteristics and advantages of the invention will more clearly emerge from the following description, which is given as a rough guide and in no way as a limited guide, with reference to the appended figures, from which:

- figure 1 is a partial view of a cross-section of a rotor with salient poles of a synchronous electric machine according to a plane perpendicular to the rotational axis of the rotor, according to a first embodiment;
- figure 2 is an overhead view of a pole body of a rotor with salient poles such as illustrated in figure 1;
- figure 3 is a partial view of a cross-section of a rotor with salient poles of a

synchronous electric machine according to a plane perpendicular to the rotational axis of the rotor, according to a second embodiment.

In all figures, common elements bear the same reference numbers unless indicated otherwise.

Figure 1 illustrates a partial view of a cross-section of a rotor 100 with salient poles of a synchronous machine according to a plane perpendicular to the rotational axis of the rotor.

Figure 1 particularly illustrates a space 20 located between two salient poles 10. Each salient pole 10 comprises a polar body or pole body 1 surrounded by a field coil 3. The pole body 1 is a part forming an integral part of a rim 4 constituting the rotary field of the magnetic circuit of the synchronous electric machine. The rim 4 is preferably made from a stack of magnetic steel sheets hot-mounted onto a shaft or a hub (not illustrated).

According to another embodiment, the pole body 1 is a solid single-unit part forming an integral part of the shaft.

According to an advantageous mode of the invention, the rim 4 has a substantially polygonal shape. The polygonal shape of the rim is defined according to the number of poles that the rotor of the synchronous machine has.

The field coil 3 is made from a copper conductor having a circular or rectangular cross-section surrounding the pole body 1 with a certain number of coil turns. In a first embodiment, the field coil 3 is made from radial layers 11 (i.e. positioned according to different radii from the centre of the rotor) of flat conducting wire coil 12 wound in a spiral. Each radial layer 11 is radially spaced apart by spacers 14, 15a and 15b. The spacers 14, 15a and 15b are formed either from an insulating material or from a conducting material that needs to be insulated by an insulating material, the spacers made from a conductive material having improved mechanical properties.

The insulation of the turns of the field coil 3 is achieved by insulating strips pre-impregnated with a thermosetting resin. The coil is then pressed and undergoes a heat treatment which produces a compact assembly with excellent thermal conductivity.

According to another embodiment of the invention, the field coil 3 is made with fibreglass-insulated wires. The insulated wire is then wound over several layers. Varnish or resin is interposed between each wire layer to provide the field coil 3 with its final rigidity after polymerisation.

It is also possible, according to another embodiment of the invention, to make the field coil 3 with thermoadhesive enamelled wires. The thermoadhesive wires are enamelled wires covered with an outer layer enabling bonding of the coil turns assembled by polymerisation of this outer layer under the effect of temperature, thus making the

application phase of a varnish or resin during production of the field coil 3 unnecessary.

Pole tips 2 are located, in pairs, on either side of the pole body 1 over its entire length, a single pair of pole tips 2 being illustrated on each pole body 1 in figure 1. The pairs of pole tips 2 hold the field coil 3 in position on either side of pole body 1. For this purpose, the pole body 1 comprises slots 6a corresponding to the shape of the catches 6b of the pole tips 2; the slots 6a of each sheet of the stack being aligned over the entire length of the pole body 1, thus forming a conduit. The catches 6b enable the pole tips 2 to be positioned by interlocking and then by sliding in the slots 6a without any other fixation means. The interlocking takes place at each end of pole body 1 and the sliding takes place along the longitudinal direction of said pole body 1. The catches 6b have the shape, for example, of a hook oriented substantially towards the centre of the rotor, composed of a first portion 7 having a substantially triangular cross-section, meeting a second portion 9 having a substantially rectangular cross-section, the two portions 7 and 9 being connected by a bent element 8.

The specific shape of the catches 6b allows the pole tips 2 to be radially held in position, and enables the stresses to be supported, said stresses being caused by the centrifugal force of the field coil 3 during the rotation of the rotor, and particularly by the radial component.

The spacers 14, 15a and 15b are uniformly inserted between the different radial layers 11, thus forming an inter-radial layer 11 space 23 enabling coolant to flow between the radial layers 11, illustrated by arrows. On a radial layer 11, the spacers 14, 15a and 15b are uniformly distributed over the entire length of radial layer 11. According to one advantageous embodiment of the invention, each spacer 14, 15a and 15b is longitudinally spaced apart by a second spacer, at a distance of substantially between ten and one hundred millimetres.

The spacers 14 are symmetrical plates in relation to a horizontal plane having a substantially rectangular shape that is several millimetres thick. The spacers 14 comprise an excessive thickness 24 at their right end and an excessive thickness at their left end, the excessive thicknesses 24 and 25 being symmetrical on either side of the horizontal plane of symmetry. Thus, the excessive thicknesses 24 and 25 enable two radial layers 11 of the field coil 3 to be encompassed and surrounded, one radial layer 11 in the upper portion of the spacer 14 and one radial layer 11 in the lower portion of the spacer. Therefore, by their shape and layout, the spacers 14 enable the different radial layers 11 of the field coil 3 to be held apart by creating the interlayer space 23 for the flow of a coolant, as illustrated by arrows in figure 1.

The left excessive thicknesses 25 of the spacers 14 are also suitable for maintaining the field coil 3 of the periphery of the pole body 1 at a distance, whereby the outer face

of the spacer 14 at the level of the excessive thickness 25 is in contact with the pole body 1. In this way, a space 27 is formed between the field coil 3 and the outer surface of the pole body 1; the space 27 being equivalent to the width of the excessive thickness 25. Thus, the space 27 guarantees the coolant flow and guarantees ground insulation between the field coil 2 and the peripheral surface of the pole body 1.

The upper spacer 15a and lower spacer 15b, i.e. the spacers positioned above the last radial layer 11 or upper layer and below the first radial layer 11 or lower layer of the field coil 3 have a slightly different shape to the spacers 14 previously described. The spacers 15a and 15b are also plates having a substantially rectangular shape that is several millimetres thick. The spacers 15a and 15b also comprise a left excessive thickness and a right excessive thickness at their two ends, but only on one of the two faces of the spacer. The second face of the spacer 15a, 15b comprises a central excessive thickness 26 having a substantially rectangular shape located substantially at its centre and enabling the spacers 15a and 15b to be positioned and held in place.

The upper face of the upper spacer 15a comprising the excessive thickness 26 enables the spacer 15a to be held in place and positioned by means of the pole tips 2 when the latter are positioned on the pole body 1. Similarly, the lower face of the lower spacer 15b comprising the central excessive thickness 26 enables the spacer 15b to be positioned and held in place by means of the support sheet 16.

The pole tips 2 and the support sheet 16 have a cut-out of material in the shape of the excessive thickness of the spacers 15a and 15b so as to accommodate said excessive thickness and hold said spacers.

The support sheet 16 is a V-shaped folded sheet positioned at the level of a space 20 of the rotor 100 with salient poles, i.e. between two salient poles 10 and more precisely between two pole bodies 1.

At the level of the space 20 of the rotor 100, two field coils 3, each surrounding a pole body 1, are opposite each other. The support sheet 16 holds the portion of the opposing field coils at the level of the space 20 of the rotor 100. For this purpose, the support sheet 16 is inserted between two pole bodies 1 when the field coils 3 are assembled around the pole bodies 1 and as the pole tips 2 are inserted into the pole body 1. In a first embodiment illustrated in figure 1, screw bosses 17 are used under the support sheet 16 in order to hold the field coil 3 radially pressed against the pole tips 2 at a certain pressure.

The upper portion of the field coil 3 is radially held in place by the pole tips 2, and its lower portion by the support sheet 16. The radial holding of the lower portion of the field coil 3 may also be achieved by any other equivalent means enabling the field coil 3 to be pressed against the pole tips 2.

According to a second embodiment, the radial holding of the lower portion of the field coil 3 may be carried out by means of a set of compressed springs 31, as illustrated with reference to figure 3.

Therefore, the spacers 14, 15a and 15b as well as the holding pressure exerted on the field coil 3 and on the spacers by the pole tips 2 in its upper portion and by the support sheet 16 in its lower portion, enable the field coil 3 to be held in position and, in particular, allow for the compensation of the tangential component of the centrifugal force during the rotation of the rotor.

A space 18 is provided under the support sheet 16. This space 18 is suitable for, on the one hand, facilitating the insertion of the support sheet 16 under the field coils 3 and, on the other hand, enabling a longitudinal distribution of the coolant resulting in a fluid flow, illustrated by arrows, through the radial layers 11 of the field coil 3.

In another embodiment of the invention, illustrated by figure 3, it is also possible to enlarge the space 18 by making an aperture in the rim 4 so as to increase the flow of coolant inside the field coil 3. It is also possible to position a fan at the inlet of this space 18 so as to create a coolant flux or increase the natural flux created by the rotation of the rotor.

When the rotor 100 is rotated, the surrounding ambient air or coolant rushes into the space 18; the incoming flow of coolant can be increased by adding a fan at the inlet of the space 18 as described above.

The coolant flows through the field coil 3 according to the arrows provided, which explicitly illustrate the flow path.

The coolant then migrates from the space 18 through a pipe present in the support sheet 16 to the space 27. The coolant then flows from the space 27 towards the interlayer spaces 20 created by the spacers 14, 15a and 15b, and then escapes to the space 20, thus enabling the fluid to be renewed.

The coolant flowing in the spaces 27 and 23 results in thermal exchanges with the different radial layers 11 of the field coil 3, thus enabling an advantageous cooling of the coil.

It is also possible to block the space 20 between two salient poles so as to force the flow of air in the space 18 and thus improve the cooling of the field coil 3 by increasing the coolant flow rate through the radial layers 11.

Figure 2 is an overhead view of a pole body 1 of a rotor 100 with salient poles 10 of a synchronous electric machine according to the invention, illustrated with reference to figure 1.

Figure 2 particularly illustrates a series of pole tips 2 positioned on the pole body 1 and radially blocking the field coil 3 of the pole.

Flanges 5, located at the ends of the pole body 1 (only one flange 5 is illustrated), are held secured to the rim 4 by means of a screw-type fixation system. The flanges 5 are solid parts made from machined, forged or moulded steel that enable the pole tips 2 to be held in position after their placement on the pole body 1. They thus prevent any longitudinal displacement of the pole tips 2. Indeed, at the ends of the pole body 1, the flanges 5 obstruct the slots 6a of the pole body 1 corresponding to the catches 6b such that the pole tips 2 can no longer be removed or displaced in the longitudinal direction of the pole body 1. The flanges 5 also enable the front portion of the field coil 3 to be radially held in position and enable the field coil 3 assembly to be positioned axially.

The combined use of the pole tips 2 and the flanges 5 to replace a pole shoe according to the prior art provides two uncovered areas 21 and 22 at each end of the field coil 3. These areas 21 and 22 improve the cooling of the field coil 3 by increasing its contact surface with ambient air or with any other coolant.

The device illustrated in figure 3 comprises the same elements and the same references as the device illustrated in figures 1 and 2, with the exception of the means for radially holding the field coil 3 by a set of compressed springs 31.

Moreover, figure 3 illustrates a second embodiment of the space 18 making an aperture in the rim 4 increasing the flow of coolant inside the field coil 3.

The mounting of the illustrated rotor with salient poles for a synchronous machine is easy and fast to achieve using a limited number of tools.

In a first step, the field coil 3 is produced separately by radial layers 11, then assembled with the spacers 14, 15a, 15b. According to a second embodiment, the field coil 3 may be produced by successive coil turns on each layer, starting from an outer layer of the field coil and then going back up layer by layer to the inner layer of the field coil 3 and then going back down to the outer layer: this operation is repeated until the coil is fully wound. This embodiment thus reduces the number of brazed connections.

In a second step, the complete and polymerised field coil 3 is then inserted around the pole body 1 in a position that is closer to the rotor centre, allowing the slots 6a of the pole body 1 to be completely cleared.

The pole tips 2 are threaded by sliding on the pole body 1 by means of the slots 6a.

The flanges 5 are then threaded and secured on the rim 4 or on the pole body 1 by means of screws. The pole tips 2 are thus locked longitudinally in place.

The field coil 3 is then pressed against the pole tips 2 so as to free a space 18 under the field coil in order to insert the support sheet 16 by sliding in the longitudinal direction of the pole body 1. The support sheet 16 is then held pressed against the field coil 3 by means of screw bosses 17 that are mounted by force, a set of compressed springs 31 or any other equivalent means.

The screw bosses 17 or set of compressed springs 31 exert a certain contact pressure on the coil, the outer portion of which is held by the pole tips 2 and the inner portion of which is held by the support sheet 16. The field coil 3 is therefore radially held in position both when the rotor is at a standstill and when it is rotating.

All of the operations described for the assembly of the pole tips 2 and the flanges 5 on the pole body 1 are easy to perform and do not require special tooling.

The purpose of the invention is therefore the production of a multipolar rotor with salient poles for a synchronous electric machine allowing for the effective cooling of the field coil, thus significantly improving the service life of the windings. Furthermore, the clever shape of the pole tips combined with the use of spacers significantly reduces the use of key wedges for the tangential holding of the field coil during rotation of the rotor, thus improving the cooling of the coil while increasing the surface of the coil in contact with a coolant such as air.

Finally, the rotor with salient poles according to the invention provides for simple and rapid assembly without the need for special tooling. The clever shape of the pole tips allows the field coil to be both quickly and easily assembled as well as held in place when the rotor is at a standstill and during its rotation.

Moreover, when a field coil required cleaning, repair or replacement, the disassembly operation is made much easier, without resorting to the use of special tooling, and faster.

This document essentially describes a multipolar rotor with salient poles for a synchronous electric machine comprising a laminated pole body and a laminated rim; however, the invention is also applicable to a multipolar rotor with salient poles for a synchronous electric machine comprising a solid pole body. This document essentially describes a multipolar rotor with salient poles comprising pole bodies integrated with the rim of the rotor; however, the invention is also applicable to a multipolar rotor with salient poles comprising pole bodies added to a rim or to a shaft by means of plugs, dovetails or screws.

Other advantages of the invention are, in particular, as follows:

- improved cooling of the multipolar rotor no longer requiring the use of key wedges;
- facilitated industrial production;
- significant increase in coil service life;
- elimination of the need for the ground insulation of field coils;
- easy disassembly of field coils during maintenance, renovation or repair operations;
- insensitivity to the electrical effects of field coil pollution.

Szabadalmi igénypontok

1. Többpólusú szinkron forgó gép forgórész, amely tartalmaz:

- pólustestet (1) tartalmazó több kiálló pólust (10), ahol a kiálló pólusokat (10) több tekercselő huzal rétegből (11) álló indukciós tekercsek (3) veszik körül, a több kiálló pólus (10) egy gyűrűvel (4) van egybeépítve, a gyűrűn (4) mélyedés (18) található két kiálló pólus (10) között, a forgórész hűtésére;
 - több távtartót (14, 15a, 15b), ahol a több távtartó (14, 15a, 15b) közül mindegyik távtartó első teret (23) hoz létre a rétegek közül két egymást követő tekercselő huzal réteg (11) között, egy hűtőközeg keringetéséhez a több rétegben elrendezett tekercselő huzal rétegek (11) között, ahol a forgórész tartalmaz egy második teret (27) a pólustest (1) és a több rétegben elrendezett tekercselő huzal rétegek (11) között, a hűtőközeg keringetéséhez az indukciós tekercs (3) és a pólustest (1) között;
- ahol a forgórészre az jellemző, hogy:
- az indukciós tekercset (3) képező tekercselő huzal rétegeket (11) támasztólemez (16) sugárirányban tartja;
 - a forgórésznek ventilátora van a hűtőközeg tengelyirányú keringési áramának létrehozásához a két kiálló pólus (10) közötti mélyedésben (18) a támasztólemez (16) alatt;
 - a támasztólemeznek (16) legalább egy vezetéke van a hűtőközeg keringetéséhez a mélyedéstől (18) és a második tér felé; ahol az első és második tér úgy van elrendezve, hogy a hűtőközeg a második térből az első tér felé áramlik két tekercselő huzal réteg között.

2. Az előző igénypont szerinti többpólusú szinkron forgó gép forgórész, azzal jellemezve, hogy a kiálló pólusok (10) mindegyik kiálló pólusa (10) eltávolítható pólusheggyel (2) van ellátva, amelyek egymással szemben helyezkednek el a pólustest (1) két oldalán,

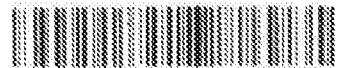
3. A 2. igénypont szerinti többpólusú szinkron forgó gép forgórész, azzal jellemezve, hogy a több pólushegy (2) közül mindegyik pólushegy (2) a pólustestben (1) van elhelyezve, és a pólustestben (1) két horony (6a) van kialakítva a pólustest (1) két oldalán az egymás felé néző pólushegyek (2) befogadására.

4. A 3. igénypont szerinti többpólusú szinkron forgó gép forgórész, azzal jellemezve, hogy a két horony (6a) a pólustest (1) hossza mentén folytonosan van elrendezve.



5. Az 1 - 4. igénypontok bármelyike szerinti többpólusú szinkron forgó gép forgórész, azzal jellemezve, hogy a több rétegben elrendezett tekercselő huzal rétegek (11) lapos vezető huzalból (12) vannak kialakítva.

6. Az 1 - 5. igénypontok bármelyike szerinti többpólusú szinkron forgó gép forgórész, azzal jellemezve, hogy a második tér (27) a több távtartó (14, 15a, 15b) egyes távtartóival van kialakítva.



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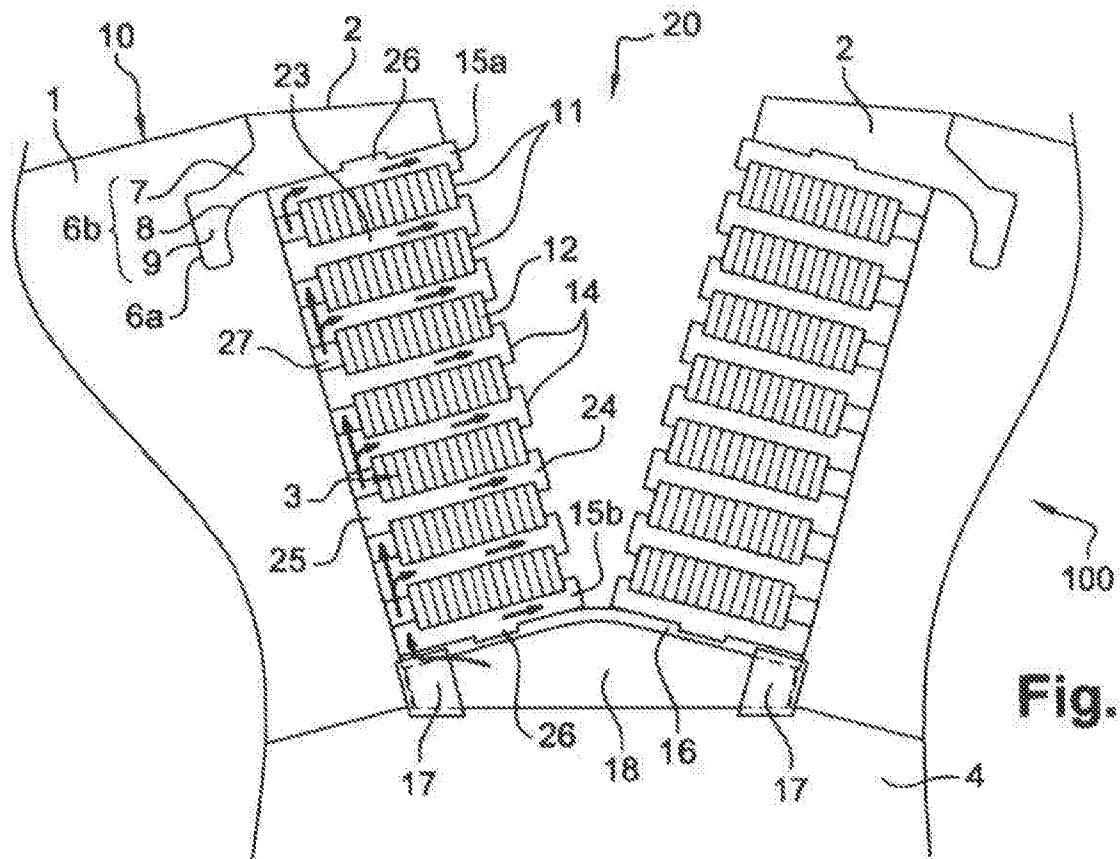


Fig. 1

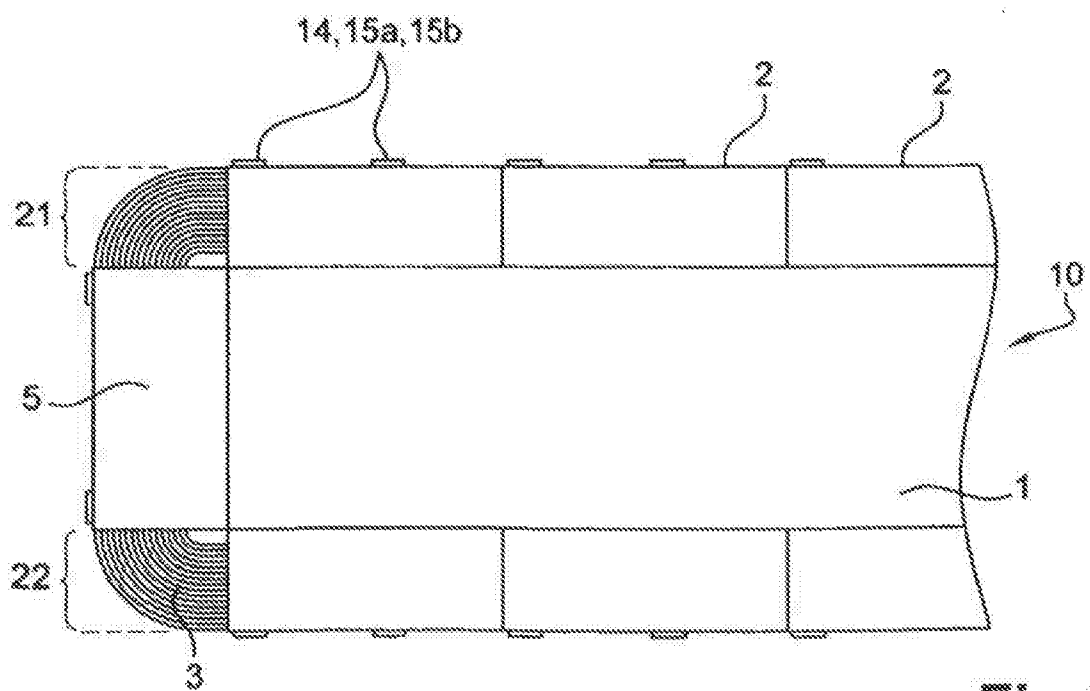
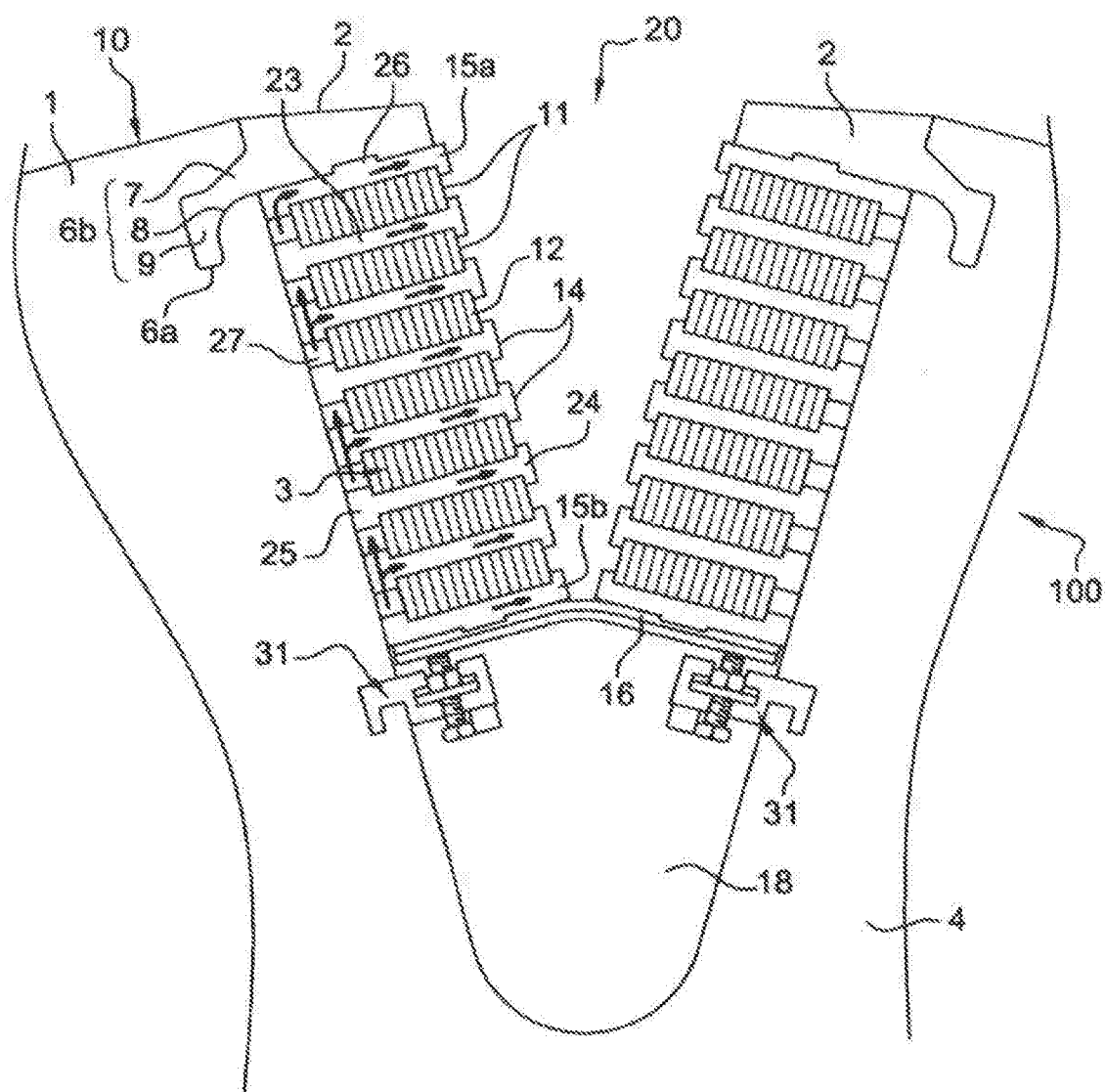


Fig. 2

**Fig. 3**