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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) IMPROVED COMMUTATOR, ROTOR COMPRISING SAID IMPROVED COMMUTATOR, ELECTRIC MOTOR COMPRISING SAID ROTOR AND METHOD FOR MANUFACTURING SAID ROTOR

(57) Commutator preferably made of copper, provided with an improved coupling system with winding wires preferably made of aluminum, wherein a main body (13) of the lamellae (12) has a defining one or more grooves (16;17) adapted to intimately receive the free end of the winding wire (22a, 22b), and a hook-shaped flexible appendix adapted to fold and then compress said winding wire (22a, 22b) within the respective groove (16; 17).

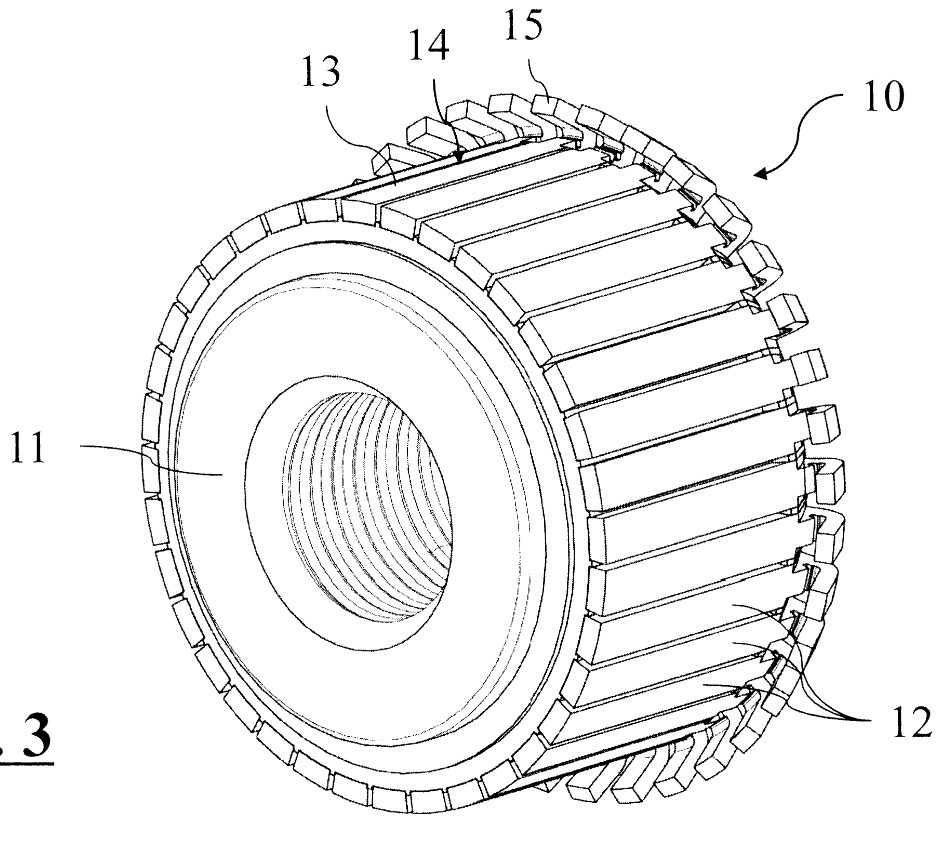

Fig. 3

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Description

Field of application

[0001] The present invention relates to a commutator, specifically adapted for a rotor of an electric motor. The invention also relates to said rotor, the related electric motor and a method for manufacturing said rotor.

[0002] Said electric motor is liable to multiple applications, for example it can be suitably used as an inner component of household appliances, such as washing machines, dryers or dishwashers.

Background art

[0003] The so-called universal motors are electric motors provided with series-excited rotor and stator windings, which have the particular feature of being able to be powered both in direct current and in alternating current.

[0004] The universal motors maintain, also when supplied with alternating current, the high starting torque and the compact dimension typical of DC motors, and are therefore traditionally used in many household appliances applications.

[0005] The cost competition in the field is recently fostering the use of aluminum instead of the more valuable copper, traditionally used for the windings of the machine.

[0006] Although it is attractive in terms of cost reduction, this replacement has been hindered to date by significant technical difficulties during the production phase, in particular related to the use of an aluminum wire - whether solid or copper-clad (CCA) - for manufacturing the rotor windings.

[0007] The commutators used in the universal motors usually have a hook, consisting of a lamella end portion folded on itself, adapted to lock the free end of the winding wire. Electric connection between hook and wire is ensured by an electric discharge which, along with the folding of the hook, arranges for the enamel to be removed and - in case of copper-to-copper connection - defines a partial interpenetration between the two elements.

[0008] In presence of solid aluminum or CCA wires, which have lower ductility than copper and therefore are more subject to breakage due to traction and compression, the closure of the hook, however, often causes the incision and / or local breakage of the wire, so that production waste considerably and uneconomically increases.

[0009] In an attempt to solve this problem, it has been recently proposed to form, by chip removal, a surface flattening at the point of attachment of the winding wires, as shown in the accompanying figures 7 and 7a. The ends of the aluminum wires 22a to be coupled to the main body 13 of the copper lamella are therefore placed on a supported flattening S of the attachment surface 14, where they are held by the folding of the flexible appendix 15 during the electric discharge forming the electric connection.

[0010] Such solution proposal has only partially reduced the risk of damage of the wire, and the formation of the copper/aluminum contact in the commutator remains therefore an unsolved critical issue.

[0011] The technical problem underlying the present invention is therefore to conceive a commutator with a system for connecting the winding wires which prevents damage and/or breakage episodes, although it ensures a limited contact resistance to the wire/commutator interface.

[0012] It is observed that the technical problem mentioned above, herein specifically described with reference to the universal electric motor, the research of the Applicant mainly focused on, is obviously extendible to any electric machine provided with commutator.

Summary of the invention

[0013] The technical problem previously identified is solved by a commutator for rotor of electric motor, comprising: a rotating support and a plurality of lamellae made of conductive material, preferably copper, mutually insulated and arranged around an external periphery of said rotating support; each of said lamellae comprising: a main body defining an external surface adapted to form a temporary electric connection with a brush of said electric motor; and a hook-shaped flexible appendix, which can be folded over an attachment portion of the contact surface, wherein said attachment portion has at least one groove transversal to the respective lamella and shaped to intimately receive (that is by general mechanical coupling - by either a clearance fit, a transition fit, or a clearance fit - between wire and groove) the free end of a winding wire, preferably an aluminum wire (that is: solid aluminum or CCA) of said rotor.

[0014] In other words, the attachment end of the aluminum wire is recessed in the transversal groove, within which it is inserted by mechanical coupling.

[0015] Thanks to this solution, a substantial restraint of the wire is formed, which prevents, as demonstrated by the experimental results of the Applicant, cut or damage phenomena due to the subsequent steps of the manufacturing process (folding of the flexible appendix and electric discharge for removing the enamel).

[0016] Preferably, the groove is shaped to receive the free end of the winding wire coupled with interference fit: indeed, it has been observed that the prevention of damage is significantly better in this case.

[0017] The groove has a depth preferably higher than half the length measured along the development direction of the respective lamella. Therefore, it has a substantially U-shaped and significantly recessed profile, which allows recessing a cylindrical product namely with circular section such as the winding wire.

[0018] Preferably, the groove has a substantially square or trapezoidal section profile, with depth approximately equal to the minimum length.

[0019] The flexible appendix can be preferably folded so as to get closer to said attachment portion coming into contact with the winding wire housed in the groove. Still preferably, the flexible appendix is adapted to press onto a portion of winding wire which remains exposed after the insertion of the wire, thus contributing to the compression of the wire itself within the volume of the groove.

[0020] Preferably, the main body of each of the lamellae has a head end with transversal width lower than the transversal width of the rest of the main body; said flexible appendix being jointed to said head end; said groove transversely crossing said head end.

[0021] Still preferably, at least one of the lamellae has at least two side-by-side grooves at said attachment portion, each of said grooves being shaped for coupling a different free end of winding wire of said rotor. It should be observed that the two side-by-side grooves are distinct, so that each winding wire independently recesses into a specific groove.

[0022] The technical problem noticed above is also solved by a rotor for electric motor comprising, besides a commutator according to what has been previously described: a shaft to which the rotating support is rigidly constrained; and a rotor winding also integral with said shaft; wherein the free ends of the winding wires are coupled within the grooves of the lamellae of said commutator and the flexible appendices are folded over said winding wires.

[0023] In particular, to form the recessing described above, the grooves are suitably dimensioned with respect to the winding wires.

[0024] Each groove preferably has a length measured along the development direction equal or lower than 120% of the diameter of the respective winding wire inserted therein; preferably said length is equal or lower than the diameter of the respective winding wire; still preferably, said length is equal or lower than 90% of the diameter of the respective winding wire.

[0025] For example, for wires with diameter between 0,6 mm and 0,7 mm, the length of the recess can be equal to 0,4 mm.

[0026] Each groove preferably has a depth lower than the diameter of the respective winding wire inserted therein, but higher than half of said diameter; preferably said depth is equal or lower than 90% of said diameter.

[0027] It should be observed that in particular wherein the groove is formed close to the interface with the flexible appendix, its two upper edges can be at a different distance with respect to the bottom. In particular, the edge facing towards the flexible appendix can be lowered with respect to the edge facing towards the external surface of the main body. In this way, the folding of the flexible appendix in a substantially parallel position and almost, if not entirely, in contact with the external surface is facilitated. Indeed, the flexible appendix, in a folded position, must be able to contact and exert a pressure on the winding wires mainly recessed in the grooves of the respective lamella.

[0028] In the present description, the term depth is to be considered as the distance of the bottom of the groove with respect to the edge facing towards the main body of the lamella, also in case of asymmetric groove described above.

[0029] The technical problem previously identified is also solved by an electric motor, by way of non-limiting example a universal motor comprising a rotor according to what has been previously described rotatably free within a stator body.

[0030] Said motor can be advantageously employed within large household appliances, for example it can be configured to foster rotation of the basket in a washing machine or a dryer.

[0031] The technical problem previously identified is also solved by an embodiment of a rotor according to what has been previously described. Such method comprises in particular the steps of:

forming a commutator according to what has been previously described;

for each lamella, with the respective flexible appendix in an undeformed position, inserting - preferably forcing - within the at least one groove the respective free end of the winding wire;

for each lamella, bringing said flexible appendix into a folded position so as to compress the winding wire inserted in the one or more grooves;

for each lamella, once the flexible appendix has been folded, it is electrically coupled to said winding wire by electric discharge.

[0032] The electric discharge mentioned above can occur in a known manner by applying two electrodes to the flexible appendix and to the lamella, possibly modifying the machine parameters (power, time, force) according to the use of an aluminum wire instead of the traditional copper wire.

[0033] It should be noticed that the formation of the commutator comprises a step of forming the transverse grooves on the main body of each lamella. Such step is preferably performed by operating, via a tool specifically designed for this purpose, a local compression on the lamella, rather than by chip removal.

[0034] Further features and advantages will become clearer from the following detailed description of a preferred, but not exclusive, embodiment of the present invention with reference to the attached figures that are given for instance and not limiting to it.

Brief description of drawings

[0035]

figure 1 represents a perspective view of an electric motor assembly according to the present invention, partially sectioned to show the inner commutator;

figure 2 represents a perspective view of a rotor for electric motor according to the present invention;

figure 3 represents a perspective view of a commutator according to the present invention, in a preliminary configuration with the connection hooks or the flexible appendices of the lamellae in open configuration;

figure 4 represents an enlarged detail of the commutator of Figure 3;

figure 5 represents a diametric sectional view of a first lamella, adapted to couple with a single winding wire, of the commutator of figure 3;

figure 5a represents an enlarged detail of the view of Figure 5;

figure 6 represents a diametric sectional view of a second lamella, adapted to couple with two winding wires, of the commutator of figure 3;

figure 6a represents an enlarged detail of the view of Figure 6;

figure 7 represents a diametric sectional view of a detail of a commutator according to the prior art, in a preliminary assembly step with the winding wire in a position below the connection hook that is still not tightened;

figure 7A represents the detail of Figure 7, in a final assembly step with the connection hook tightened on the winding wire;

figure 8 represents a diametric sectional view of a detail of the device of figure 3, in a preliminary assembly step with two winding wire in a position below the connection hook that is still not tightened;

figure 8A represents the detail of Figure 8, in a final assembly step with the connection hook tightened on the winding wire;

Detailed description

[0036] With reference to the attached figure 1, a universal motor according to the present inventionis generally identified by 1.

[0037] In the preferred embodiment illustrated herein, said transverse motor 1 is specifically adapted for use in household appliances applications, in particular to operate the rotating basket of a washing machine or similar device.

[0038] The transverse motor 1 comprises an external frame 5, comprising a plurality of feet adapted to fix the casing of the household appliance.

[0039] A stator 3 consisting of coils wound around the poles of a magnetic circuit is provided integral to the said external frame 5. Said windings are preferably formed with solid aluminum wires, or with copper-clad aluminum wire (CCA).

[0040] Within said stator 3 a rotor 2 is rotary assembled, supported by two bearings or bushings 8 at the opposite ends of the external frame 5. One of the ends of the rotor 2, coming out of the external frame 5, has a pulley 4 for operating a belt for transmitting motion to the basket of the washing machine.

[0041] The rotor 2 has a cylindrical rotor body 21, on which a plurality of slots 23 are formed for receiving winding wires 22a; 22b. Such wires are made of aluminum, preferably solid aluminum to enable a reduction in costs as high as possible, or alternatively of copper-clad aluminum.

[0042] Laterally to the external frame 5 two brushes 6 are fixed, which are adapted to allow the rotor 2 to be powered by means of a sliding electric connection above a commutator 10.

[0043] The commutator 10 is keyed over a shaft 7 of the rotor 2, and in particular comprises a rotating support 11, preferably dielectric, which supports a plurality of lamellae 12, which are juxtaposed but disjointed and electrically separated from each other.

[0044] Said lamellae 12, preferably made of copper, have a main body 13 developing lengthwise in a direction parallel to the axis of the shaft 7. Said main body 13 is jointly associated with the underlying rotating support 11 by means of dovetail couplings. An external surface 14 of said main body 13 forms the sliding electric connection with the brushes 6 during the operation of the universal motor 1.

[0045] The end of said lamellae 12 facing towards the rotor winding has a head end 18 with a transverse width W2 lower than the transverse width W1 of the rest of the main body 13. At the end of said head end 18 a flexible hook-shaped appendix 15 develops, whose function - as will become clearer from the following description - is that of forming the electric connection between the lamella 12 and one or more free ends of the winding wire 22a; 22b of the rotor 2.

[0046] As shown in Figures 8, 8A, such flexible appendix 15, formed as an enbloc with the main body 13, namely also made of copper, is elastically deformable between an open starting position, in which it remains far away from the external surface 14, and a closed final position, in which it gets close to the external surface 14, in particular to an end portion of such surface, hereinafter identified as abutment portion 14a.

[0047] There are two types of lamellae 12 of the commutator 10: the greater part is adapted to couple with a single winding wire 22a, whereas at least one lamella is adapted to couple with two different winding wires 22a;

22b.

[0048] The lamellae of the first type, illustrated by way of example in Figures 5 and 5a, have a groove 16 intended to receive the winding wire 22a, transversely formed on the head end 18 at the interface with the flexible appendix 15. The lamella adapted instead for the connection with two wires, illustrated by way of example in Figures 6 and 6a, has instead two grooves 16; 17 intended to receive the two winding wires 22a; 22b: a first groove 16 at the interface with the flexible appendix 15; and a second groove 17, separated from the first one, formed in a position further away with respect to the flexible appendix 15.

[0049] The groove 16 close to the flexible appendix 15 has, in both types of lamella 12, an asymmetric U-shaped profile which connects the external surface 14 from one side to an edge E on the other side, slightly lowered with respect to the level of the external surface 14. The lowered edge E, contiguous to the pivot point of the flexible appendix 15, facilitates its collapse in a position parallel and juxtaposed to the external surface 14.

[0050] The throats 16; 17, net of the lowered edge, have profiles with a substantially square section of equal size. Said profiles are configured to allow the coupling with interference fit of the winding wires 22a; 22b, that is they have lower dimension than the diameter of the wire they receive. Preferably, the dimension in depth D and length L (the latter measured along the development direction of the lamella 12) are both between 55% and 90% of the diameter of the wire they receive.

[0051] By way of example, considering a first winding wire 22a with a diameter equal to 0.6 mm and a second winding wire 22b with a diameter equal to 0.67 mm, the grooves 16; 17 can have a sideway square section profile of 0.4 mm.

[0052] It is observed that the grooves 16; 17 mentioned above, which are difficult to form by chip removal, are preferably formed via a dedicated tool which works on the lamella 12 by compression, locally caving it.

[0053] During the assembly of the rotor 2, the free ends of the winding wires 22a; 22b are forcedly inserted, with methods similar to those of the insertion of the winding wires into the rotor or stator slots, within the respective grooves 16; 17 of the commutator 10. Given the dimensional difference, the end of the wire locally deforms inside the groove 16; 17, adapting its own section and coming in contact with the walls of the groove itself.

[0054] The subsequent folding of the flexible appendix 15 defines a further compression of the winding wire 22a; 22b, which is thus confined within the volume defined by the groove 16; 17 and by the flexible appendix 15 which overlooks it.

[0055] Subsequently, according to known methods, an electric discharge is formed with electrodes placed in contact with the lamella 12 and the flexible appendix 15, removing the coating of the wire and forming a mechanical and electric coupling between the winding wire 16; 17 and the lamella 12 of the commutator 10.

[0056] As can be seen from the comparison between Figures 7, 7A and Figures 8, 8A, the commutators according to the prior art do not have a wire insertion groove; the compression performed by the flexible appendix 15 involves therefore most of the wire body, transmitting a strong and localized stress which can cause the breakage of the element.

[0057] In the commutator according to the invention, the groove 16; 17 allows, on the other hand, the deformation of the wire itself to be contained within a channel, avoiding the breakage or local damage thereof.

[0058] The interface between the aluminum wire 22a; 22b and the copper lamella 12, at the flexible appendix 15, defines a galvanic torque which can cause corrosion phenomena over time, with consequent oxidation of the contacts and loss of electric continuity. In order to prevent said corrosion phenomena, the rotor 2 provides a protective coating, in particular at the commutator 10 above the flexible appendices 15 which block the wires 22a; 22b.

[0059] Obviously, a skilled person, with the purpose of meeting contiguous and specific needs, may apply to the above-mentioned invention numerous changes and variants, all however within the scope of protection of the invention defined by the following claims.

Claims

1. Commutator (10) for rotor (2) of electric motor (1), comprising: a rotating support (11) and a plurality of lamellae (12) made of conductive material, mutually insulated and arranged around an external periphery of said rotating support (11); each of said lamellae (12) comprising: a main body (13) defining an external surface (14) adapted to form a temporary electric connection with a brush of said electric motor (1); and a hook-shaped flexible appendix (15), which can be folded over an attachment portion (14a) of the contact surface (14) **characterized in that** said attachment portion (14a) has at least one groove (16; 17) transverse to the respective lamella (12) and configured to intimately receive the free end of a winding wire (22a; 22b) of said rotor (2).

2. Commutator (10) according to claim 1, wherein said groove (16; 17) is configured to receive the free end of the winding wire (22a; 22b) coupled with interference fit.

3. Commutator (10) according to one of the previous claims, wherein said groove (16; 17) has a depth (D) higher than half the length (L) measured along the development direction of the respective lamella (12).

4. Commutator (10) according to one of the previous claims, wherein the main body (13) of each of said lamellae (12) has a head end (18) with transversal

width (W2) lower than the transversal width (W1) of the rest of the main body (13); said flexible appendix (15) being jointed to said head end (18); said groove (16; 17) transversely crossing said head end (18).

5. Commutator (10) according to one of the previous claims, wherein at least one of said lamellae (12) has at least two grooves (16; 17) side by side at said attachment portion (14a), each of said grooves being shaped for coupling with a different free end of winding wire (22a; 22b) of said rotor (2).

6. Commutator (10) according to one of the previous claims, wherein said lamellae (12) are made of copper.

7. Rotor (2) for electric motor (1) comprising: a shaft (7); a commutator (10) according to one of the previous claims whose rotating support (11) is rigidly constrained to said shaft (7); and a rotor winding also integral to said shaft (7); free ends of winding wires (22a; 22b) defining said winding rotor being coupled within the grooves (16; 17) of the lamellae (12) of said commutator (10), said flexible appendices (15) being folded over said winding wires (22a; 22b).

8. Rotor (2) according to claim 7, wherein said winding wires (22a; 22b) are at least internally made of aluminum.

9. Rotor (2) according to one of claims 7 or 8, wherein said groove (16; 17) has a length (L), measured along the development direction of the lamella (12), equal or lower than 120% of the diameter of the respective winding wire (22a; 22b) inserted therein.

10. Rotor (2) according to claim 9, wherein the length (L), measured along the development direction of the lamella (12), is equal or lower than 90% of the diameter of the respective winding wire (22a; 22b).

11. Rotor (2) according to one of claims 7-10, wherein said groove (16; 17) has a depth (D) lower than the diameter of the respective winding wire (22a; 22b) inserted therein, but higher than half the said diameter.

12. Rotor (2) according to claim 11, wherein said depth (D) is equal or lower than 90% of said diameter of the respective winding wire (22a; 22b).

13. Rotor (2) according to one of claims 7-12, wherein for each lamella (12) at least one groove (16), placed close to the interface with the flexible appendix (15), has an edge (E) facing towards said flexible appendix (15) lowered with respect to the external surface (14) to which the profile of the groove (16) connects on the opposite side.

14. Electric motor (1) comprising a rotor (2) according to one of claims 7-13, said rotor (2) being rotary free within a stator body (3).

15. Method of forming a rotor (2) according to any one of claims 7-13, said method comprising the steps of:

forming a commutator (10) according to one of claims 1-6;
for each lamella (12), with the respective flexible appendix (15) in undeformed position, inserting within the at least one groove (16, 17) the respective free end of the winding wire (22a; 22b);
for each lamella (12), bringing said flexible appendix (15) into a folded position so as to compress the winding wire (22a; 22b) inserted in the one or more grooves (16; 17);
for each lamella (12), once the flexible appendix (15) has been folded, electrically coupling it to said winding wire (22a, 22b) by electric discharge.

Amended claims in accordance with Rule 137(2) EPC.

1. Rotor (2) for electric motor (1) comprising: a shaft (7); a commutator (10) comprising: a rotating support (11) and a plurality of lamellae (12) made of conductive material, mutually insulated and arranged around an external periphery of said rotating support (11); each of said lamellae (12) comprising: a main body (13) defining an external surface (14) adapted to form a temporary electric connection with a brush of said electric motor (1); and a hook-shaped flexible appendix (15), which can be folded over an attachment portion (14a) of the contact surface (14), said attachment portion (14a) having at least one groove (16; 17) transverse to the respective lamella (12) and configured to intimately receive the free end of a winding wire (22a; 22b) of said rotor (2); wherein said lamellae (12) are made of copper; said rotating support (11) being rigidly constrained to said shaft (7); the rotor (2) further comprising a rotor winding also integral to said shaft (7); free ends of winding wires (22a; 22b) defining said winding rotor being coupled within the grooves (16; 17) of the lamellae (12) of said commutator (10), said flexible appendices (15) being folded over said winding wires (22a; 22b); **characterized in that** said winding wires (22a; 22b) are at least internally made of aluminum; **in that** said groove (16; 17) is configured to receive the free end of the winding wire (22a; 22b) coupled with interference fit; **in that** the length (L), measured along the development direction of the lamella (12), is lower than the diameter of the respective winding wire (22a; 22b); and **in that** said groove (16; 17) has a depth (D) lower than the diameter of the respective winding wire (22a; 22b) inserted therein, but higher than half the said diameter.

2. Rotor (2) according to claim 1, wherein said groove (16; 17) has a depth (D) higher than half the length (L) measured along the development direction of the respective lamella (12).

3. Rotor (2) according to one of the previous claims, wherein the main body (13) of each of said lamellae (12) has a head end (18) with transversal width (W2) lower than the transversal width (W1) of the rest of the main body (13); said flexible appendix (15) being jointed to said head end (18); said groove (16; 17) transversely crossing said head end (18).

4. Rotor (2) according to one of the previous claims, wherein at least one of said lamellae (12) has at least two grooves (16; 17) side by side at said attachment portion (14a), each of said grooves being shaped for coupling with a different free end of winding wire (22a; 22b) of said rotor (2).

5. Rotor (2) according to one of the previous claims, wherein the length (L), measured along the development direction of the lamella (12), is equal or lower than 90% of the diameter of the respective winding wire (22a; 22b).

6. Rotor (2) according to one of the previous claims, wherein said depth (D) is equal or lower than 90% of said diameter of the respective winding wire (22a; 22b).

7. Rotor (2) according to one of the previous claims, wherein for each lamella (12) at least one groove (16), placed close to the interface with the flexible appendix (15), has an edge (E) facing towards said flexible appendix (15) lowered with respect to the external surface (14) to which the profile of the groove (16) connects on the opposite side.

8. Electric motor (1) comprising a rotor (2) according to one of claims 1-7, said rotor (2) being rotary free within a stator body (3).

9. Method of forming a rotor (2) according to any one of claims 1-7, said method comprising the steps of:

forming the commutator (10);
for each lamella (12), with the respective flexible appendix (15) in undeformed position, inserting within the at least one groove (16, 17) the respective free end of the winding wire (22a; 22b);
for each lamella (12), bringing said flexible appendix (15) into a folded position so as to compress the winding wire (22a; 22b) inserted in the one or more grooves (16; 17);
for each lamella (12), once the flexible appendix (15) has been folded, electrically coupling it to said winding wire (22a, 22b) by electric discharge.

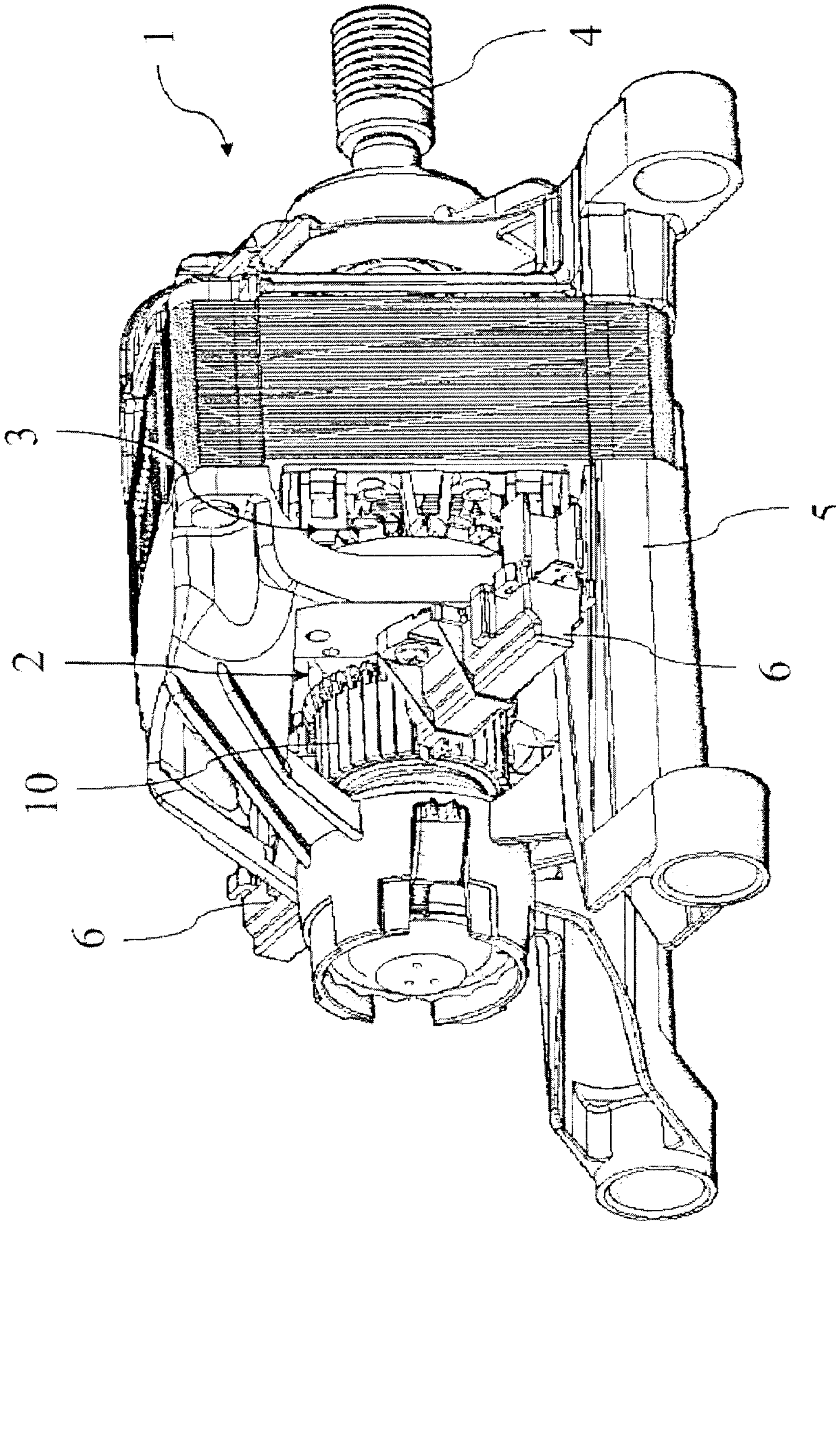


Fig. 1

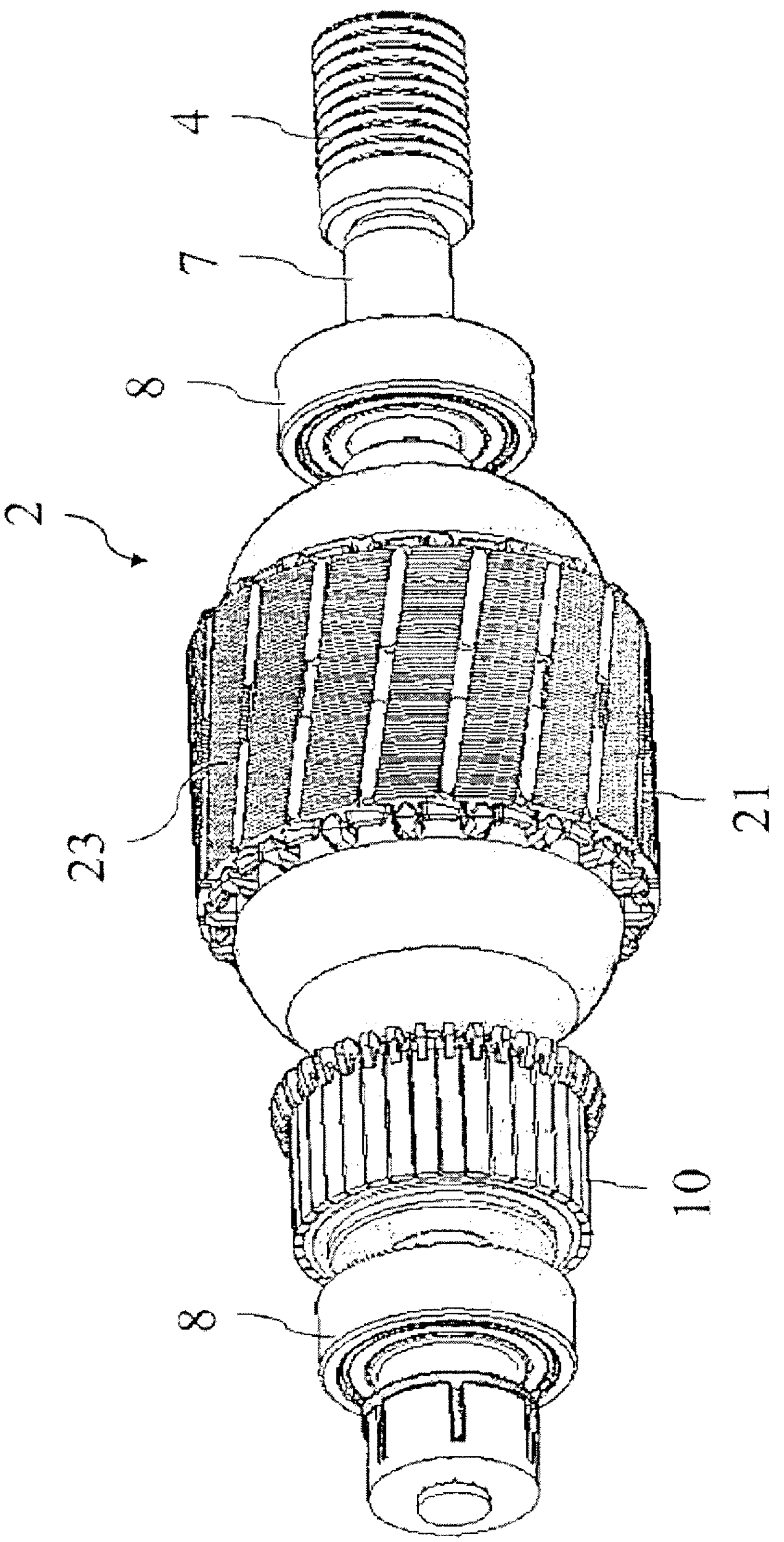


Fig. 2

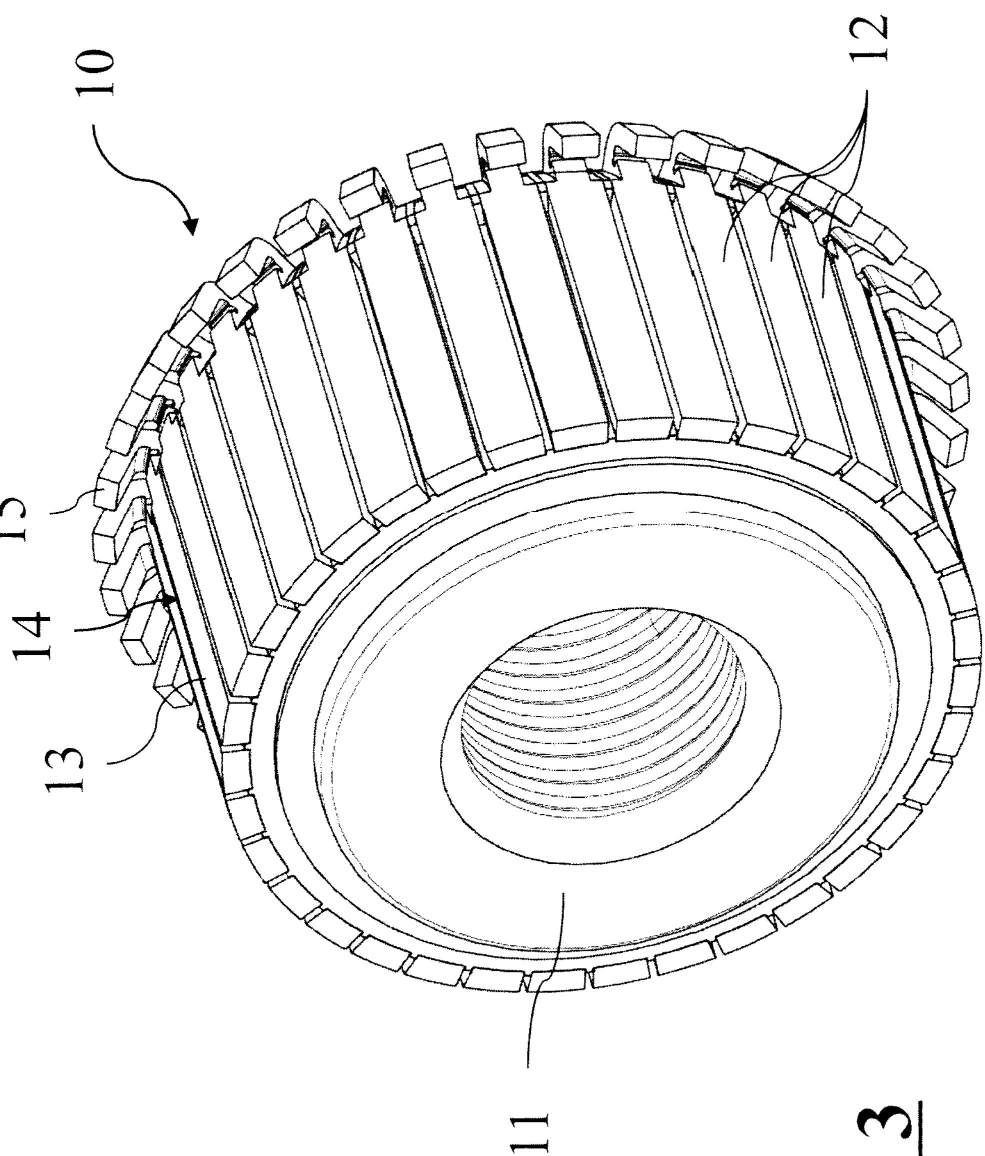


Fig. 3

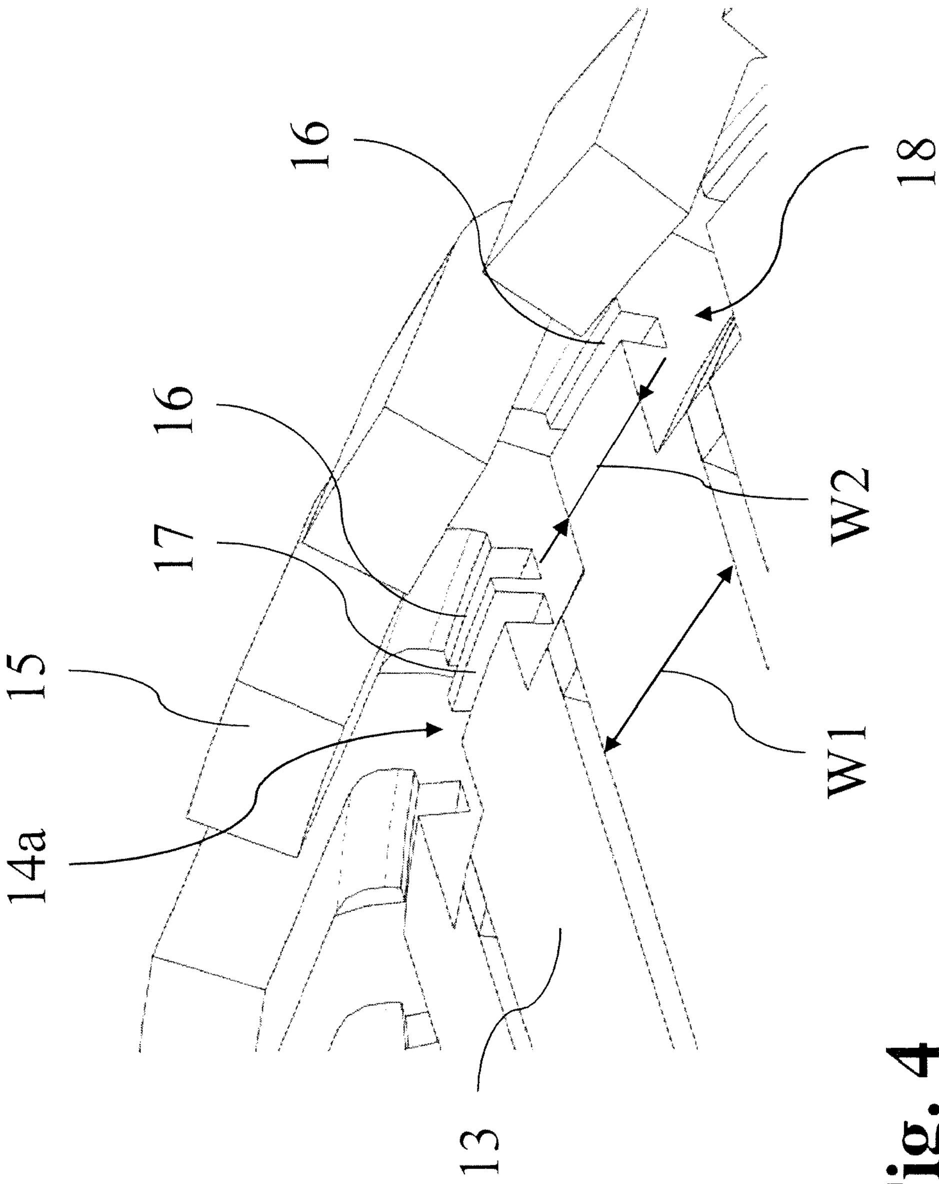


Fig. 4

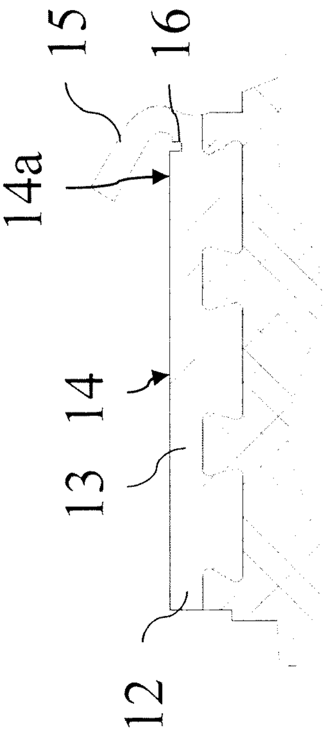


Fig. 5

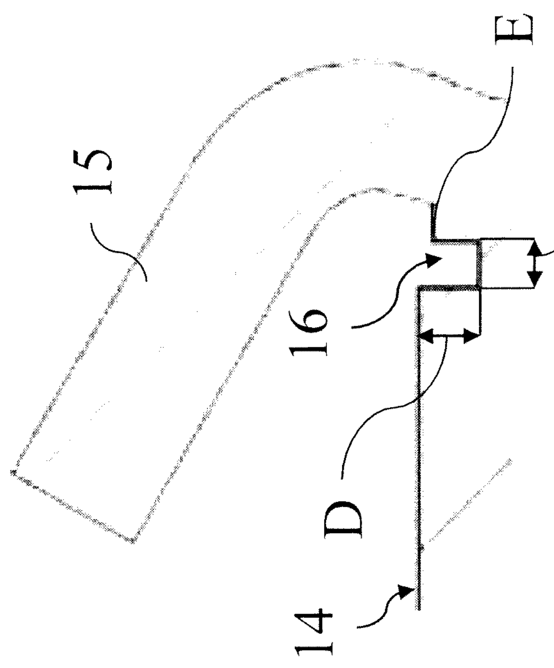


Fig. 5a

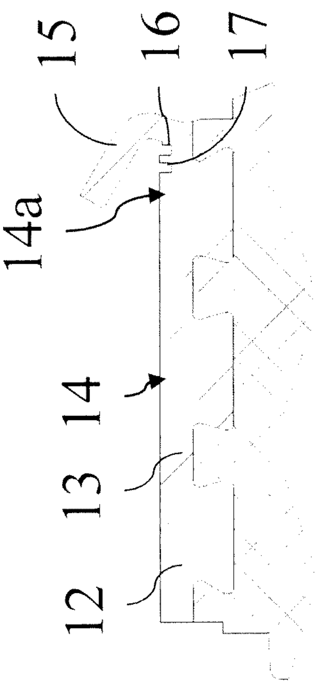


Fig. 6

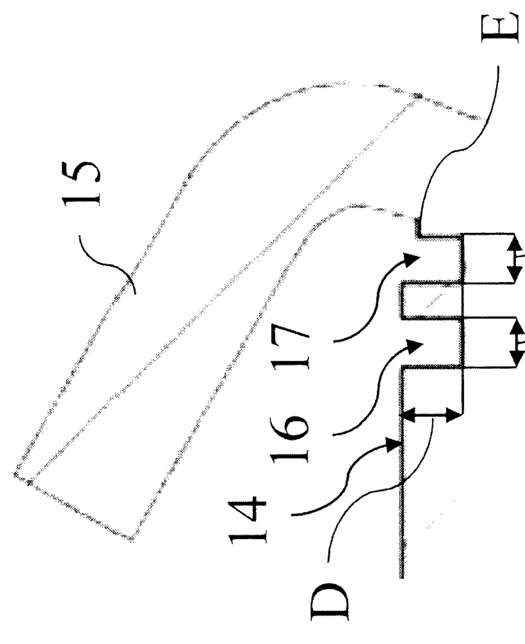


Fig. 6a

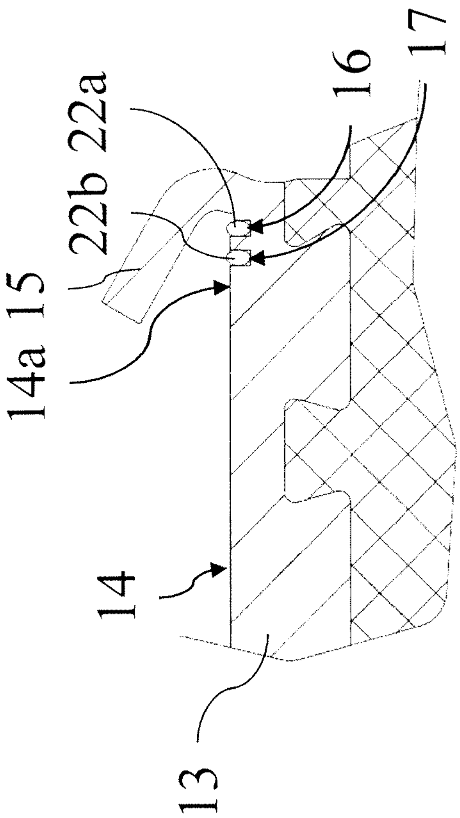


Fig. 8

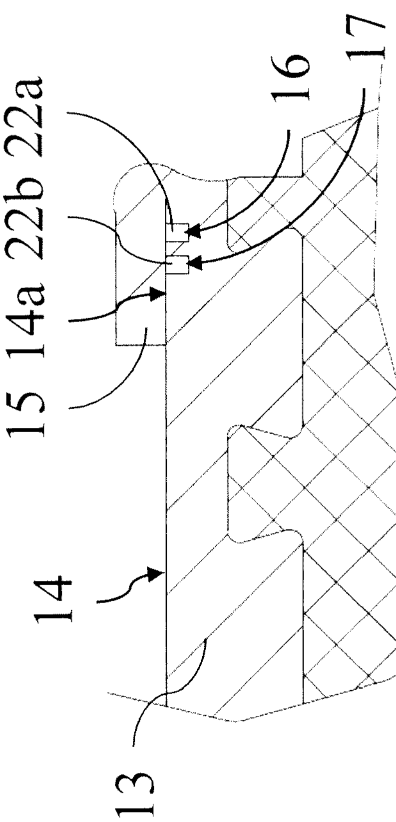
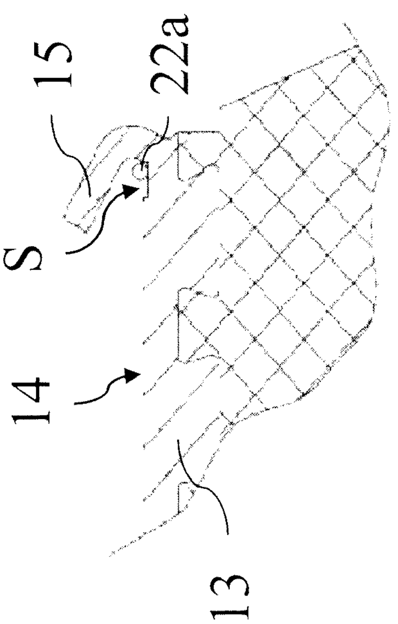
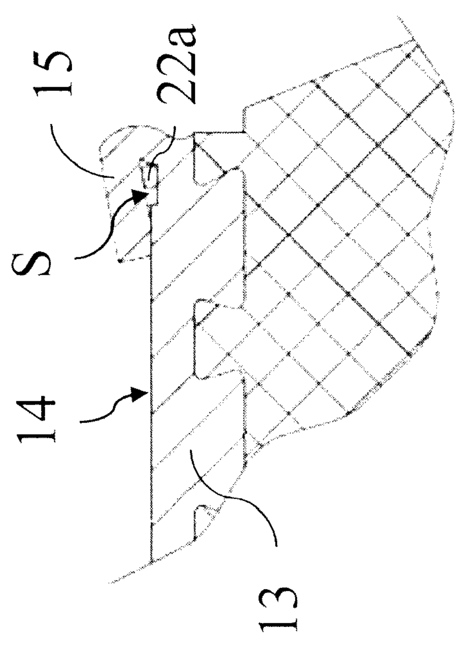


Fig. 8a



PRIOR ART

Fig. 7



PRIOR ART

Fig. 7a

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Application Number
EP 18 42 5005

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Place of search	Date of completion of the search	Examiner
The Hague	4 July 2018	Fernandez, Victor

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