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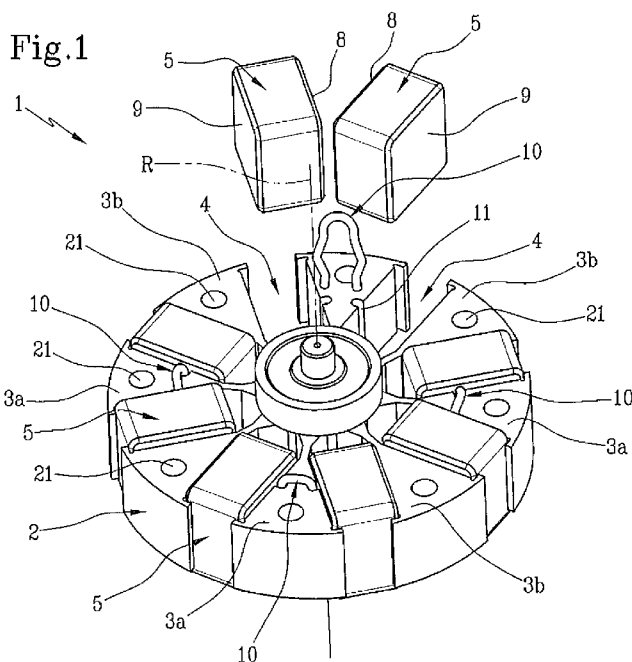
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(54) Title: A ROTOR FOR AN ELECTRICAL MACHINE AND RELATIVE ASSEMBLY METHOD



(57) Abstract: Described is a rotor (1) for an electrical machine comprising a laminated core (2) having a main axis (R) and a plurality of poles {3a, 3b} delimiting a plurality of radial seats (4) extending along the main axis (R), each seat (4) being delimited by a first and a second pole (3a, 3b); the rotor comprising a plurality of magnets (5) inserted in the seats (4) and a plurality of springs (10) locking the magnets (5) in the seats (4); the springs (10) acting between each magnet (5) and the first pole (3a) delimiting the relative seat (4) for pushing each magnet (5) towards the second pole (3b) delimiting the same seat (4),

DescriptionA rotor for an electrical machine and relative assembly methodTechnical Field

This invention relates to a rotor for an electrical machine, in particular a rotor with permanent magnets, and the system of locking the magnets in the relative seats; this invention also relates to the method for assembling the rotor.

Background Art

The rotors of motors with permanent magnets of known type, used especially in brushless motors, usually consist of a laminated core, that is to say, a core made up of a pack of thin metal laminations and having a principal axis that coincides with the axis of rotation of the motor.

The rotor normally has a plurality of longitudinal slots and a central hole, which extend parallel to the main axis, for accommodating the magnets and a drive shaft, respectively.

The slots form in the laminated core a sort of segment structure, forming the poles of the rotor, where each segment, which remains connected to a central portion of the laminated core surrounding the hole of the shaft, separates two adjacent slots.

The magnets extend along the axis of the rotor, in which they are positioned radially, arranged, in general, against a pair of respective contact elements at the outer end of the relative slot which is generally open on the outer surface of the rotor (except for the aforesaid contact elements).

A common problem with this type of rotor is linked to the method of fixing the magnets in the relative slots.

The magnets must be attached in the slots in a precise position both for the correct electromagnetic operation of the motor and so as not to trigger vibrations during operation of the motor.

In the reference rotors for this invention, that is, with the magnets positioned radially, one prior art solution glues the

magnets in the relative seats. The magnets with glue on them are inserted in the relative slot and held by a special tool abutted against the outer contact elements until the glue sets.

5 In a different embodiment, the magnets are held in position in the slot by a tool whilst the rotor is inserted in a mould where plastic is injected. In this way, the magnets are co-pressed with the laminations and held in position by the plastic.

The aforesaid prior art solutions are relatively expensive due to the assembly complexity.

10 In another embodiment, which is the one most commonly used, each magnet is held abutted against the contact elements by a radially pushing spring interposed between the magnet and the central portion of the laminated core.

15 These springs may be single (one for each magnet) or grouped together in a singular annular element.

In this solution a major disadvantage is that given a magnet, the corresponding spring, due to the mechanical tolerances for inserting the magnet, may push the magnet in a not perfectly radial direction so that it abuts against only one of the contact elements prepared, that is, against only one of the segments which delimit the slot.

20 In some cases, there may be segments which are not stabilised by the magnets and which therefore vibrate during operation of the motor.

25 Moreover, the magnet may chip at the contact element due to the reduced contact surface of the latter.

Disclosure of the Invention

30 In this context, the main technical purpose of this invention is to provide a rotor for an electrical machine which is free of the above-mentioned drawbacks.

A further aim of this invention is to provide a rotor which is relatively economical and easy to assemble.

35 Another aim of this invention is to provide a rotor which is not at risk, in use, of mechanical vibrations.

The above mentioned purpose and aims are substantially achieved by a rotor for an electrical machine having the characteristics defined in claim 1.

5 Brief Description of the Drawings

Further features and advantages of the present invention are more apparent in the detailed description below, with reference to a preferred, non-limiting, embodiment of a rotor for an electrical machine, as illustrated in the accompanying drawings, in which:

10 - Figure 1 is a partly exploded, schematic perspective view of a first embodiment of an eight-pole rotor according to this invention;

- Figure 2 is a schematic perspective view of an enlarged detail of the rotor of Figure 1;

15 - Figure 3 is the cross-section III - III of the detail of Figure 2;

- Figure 4 is a schematic perspective view of the rotor shown in the drawings listed above;

20 - Figure 5 is a schematic perspective view a detail of a second embodiment of a rotor according to this invention;

-- Figure 6 is a partly exploded, schematic perspective view of a third embodiment of an eight-pole rotor according to this invention;

25 - Figure 7 is a schematic perspective view of a detail of the rotor of Figure 6;

- Figure 8 is a partly exploded, schematic perspective view of a third embodiment of an eight-pole rotor according to this invention;

30 - Figure 9 is a schematic perspective view of a detail of the rotor of Figure 8;

Description of the preferred embodiments of the invention

35 With reference to the accompanying drawings, in particular to Figures 1, 6 and 8, the numeral 1 denotes a rotor for an electrical machine according to this invention.

The rotor 1 comprises a laminated core or pack 2 of laminations having a main axis R and a plurality of poles 3a, 3b delimiting a plurality of seats 4.

5 The poles or teeth 3a, 3b are in the form of segments which extend radially from a central nucleus of the laminated core 2.

The seats 4 are also radial and extend (in length) according to the main axis R and are each delimited by a first pole 3a and by a second pole 3b.

10 The rotor 1 comprises magnets 5, eight in the example illustrated, each inserted in a corresponding seat 4.

The rotor 1 comprises elastic means of locking the magnets 5 in the seats 4 acting between each magnet 5 and the first pole 3a delimiting the relative seat 4 for pushing each magnet 5 towards the second pole 3b delimiting the same seat 4.

15 As illustrated, each first pole 3a has two faces 6, advantageously flat, delimiting adjacent seats 4 and each second pole 3b has two faces 7, advantageously flat, delimiting adjacent seats 4.

20 In other words, each seat 4 is delimited by a flat face 6 of a first pole 3a and by a flat face 7 of a second pole 3b.

Given a seat 4, the faces 6 and 7 which delimit the seat are opposite and parallel to each other so that the elastic means push the corresponding magnet 5 from the first pole 3a against the flat face 7 of the second pole 3b.

The magnets 5 are parallelepiped in shape and have a pair of flat, parallel faces 8 and 9. Preferably, the magnets 5 also have the outer surfaces ground smooth.

25 Numeral 8 in the accompanying drawings indicates the face of the magnets 5 facing pole 3a and numeral 9 indicates the face of the magnets 5 facing pole 3b, in particular, the relative faces 6 and 7.

30 The elastic means are shaped so as to push the flat face 9 of the magnet 5 against the flat face 7 of the corresponding second pole 3b delimiting the relative seat 4.

In the preferred embodiments illustrated, the aforementioned elastic means comprise a plurality of springs 10.

In general, the springs 10 are fork-shaped and they are inserted on every other tooth, that is, they are inserted on the poles 3a in the accompanying drawings provided merely by way of example.

5 Each spring 10 pushes on two adjacent magnets 5 forcing them against the faces 7 of the teeth 3b located on the opposite side to the spring 10 relative to the magnet 5, as described in more detail below.

10 In this way, each ferromagnetic tooth or pole 3a, 3b is held still by the magnets 5 which surround it.

Looking in more detail at the positioning of the springs 10, it should be noted that each pole 3a has engagement means for the relative elastic means, that is, for the springs 10.

15 More specifically, the engagement means for the springs 10 are in the form of grooves 11 on the faces 6 of the poles 3a.

The grooves 11 extend in parallel to the main axis R and, given a pole 3a, are aligned according to a cylindrical surface having an axis corresponding with the main axis.

20 The springs 10 are shaped so as to squash into the relative groove 11 after inserting the magnets 5 so as to completely fill the groove 11, optimising the magnetic circuit since the springs 10 are preferably made of ferromagnetic material.

25 In general, therefore, the elastic means comprise a plurality of springs 10, each of which is associated with a pole 3a for pushing the corresponding magnets 5 towards the poles 3b delimiting the relative seats 4.

With particular reference to Figures 3, 4, 5, 7 and 9, the springs 10 for rotors 1 according to this invention are illustrated in more detail.

30 The springs 10 have a base stretch 12 from which two substantially parallel prongs 13, 14 extend designed to engage inside the grooves 11.

35 The base stretch 12 is preferably curvilinear for clasping the poles 3a and collaborating in holding in position the prongs 13 and 14.

Moreover, the base stretch 12 extends according to a circumference concentric with the rotor 1.

The grooves 13, 14 extend in parallel to the main axis R and are aligned according to a cylindrical surface having an axis
5 corresponding with the main axis R.

The prongs 13, 14 have a first rectilinear stretch 15 and at least a second, elastically yielding, undulating stretch 16.

The undulating stretches 16 have opposite convexities relative to the pole 3a each facing towards a corresponding seat 4 and
10 projected inside the seat 4.

The undulating stretch 16 of the prongs 13 and 14 acts on the magnets 5 inserted in two seats 4 adjacent to each other.

The rectilinear stretch 15 of the prongs 13, 14 allows, after the spring 10 has been positioned in the rotor, on the relative pole
15 3a, no part of the spring 10 in the seats 4 for the first millimetres so as to be able to position the magnets 5 which are then pressed inside the seats 4.

The magnets 5 and the relative seats 4 have very small assembly tolerances, in the order of a tenth of a millimetre, so it
20 is important, for a correct positioning of the magnets 5 at the mouth of the seats 4, that there are no parts of the springs 10.

After inserting the magnets 5 in the seats 4, the springs 10 will be fully extended in the relative groove 11 (except for a decimal portion of the convex part 16 which protrudes for pushing
25 the magnet), allowing the completion of the magnetic circuit.

In a first embodiment, illustrated in figures 1 to 4, intended preferably for motors with an output of approximately 100-300 Watts and rotors with the laminated pack having a length of up to 20 mm and a diameter of up to 100 mm, a spring 10 made of spring wire and
30 having a single undulating stretch 16 for each prong 13, 14 is sufficient.

As illustrated in Figure 5, in a second embodiment, intended preferably for longer motors, up to approximately 100 mm, and therefore with heavier magnets 5 for the same diameter of the rotor
35 1, the prongs 13, 14 of the spring 10 each have a second undulating

stretch 17 extending from the first undulating stretch 16.

The second undulating stretches 17 have opposite convexities each facing towards a corresponding seat 4 for the magnet 5 and projected inside the seat 4 for applying a pushing action on the corresponding magnet 5.

A steel spring wire is preferably used for the aforesaid embodiments.

So that the prongs 13, 14 of the spring 10, in particular the rectilinear stretches 15, do not obstruct the seat 4, the diameter of the wire is less than the depth of the relative groove 11.

In a third embodiment, illustrated in Figures 6 and 7, preferably adopted for rotors with the length of the laminated pack up to 20 mm and the diameter greater or much greater than 100 mm, for which the magnets 5 have, concordantly, radial extension greater than the previous solutions, the springs 10 are made with metal strip suitably shaped in such a way as to apply an adequate pushing action on the magnets 5.

The shape of the spring 10 made with the metal strip corresponds with the shape of the spring 10 made with wire, that is, the spring 10 has a head or base portion 12 and two prongs 13, 14 which protrude in parallel from the base 12.

The spring 10 extends substantially for the full length of the rotor and has a length of the same order of magnitude as the corresponding tooth 3a.

The width of the metal strip is selected on the basis of the force to be applied to the magnet 5 and the weight of the magnet.

In the same way as the aforementioned embodiments, the prongs 13, 14 have a first rectilinear stretch 15 and at least a second, elastically yielding, undulating stretch 16.

The undulating stretches 16 have opposite convexities each facing towards a corresponding seat 4 and projected inside the seat 4.

The undulating stretch 16 of the prongs 13 and 14 acts on the magnets 5 inserted in two seats 4 adjacent to each other.

The rectilinear stretch 15 of the prongs 13, 14 allows, after

the spring 10 has been positioned in the rotor, on the relative pole 3a, no part of the spring 10 in the seats 4 for the first millimetres so as to be able to position the magnets 5 which are then pressed inside the seats 4.

5 Alternatively, in an embodiment not illustrated, the metal strip spring is replaced by two or more springs 10, of the type described previously, suitably dimensioned, made from wire and spaced radially along the pole 3a.

10 As illustrated in Figure 8, in a fourth embodiment, in the case of longer motors, up to and longer than 100 mm, and with a larger diameter, up to and greater than 100 mm, therefore with heavier magnets, the prongs 13, 14 of the spring 10 have a plurality of undulating stretches 18, 19, 20 extending from the first undulating stretch 16.

15 The additional undulating stretches 18, 19, 20 have opposite convexities each facing towards a corresponding seat 4 for the magnet 5 and projected inside the seat 4 for applying a pushing action on the corresponding magnet 5.

20 It should be noted that, even the springs 10 made from metal strip have initial rectilinear stretches 15 which allow the correct positioning (at the mouth of the corresponding seat 4) of the magnets 5 before inserting them in the corresponding seats.

25 The undulating stretches 16, 17, 18, 19, 20 of the different springs 10 are suitably made for exerting on the corresponding magnets 5 a pushing force perpendicular to the surface of the magnet 5 abutting against the spring 10.

 This pushing force corresponds to a tangential force between the opposite face 9 of the magnet 5 and the face 7 of the pole against which the spring 10 is supported and pressed.

30 Advantageously, the springs 10 are made, as indicated, from ferromagnetic material and they are therefore less expensive than springs made of non-magnetic material used in the prior art solutions so as not to short-circuit adjacent magnets and lose magnetic flow.

35 The use of magnetic material for the springs 10 allows

substantially to eliminate the dispersion of the flow which there would be in the air of the seat of the spring 10.

The springs 10 push, in practice, tangentially to the circumference passing through the grooves 11, each magnet 5 to move it next to the corresponding pole 3b. The force pushing the magnet 5 acts perpendicularly to the magnet 5 in such a way that the friction force holding the magnet 5 in the seat 4 is generated on the entire face 9 of the magnet resting on the iron of the pack 2 of laminations.

In order to uniformly distribute the force of the springs 10 on the corresponding magnets, the springs 10 are positioned substantially on a middle section (considering the radial extension) of the corresponding magnet 5.

According to this invention, the springs 10 yield, deforming plastically, after the magnets 5 have been positioned, maintaining the elastic characteristic sufficient to push the magnet 5 against the face 7 of the pole 3b and suitable to support the thermal expansion of the motor in use.

Advantageously, the loss of part of the elastic characteristics allows the correct sizing of the spring 10 with pre-load values which are permissible and suitable for the push of the magnet 5.

With particular reference to Figures 1, 2, 6 and 8, it should be noted that the laminated core 2 has a plurality of holes 21 in the poles 3a, 3b which extend according to axis R.

The purpose of the holes 21 is weight reduction and they define means of engagement in the rotor for the tools which, during assembly of the motor, move the rotor 1.

A preferred method for assembling the rotor 1, given the pack 2 of laminations, comprises the steps of positioning all the springs 10 astride the relative pole 3a and simultaneously inserting all the magnets 5.

Alternatively, if one magnet 5 at a time is to be inserted, the poles 3a, 3b are maintained in reciprocal position using a tool, not illustrated, equipped with a plurality of pins which engage the

aforementioned holes 21.

5 With reference in particular to Figure 2, it should be noted that the laminated core 2 has teeth 22 acting on the magnets 5 at the outer peripheral ends of the poles 3. These teeth 22 extend longitudinally according to the axis R and define a radial reference for positioning the magnets 5; advantageously, the magnets 5 are held in the relative seats 4, as mentioned above, by the friction between the faces 9 of the magnets 5 and the faces 7 of the poles 3b and not by the aforementioned teeth 22.

Claims

1. A rotor for an electrical machine comprising:
a laminated core (2) having a main axis (R) and a plurality of poles (3a, 3b) delimiting a plurality of radial seats (3) extending along the main axis (R), each seat (4) being delimited by a first and a second pole (3a, 3b), the rotor comprising
a plurality of magnets (5) inserted in the seats (4) and
elastic means (10) for locking the magnets (5) in the seats (4),
the rotor being characterised in that the elastic means (10) operate between each magnet (5) and the first pole (3a) delimiting the relative seat (4) for pushing each magnet (5) towards the second pole (3b) delimiting the same seat (4).
2. The rotor for an electrical machine according to claim 1, characterised in that the first pole (3a) has a first face (8) delimiting the seat (4) and the second pole (3b) has a second face (7) delimiting the seat (4), the first and second face (6, 7) being parallel to each other, the elastic means (10) pushing the corresponding magnet (5) against the second face (7).
3. The rotor for an electrical machine according to claim 1 or 2, characterised in that the elastic means (10) comprise a plurality of springs (10), at least one of the springs (10) being associated with each first pole (3a) for pushing each magnet (5) towards the second pole (3b) delimiting the relative seat (4).
4. The rotor for an electrical machine according to any of the foregoing claims, characterised in that the elastic means (10) comprise a plurality of springs (10) having a base stretch (12) from which two parallel prongs (13, 14) extend, the prongs (13, 14) having a first rectilinear stretch (15) and at least one elastically yielding undulating stretch (16), each spring (10) being fitted on a corresponding first pole (3a), the undulating stretch (16) of the prongs (13, 14) operating on the magnets (5) of two of the seats (4) adjacent to each other.
5. The rotor according to claim 4, characterised in that the

prongs (13, 14) extend parallel to the main axis (R) and are aligned according to a cylindrical surface having an axis corresponding with the main axis (R).

6. The rotor according to any of the foregoing claims, characterised in that each first pole (3a) has means (11) for engaging the relative elastic means (10).

7. The rotor according to claim 6, characterised in that the engagement means (11) are in the form of grooves (11) on the faces (6) of the first pole (3a), the prongs (13, 14) being inserted in the grooves (11), the undulating stretch (16) having the convexity facing towards the adjacent seat (4).

8. The rotor according to claim 7, characterised in that the grooves (11) extend parallel to the main axis (R) and lie on a cylindrical surface having an axis corresponding with the main axis (R).

9. The rotor according to any of the foregoing claims, characterised in that the magnets (5) are parallelepiped in shape and have a pair of parallel faces (8, 9) facing corresponding parallel faces (6, 7) of the relative seat (4), the elastic means (10) being shaped for pushing a face (9) of the magnet (5) against the face (7) of the corresponding second pole (3b) delimiting the relative seat (10).

10. The rotor according to any of the foregoing claims, characterised in that the elastic means (10) comprise a plurality of springs (10) made from ferromagnetic material.

11. The rotor according to any of the foregoing claims, characterised in that the elastic means (10) comprise a plurality of springs (10) made from metal strip.

12. The rotor according to any of the foregoing claims, characterised in that the elastic means (10) comprise a plurality of springs (10) made from spring wire.

13. A method for assembling a rotor for an electrical machine according to any of the foregoing claims, characterised in that it comprises:

a step of positioning the elastic means astride each first pole

(3a),

a step of positioning each magnet (5) at the relative seat (4),

a step of inserting the magnets (5) in the relative seats (4).

14. The method according to claim 13, characterised in that the inserting step occurs simultaneously for all the magnets (5).

15. The method according to claim 13 or 14, characterised in that it comprises a step of relative locking of the first and second poles (3a, 3b) using the holes (21), the inserting step occurring one magnet (5) at a time.

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Fig.1

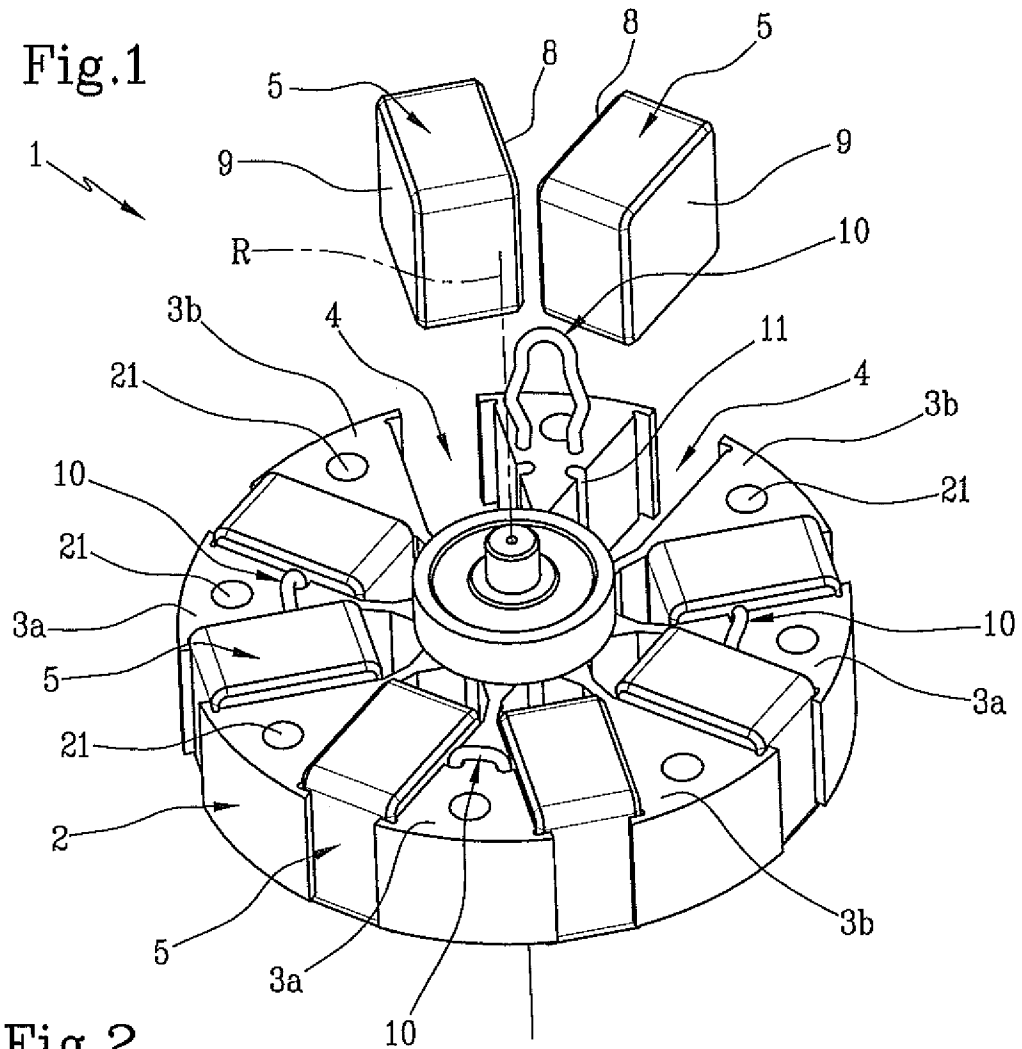
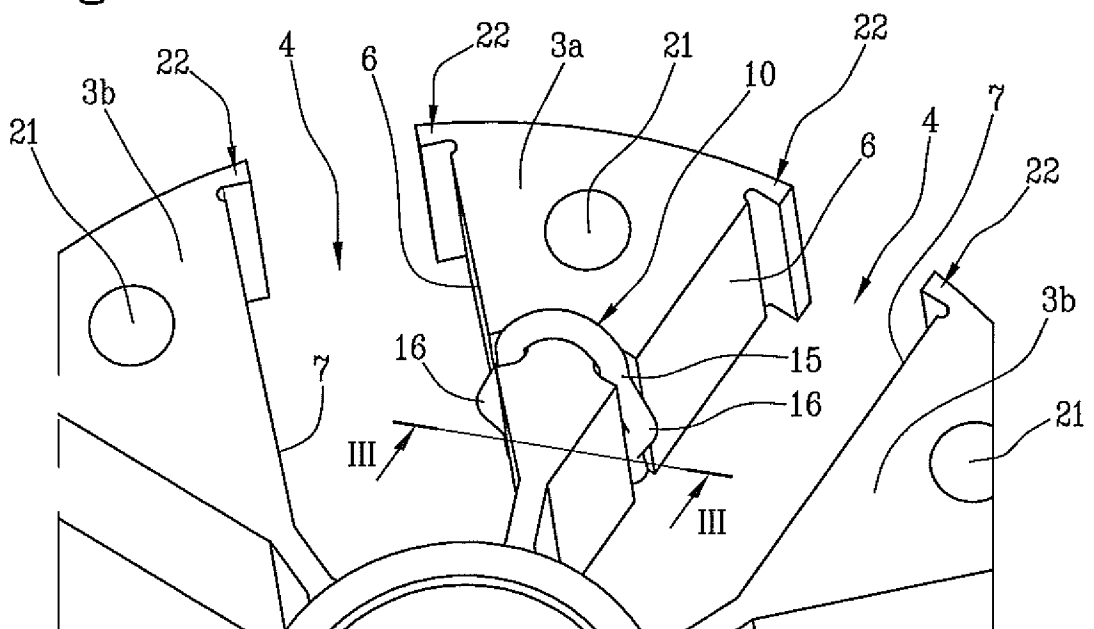


Fig.2



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Fig.3

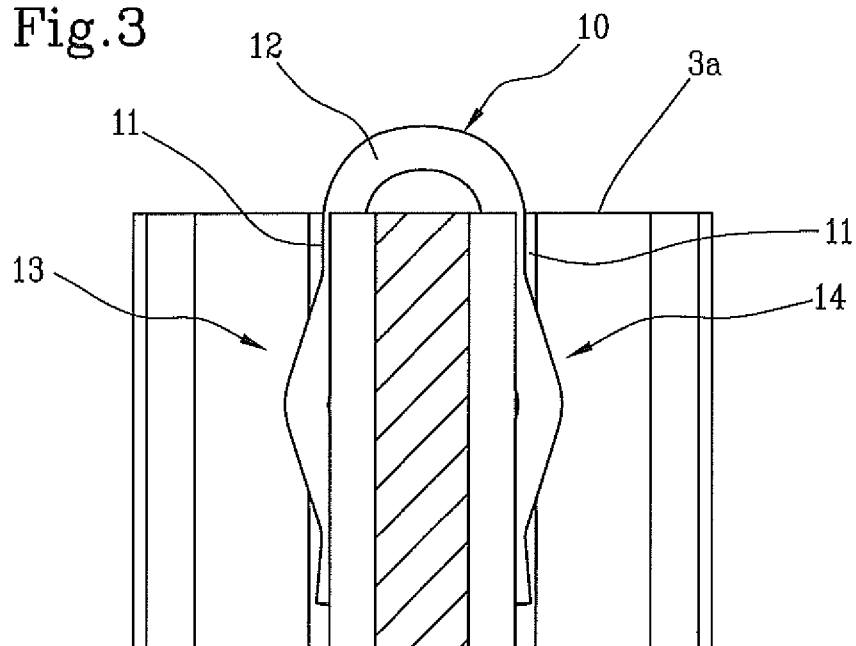


Fig.4

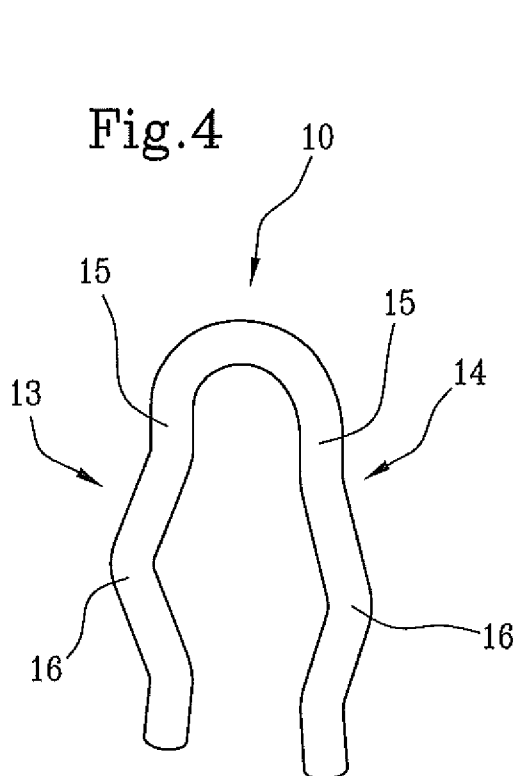
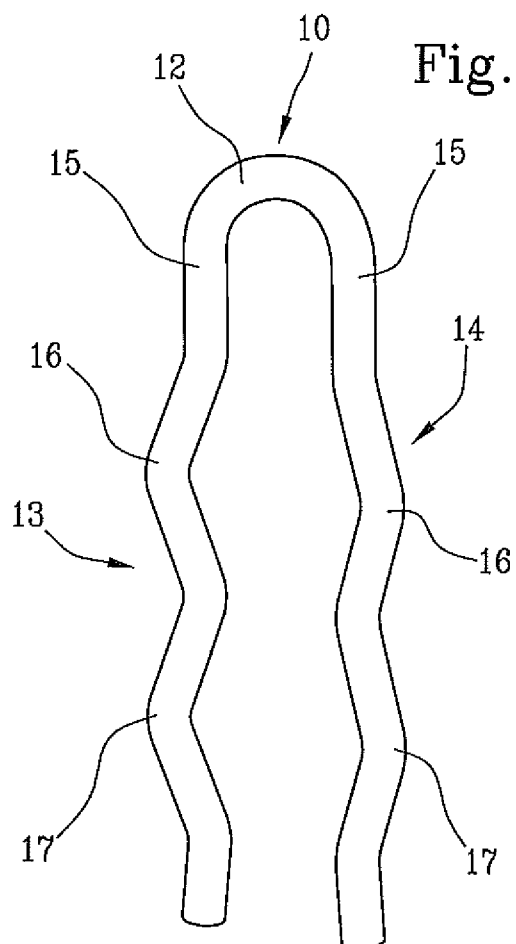


Fig.5



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Fig.8

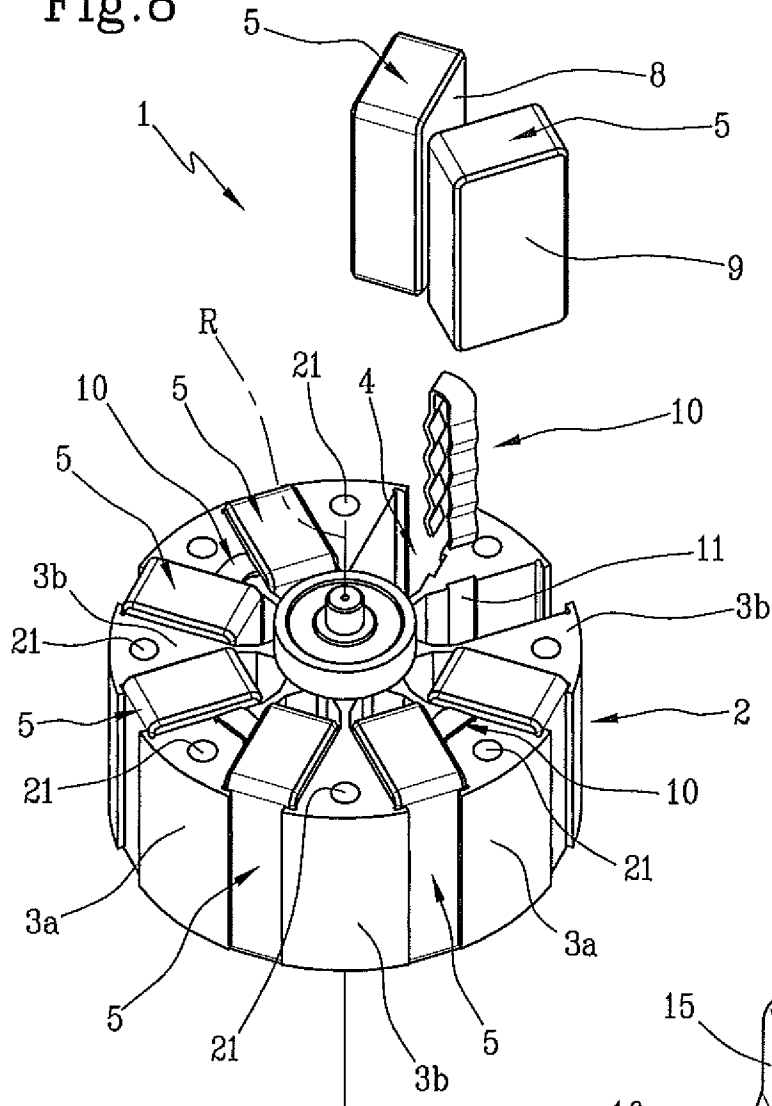


Fig.9

