(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 July 2014 (10.07.2014)

(10) International Publication Number
WO 2014/107474 A1

(51) International Patent Classification:
H02K 1/06 (2006.01) *H02K 15/02* (2006.01) *H02K 1/12* (2006.01)

(21) International Application Number: PCT/US2014/000004

(22) International Filing Date: 6 January 2014 (06.01.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/848,457 4 January 2013 (04.01.2013) US

(72) Inventor; and
(71) Applicant : CALLEY, David [US/US]; 10220 Ciervo Trail, Flagstaff, AZ 86004 (US).

(74) Agent: CALLEY, David; 10220 Ciervo Trail, Flagstaff, AZ 86004 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: METAL RIBBON STATOR AND MOTOR COMPRISING SAME

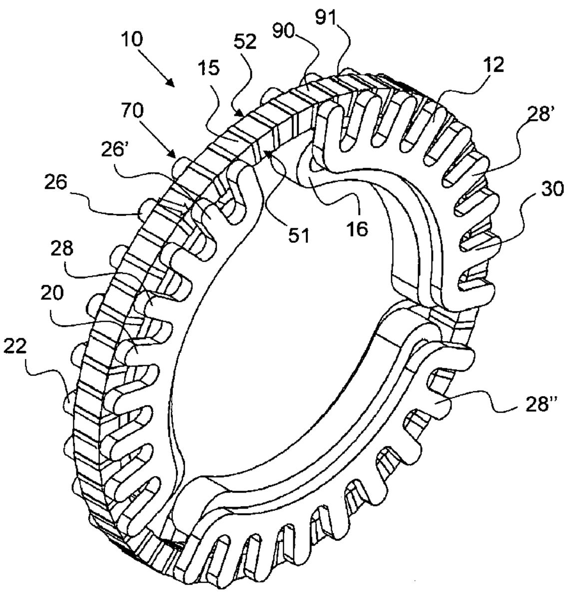

FIG. 1

(57) Abstract: A stator made from a ribbon of metal having multiple layers of slit metal, and motors made therefrom are described. A ribbon having multiple layers of metal is formed into a stator such as by flattening or pleating the ribbon to form each or pole or a stator having a plurality of stator teeth. The stator formed from metal ribbon may be configured into any suitable type of motor, such as a axial transverse flux motor. A magnetic flux return may also be made out of metal ribbon.

WO 2014/107474 A1

METAL RIBBON STATOR AND MOTOR COMPRISING SAME

BACKGROUND OF THE INVENTION

Cross Reference to Relate Applications

[0001] This application claims the benefit of U.S. Provisional Patent Application No.: 61/848,457, filed on January 4, 2013, the entirety of which is incorporated herein by reference.

Field of the Invention

[0002] The present invention relates to a stators for electric motors, and in particular stators comprising a multilayer amorphous ribbon

Background

[0003] The present invention is an axial transverse flux motor providing high torque density, low cost construction and providing for high RPM operation by allowing for use of materials that do not require stamping for assembly. The design uses non-oriented and flux conduction material in a “ribbon” or “tape”, typically formed by slitting. For lower RPM operation, silicon steel works well. For higher RPM operation, amorphous metal is a good material of choice in that it has high permeability and low loss at both low and high frequency applications. Amorphous metal, such as Metglass available from Metglas Inc, Conway SC or AT & M, Beijing China, or Nanocrystalline materials are very difficult to machine or form into shapes suitable for stator configurations.

[0004] There exists a need for a motor/generator stator made from material allowing for a range of non-oriented slit materials including silicon steel, amorphous metal, and Nanocrystalline materials that is also simple to assembly, high in torque density, allows for tight tolerances, requires very few parts, thereby reducing assembly cost and the potential for parts being incorrectly assemble or positioned. There exists a need for a motor that has low loss at low and high rotational frequency, and especially motors with high pole counts, such as transverse flux motors.

SUMMARY OF THE INVENTION

[0001] This invention relates to an axial transverse flux motor/generator here after referred to as an AFTM motor. The pole pieces of the armature/stator of the motor are principally made from a ribbon or tape of slit magnetically conductive materials hereafter referred to as a tape. The tape is formed of layers of suitable magnetically conductive material such as silicon steel, amorphous metal, and nanocrystalline material.

[0002] The tape is formed of multiple layers of material, typically by winding into a toroid. In a first configuration, toroids are then flattened into bars forming a pole piece with at least one end remaining uncut to allow flux to travel around the end interacting with the magnet ring. In another configurations two or more poles may be formed from one toroid. These may be formed by folding or “pleating” to form the plurality of armature teeth.

[0003] The tape has a top surface and bottom surface, a first edge and a second edge. The tape formed pole or pole set may be positioned with the poles adjacent a rotor with the metal tape edge facing the magnet ring. The magnet ring shown here is formed of an assembly of magnets with flux concentrators placed between them. There may be rotating or stationary however for easy of discussion, will be referred to hereafter as the rotor. The flux that has entered the edges of pole or pole set travels substantially along the layers without crossing layers to a return part. The return part may mal also be formed of a toroid in tape or another material such as SMC. The flux then passes substantially axially to the paired pole or pole set surrounding the coil. The flux travels again through the edge of the pole or pole set substantially in plane to the rotor.

[0004] The pole or pole sets formed of tape maybe formed such that a gap is left so that flux will have a greater tendency to stay in the planes of the tape. . The individual layers of the ribbon may be adhered in discrete locations, such as by the application of a discrete amount of adhesive between two ribbon layers. In another embodiment, a discontinuous adhesive may be applied to one or more surfaces of a ribbon layer during the formation of the ribbon loop or tape. An adhesive may be a magnetic flux insulator or magnetic flux conductor and may provide a small gap between ribbon layers. In still another embodiment, a magnetic insulator may be configured between two or more of the formed stator teeth.

[0005] The poles or pole sets or otherwise formed tape may be position around at least a portion of a rotor as a stator stack. A stator stack may extend around any suitable portion of the rotor including, but not limited to, 30 electrical degrees or more, 60 electrical degrees or more , 120 electrical degrees or more, 180 electrical degrees or more, 360 electrical degrees or more and any range between and including the values provided. In an exemplary embodiment, a motor comprises three stator halves configured for approximately 120 electrical degrees on each side of the rotor forming 3 phases in a plane.

[0006] An electric motor as described herein may comprise a rotor configured between a first stator half and a second stator half. The rotor may be any suitable type of rotor including, but not limited to, a permanent magnet (PM) rotor, an alternating field rotor, a PM flux concentrator type rotor, a wound field rotor, an induction rotor, and a low loss PM flux concentrating type rotor.

[0007] A stator can be made using a tape, as described herein, in a very cost effective an efficient manner. Slitting materials provides for very high tolerances and when a slit material is formed into a tape that is used to form a stator, the adherence to tight tolerances is greatly simplified. In addition, slitting magnetically conducting materials, such as amorphous metal, is cost effective, as it requires no additional tooling to stamping, does not remove and waste the material and allows for high tolerances. Amorphous metals and other low magnetic loss materials are expensive and slitting to form a ribbon provides for extremely high utilization of the material. Furthermore, a stator can be made with only three components, a first stator half, a second stator half and a return. Since all three of these components can be made from high precision slit materials, the tolerances of the assembly can be held to very high levels. A tape formed of a plurality of ribbons provides for high mechanical strength in the axial direction. The tape may be easily formed, bent folded, pleated and shaped in the radial direction but is extremely stiff in the axial direction. Therefore, stator teeth can be easily formed without compromising the strength of the stator in the axial direction.

[0008] A stator tooth may comprise shaped tape, as described herein, and the tape may be pressed into a single pole piece or folded to form number of pole pieces to any suitable degree, such as 180 degrees, or completely back upon itself, or any other suitable degree. As mentioned above, a gap may be left so the fold in not closed and flux passing between planes may be reduced. In some embodiments, a tape is folded back upon itself and the inside surfaces touch and/or are adhered together.

[0009] The summary of the invention is provided as a general introduction to some of the embodiments of the invention, and is not intended to be limiting. It is to be understood that various features and configurations of features described in the Summary may be combined in any suitable way to form any number of embodiments of the invention. Some additional example embodiments including variations and alternative configurations of the invention are provided herein.

[0010]

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The accompanying drawings are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, and together with the description serve to explain the principles of the invention.

[0006] Figure 1 shows an isometric view of a portion a simplified exemplary in-plane three-phase axial transverse flux motor having tape stator halves configured on either side of a rotor.

[0007] Figure 2 shows a side view the exemplary simplified axial transverse flux motor shown in FIG. 1.

[0008] Figure 3 shows a cross-sectional view of exemplary axial transverse flux motor shown in FIG. 2.

[0009] Figure 4A shows a side view of an exemplary tape having a plurality of ribbon layers.

[0010] Figure 4B shows a side view of an exemplary tape having a plurality of ribbon layers and a space 5between ribbon layers.

[0011] Figure 5 shows a side view of an exemplary ribbon.

[0012] Figure 6 shows a side view of an exemplary tape loop configured on a core.

[0013] Figure 7A shows a side view of an exemplary tape loop.

[0014] Figure 7B shows a side view of an exemplary tape loop compressed.

[0015] Figure 8 shows a side view of an exemplary simplified tape formed into a stator having a plurality of stator teeth formed from the tape.

[0016] Figure 9 shows a side view of an exemplary tape formed into a stator having a plurality of stator teeth formed from the pleated tape.

[0017] Figure 10 shows a side view of an exemplary tape formed into a stator having a plurality of stator teeth formed from the pleated tape.

[0018] Figure 11 shows an isometric view of a portion an exemplary transverse flux motor having stator halves formed from tape and configured on either side of a rotor and showing angled teeth to allow for wire exits without loss of flux and shortened copper loop shape.

[0019] Figure 12 shows an isometric exploded view of a portion an exemplary in-plane three-phase transverse flux motor having stator halves formed from tape and configured on either side of a rotor with angled stator teeth portions and shortened coil path.

[0020] Figure 13 shows a side view of a portion an exemplary asymmetric transverse flux motor having three stator halves formed from tape and coil entry ends.

[0021] Figure 14 shows a side view of an exemplary stator half consisting of formed tape, and a return and showing angled teeth to allow for coil and wire exit without reducing flux area.

[0022] Figure 15 shows an isometric view of a portion an exemplary double in-plane three-phase transverse flux motor having tape stator halves configured on either side of a rotor of two rotors.

[0023] Figure 16 shows an isometric view of a portion an exemplary axially stacked three-phase transverse flux motor having tape stator halves configured on either side of a rotor of three rotors.

[0024] Figure 17 shows an isometric view of a portion an exemplary single phase transverse flux motor having a tape stator half configured on either side of a rotor.

[0025] Figure 18 shows an isometric view of a portion an exemplary single phase transverse flux motor having a discrete teeth on either side of the stator.

[0026] Figure 19 shows an isometric view of an exemplary three phase axial transverse flux motor having discrete stator teeth and flux sharing between phases.

[0027] Figure 20 a graph of the resulting electrical output from the motor shown in FIG. 19.

[0028] Figure 21 shows data used to produce the graph shown in FIG. 20.

[0029] Corresponding reference characters indicate corresponding parts throughout the several views of the figures. The figures represent an illustration of some of the embodiments of the present invention and are not to be construed as limiting the scope of the invention in any manner. Further, the figures are not necessarily to scale, some features may be exaggerated to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0030] As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. Also, use of "a" or "an" are employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

[0031] Certain exemplary embodiments of the present invention are described herein and illustrated in the accompanying figures. The embodiments described are only for purposes of illustrating the present invention and should not be interpreted as limiting the scope of the invention. Other embodiments of the invention, and certain modifications, combinations and improvements of the described embodiments, will occur to those skilled in the art and all such alternate embodiments, combinations, modifications, improvements are within the scope of the present invention.

[0032] Figure 1 shows an isometric view of a portion an exemplary simplified in-plane three-phase transverse flux motor 70 having stator 12 halves configured on either side of a rotor 15. The stator comprises a first set of stator stacks 28-28" configured on a first side 51 of the rotor 15 and a second set of stator stacks configured on a second side 52 of the rotor. The tape 30 is shown formed into a stator 12 having a plurality of teeth 26. A return 18 (not shown) is configured inside the coil 16 and magnetically couples a first stator half 20 on a fist side 51 of the rotor with a second stator half 22 on the second side 52 of the rotor. This stator has a tooth removed from each phase side to provide for wire area. The rotor is comprises of an assembly of magnets 90 and flux concentrators 91.

[0033] Figure 2 shows a side view of the motor 10 shown in FIG. 1. Three stator stacks 28-28" are configured on either side of the rotor 15 to conduct flux from the rotor through a first stator half 20, through the return and to a second stator half 22 on an opposing side of the rotor. The return coil is configured to extend between a first stator half and a second stator half. The return coil is configured on the inside diameter of the rotor Rdi as shown in Figures 1 and 2, however, a return and coil could be configured on the outside diameter Rdo of the rotor. The rotor shown in FIG. 1 and 2 is a ring having an inside and outside diameter, Rdi, Rdo respectively as shown. Again, the figure shows a tooth from each phase half removed to accommodate wire.

[0034] Figure 3 shows a cross-sectional view taken along line AA of the exemplary transverse flux motor 10 shown in FIG. 2. The cross-section shows a first stator half 20 configured adjacent the first side 51 of the rotor 15 and a second stator half 22 configured adjacent the second side 52 of the rotor 15. The return 18 is shown configured on the inside diameter of the rotor 15 and within the coil 16. The coil is looped around the return as depicted by the two sections of the coil 16, 16' in FIG. 3. The return is depicted as a tape in FIG. 3, but could be any suitable magnetic flux conducting material. The stator magnetic portion as shown in FIG. 3 consist of tape, whereby the first stator half, second stator half and the return all consist of tape, as described herein. In some embodiments, one or more of the stator halves may be attached to the return such as by being pressed together or through the use of an adhesive. As shown in FIG. 3 both the first and second stator halves 20, 22 are attached to the return 18. The width Wt of the stator half or tape is shown in FIG. 3. The control of tolerances may be more easily controlled by a slit ribbon that is configured as a stator as opposed to a plurality of parts that require assembly to form a stator and where "tolerance stack-up" occurs. In addition, the tape may be flexible along the length of the ribbon but has considerably strength and is rigid in a plane perpendicular to the tape length, or the axial direction.

[0035] As shown in FIG. 3, the flux alternates through the coil 16. It passes from the rotor 15, through ribbon edge 31, through the first stator half 20, out of the first stator half edge 31 and into the return 18 first edge 94, out the second ribbon edge 96, into the second stator half edge 99, into the second stator half 22, and finally back to the rotor 15 through the second stator half edge 99. The flux in this embodiment flows substantially along the plane of the ribbons and does not require flux to flow through the planes or from plane to plane. Again, the magnetic loop may be configured on the outside of the rotor versus the inside of the rotor as shown in FIG. 3.

[0036] As shown in FIG. 4A, an exemplary tape 30 comprises a plurality of ribbon layers 36. The edges of the individual ribbon layers make up the tape edge 31. As shown in FIG. 4B an exemplary tape 30 comprises a spacer 32 between the plurality of ribbon layers 36. This may be air as from spacing or packing factor, or spacer may be magnetically conductive or a non-magnetically conductive material such as an adhesive applied in discrete locations on the tape, such as between ribbon layers or to the outer and/or inner layer of the ribbon. The thickness Tt of the tape 30 is shown in FIG. 4A and 4B and may be any suitable thickness as described herein. A single ribbon 36 is shown in FIG. 5 with the single ribbon edge 37. The thickness Tl of single ribbon layer 36 is shown in FIG. 5 and may be very thin as described herein.

[0037] As shown in FIG. 6, an exemplary tape 30 or tape loop 34 is configured on a core 35. As described, a thin layer of magnetically conductive material may be slit and taken-up on a core. The leading and or trailing end of the ribbon may be adhered to secure the ribbon layer to the loop. As shown in FIG. 7A an exemplary tape loop 34 has been removed from the core 35 and may be flexible and bend easily along the length of the loop, or about the circumference of the loop. The tape loop 34 shown in FIG. 7A may be compressed to the point that the inside surface of the tape loop contact each other and the compressed tape loop takes on the shape of a length of tape.

[0038] As shown in FIG. 7B, a tape loop 34 may be slit or a plurality of ribbon layers may be stacked to form a tape 30 as shown in FIG. 7B. The length of an tape may be any suitable length Lt, as shown in FIG. 7B. The tape 30 shown in FIG. 7A is a tape loop, whereas the tape 30 shown in FIG. 7B is a discrete tape, having a length between a first and second end.

[0039] As shown in FIG. 8, an exemplary tape loop 34 is formed into a stator stack 28 having a plurality of stator teeth 26 formed from pleated tape. The tape pleat 38 shown in FIG. 8 comprises portions of the tape folded together with the inside tape loop 34 surface 40 contacting along the inside of the fold. The inside surface 40 does not however have to contact to form a pleat or tooth. The tape loop 34 shown in FIG. 8 comprises a first portion 44 of the tape configured as pleats, or stator teeth 26, and the remaining portion of the tape loop, or second portion 45 configured between a first end and second end of pleated portion of the tape. In another embodiment, a tape 30 is formed into pleats 38, or teeth with no second portion between the first and second end of the pleated tape as shown in FIG. 9. It is to be understood that a compressed tape loop may be formed into a stator half as shown in FIG. 9 with the entire tape loop pleated, thereby not having a second portion of the tape loop connecting the first and second end of the a pleated portion; the entire tape loop would be formed as one piece.

[0040] As shown in FIG. 9, an exemplary tape 30 is formed into a stator 28 having a plurality of stator teeth 26 formed from a discrete tape 30. A tape loop may be cut to form a discrete tape as shown in FIG. 9. The tape ends 39 of the tape shown in FIG. 9 are not in an area that will affect the tolerances. The tape ends may be adhered to the formed tape. The stator 28 comprises a tooth fold 46 and a return fold 48 and may be folded to any suitable fold angle, Fa.

[0041] A fold angle Fa is the angle measured from a line extending substantially parallel with a surface on one side of a fold, to a line extending substantially parallel with the same surface of the tape on the opposing side of a fold as shown in FIG. 9 and FIG. 10. The rotor folds 46 shown in FIG. 9 would have a fold angle of substantially 180 degrees since the inside surface of the tape touches along the rotor fold.

[0042] As shown in FIG.10 an exemplary tape 30 is formed into a stator stack 28 having a plurality of stator teeth 26 formed from pleated tape. The stator stack 28 shown in FIG. 10 is formed from a discrete length of tape 30 and the inside surface does not contact along the inside of the pleats. This type of pleat may be referred to as a saw tooth type pleat. The fold angle Fa of this type of pleat is less than the fold angle of the rotor folds shown in FIG.9. A sinusoidal pleat having a sinusoidal shape may also be employed in the formation of a stator stack. Each of the teeth shown in FIG. 94 comprise a gap within the pleat of the tooth. This gap may reduce losses.

[0043] As shown in Figure 11, a portion an exemplary in-plane three phase 70 transverse flux motor 10 comprises stator halves of formed tape configured on either side of a rotor 15. FIG 11 shows angling of the inner porting of the teeth such that clearance for the wire may be provided for without reducing teeth or flux area. The motor is an in-plane three-phase motor type 70 having three stators 28, 28', 28" on both the first rotor side 51 and second rotor side 52. These stators may be identical or not depending on design and manufacturing requirements. Each stator magnetic portion comprises a first stator half 20 and second stator half 22 and a return (not clearly shown). The coil 16 in this embodiment is configured around the return and between the first stator tooth 26, or first pole of that phase, and the last stator tooth 26", or last pole of the phase, and does not follow the contour of the rotor as shown in FIG.1. In addition, the stator halves are configured with coil entry ends 62, whereby the coil may enter without the loss of a stator tooth or active pole. The rotor and/or return folds at the coil entry end 62 may be different from the rotor and/or return folds throughout the rest of the stator half, and may be different by any suitable degree including more than about 10 degrees, more than about 30 degrees, more than about 45 degrees, more than about 60 degrees, more than about 90 degrees and the any suitable range between and including the values provided.

[0044] Figure 12 shows the exemplary in-plane three phase transverse flux motor 70 shown in FIG. 11, in an exploded view, whereby each of the components of the stator magnetic portion are shown including the first stator half 20, return 18 and second stator half 22. A return may comprise one or more portions such as 18 and 18' as shown in FIG. 12 or combining 18 and 18' into 1 part. The coil entry ends 26 are more clearly shown in FIG. 12 as well.

[0045] Figure 13 shows a side view of the exemplary in-plane three phase transverse flux motor 70 shown in FIG. 11. As shown in FIG. 13 the exemplary transverse flux motor 10 comprises three stators, 28-28" formed from tape. Note the stator teeth are slightly offset to the poles or rotor switching surfaces to reduce cogging and noise. This is an asymmetric stator 60 configuration as described herein. The stator is configured as if there are 121 poles in the rotor however there are only 120 poles. In addition, the first stator tooth 26 and last stator tooth 26' of the stator 28 are configured to allow for the entry of the coil without the loss of a tooth and useful pole, in a coil entry end 62 configuration. This configuration increases the power and efficiency of the motor.

[0046] As shown in 14 an exemplary stator half consists of formed tape 30. The tape comprises a plurality of folds 33, 33'. Fold 33 is an inside fold, where the inside surfaces of the tape are folded together or towards each other. Fold 33' is an outside fold, where the outside surfaces of the tape are folded together or towards each other. A stator may comprise any number of inside and outside folds, and each fold may have any suitable fold angle Fa, as described herein. A tape with substantially a 180 degree fold angle is folded back upon itself such that the tape on one side of the fold is substantially aligned with the tape on the other side of the fold. Also shown in FIG. 14 are the tape ends 39, and 39'. The tape ends are not located in an area that would cause any flux flow disturbance or loss. FIG 14 shows the inner porting of the teeth angling in to the return such that the space requirements for the coil (not shown) have clearance without losing a tooth and reducing flux area.

[0047] As shown in Figure 15, a portion an exemplary double in-plane three phase 74 transverse flux motor 10 comprises stator halves of formed tape configured on either side of two rotors 15, 15'. The coil 16 extends along each stator and has a coil end turn 65, whereby the coil is electrically continues with a coil extending along the adjacent stator. Very high utilization of the coil is achieved with this design with only the coil connector not being effectively engaged in power generation.

[0048] As shown in Figure 16, a portion an exemplary axially-stacked three-phase transverse flux motor 76 having tape stator halves configured on either side of a rotor of three rotors 15-15''. The stator halves 20, 22 extend substantially around the entire rotor 15'', as shown in FIG. 16.

[0049] Figure 17 shows an isometric view of a portion an exemplary single-phase transverse flux motor 78 having a tape 30 stator 28 configured on either side of a rotor. A first stator half 20 and second stator half 22 extend substantially all the way around the rotor 15. The stator halves comprises coil entry ends 62, 62', whereby the coil contacts may extend away from the coil and outside of the stator 28. This stator is configured as an asymmetric stator 60 whereby the stator teeth 26 are exemplarily aligned for 121 poles and there are only 120 poles.

[0050] As shown in FIG. 18, an axial transverse flux motor 70, comprises a plurality of discrete stator teeth 26-26''', also referred to as poles, configured on either side of the rotor 15. The discrete stator teeth are flattened tape wound toroids that are made out of separate pieces of material from each other. Each discrete stator tooth comprises a gap 94 which reduces the tendency of flux to pass through the planes of the tape which would cause additional loss. The return 18 provides mechanical support and transfers flus from a first tooth on a first side of the rotor to a second tooth on a second side of the rotor. The rotor 15 is comprises of magnets 90, 90' and flux concentrators 91 dispose between magnets. The magnets extend further radially than the flux concentrators 91, as shown. In an exemplary embodiment, the magnets 90 extend further inward, further toward the center of the motor, than the flux concentrators 91. Only a portion of the stator, two teeth per side, are shown in FIG. 18 to allow more clear depiction of the components.

[0051] As shown in FIG. 19, a multiphase arrangement where flux is shared rather than having discrete phases axially as shown in FIG. 16. Each stator stack 28 comprises 30 discrete stator teeth 26 configured radially. Each tooth, or pole, is made of a flatted tape wound toroid. The teeth are positioned around the toroid return. The return shown is a toroid of wound tape. The axial transverse flux motor 70 comprises three phases with one rotor per phase. Only four stator stack make up the full three phase assembly. Each phase only require one additional stator stack, whereas prior requires two stator stacks generally spaced apart per phase. Therefore, this motor design provides for better efficiency, smaller size and lower weight for a given output. Each rotor 15 comprises a magnet 90 and flux concentrator 91.

[0052] Figure 20 shows the electrical output from the three phases of the motor shown in FIG. 19. It can be seen that although there are some differences from phase to phase they can be essentially the same as three discrete and spaced single phased motors, as shown in FIG. 16.

[0053] Figure 21 shows the data used to produce the graph shown in FIG. 20. An approximately +/- 2% variation in voltage between phases occurs. Small refinements may be required for some applications. The variations shown may also be remnants of modeling inaccuracy, such as those caused by meshing choices.

Definitions

[0054] Tape, as used herein, is defined as a plurality of slit magnetically conducting ribbons configured one on top of another. A tape may be a tape loop wherein it is essentially continuous, or discrete having a length between a first and second end. A tape or ribbon may have any suitable thickness.

[0055] Magnetically couple, as used herein, means that magnetic flux can flow from one material to another. A material that magnetically couples a first article to a second article conducts magnetic flux from the first article and to the second article.

[0056] Teeth or a tooth, as used herein, is a pole when configured in an electric motor or generator.

[0057] A stator, as used herein, maybe fixed, pivot or rotate or move.

[0058] An armature, as used herein, maybe fixed, pivot or rotate or move.

[0059] A rotor, as used herein, maybe fixed, pivot or rotate or move.

[0060] A pole or pole piece as used herein refers a stator tooth.

[0061] It will be apparent to those skilled in the art that various modifications, combinations and variations can be made in the present invention without departing from the spirit or scope of the invention. Specific embodiments, features and elements described herein may be modified, and/or combined in any suitable manner. Thus, it is intended that the present invention cover the modifications, combinations and variations of this invention provided they come within the scope of the appended claims and their equivalents

What is claimed is:

1. A **stator comprising**:
    a. a tape comprising:
        i. a plurality of ribbon layers of flux conducting material;
    b. a plurality of stator teeth comprising;
        i. formed portions of said tape;

whereby the edge of the tape is adjacent a rotor and configured to conduct magnetic flux from the rotor.

2. The stator of claim 1, wherein the plurality of stator teeth comprise discrete stator teeth.
3. The stator of claim 1, wherein the plurality of stator teeth consists of discrete stator teeth.
4. The stator of claim 1, wherein the plurality of stator teeth comprise a gap within a tooth.
5. The stator of claim 1, wherein the plurality of stator teeth comprise a discrete stator teeth, wherein each tooth is a flattened tape wound toroid.
6. The stator of claim 1, wherein the plurality of stator teeth comprise two or more contiguous teeth.
7. The stator of claim 1, wherein a comprises a plurality of stator teeth consisting of a continuous loop.
8. The stator of claim 1, wherein the tape is a tape loop.
9. The stator of claim 1, wherein the tape consists essentially of non-oriented flux conducting material.
10. The stator of claim 1, wherein the formed portions of said tape comprises tape folds comprising a rotor fold and a return fold.
11. The stator of claim 10, wherein at least a portion of the tape folds have a fold angle of substantially 180 degrees.
12. The stator of claim 1, further comprising a return configured between a first stator half and a second stator half.

13. The stator of claim 12, wherein the first stator half and second stator half consist essentially of tape.
14. The stator of claim 12, wherein the first stator half and second stator half consist of tape.
15. The stator of claim 12, wherein the return, the first stator half and second stator half consist essentially of tape.
16. The stator of claim 12, wherein the return, the first stator half and second stator half consist of tape.
17. The stator of claim 1, wherein the stator is configured as an asymmetric stator.
18. The stator of claim 1, wherein the stator further comprises at least one coil entry end.
19. An electric motor comprising a stator comprising:
    a. a tape comprising:
        i. a plurality of ribbon layers;
    b. a plurality of stator teeth comprising;
        i. formed portions of said tape;

whereby the edge of the tape is adjacent a rotor and configured to conduct magnetic flux from the rotor.

20. The electric motor of claim 19, wherein the stator comprises a first stator half and second stator half.
21. The electric motor of claim 20, wherein a return magnetically couples the first stator half to the second stator half.
22. The electric motor of claim 21, wherein the return is made essentially of tape.
23. The electric motor of claim 22, wherein the return consists essentially of an amorphous metal ribbon.
24. The electric motor of claim 23, wherein the return is configured with a first edge adjacent a first stator half and a second edge adjacent a second stator half, whereby magnetic flux can pass from the first stator half through the return to the second stator half.
25. The electric motor of claim 21, further comprising a coil configured around the return.

26. The electric motor of claim 19, wherein the motor comprises a plurality of stators.
27. The electric motor of claim 26, wherein the motor comprises three stators configured at 120 electrical degrees from each other.
28. The electric motor of claim 27, further comprising a rotor configured between the first stator half and the second stator half.
29. The electric motor of claim 28, wherein the rotor is an alternating field rotor.
30. The electric motor of claim 18, wherein the rotor is a flux concentrator type rotor.
31. The electric motor of claim 28, wherein the rotor is a low loss flux concentrating type rotor.
32. The electric motor of claim 29, wherein the motor is a transverse flux motor.
33. The electric motor of claim 29, wherein the transverse flux motor is an axial type transverse flux motor.
34. The electric motor of claim 42, wherein the transverse flux motor is an in-plane three-phase axial type transverse flux motor.
35. The electric motor of claim 42, wherein the transverse flux motor is a double in-plane three-phase type transverse flux motor.
36. The electric motor of claim 42, wherein the transverse flux motor is an axially-stacked three-phase type transverse flux motor.
37. The electric motor of claim 42, wherein the transverse flux motor is a single-phase type transverse flux motor.
38. The electric motor of claim 42, wherein the tape is a tape loop.
39. The electric motor of claim 29, wherein the tape consists essentially of met-glass.
40. The electric motor of claim 29, wherein the tape comprises at least 50 ribbon layers.
41. The electric motor of claim 29, wherein the tape comprises at least 200 ribbon layers.
42. The electric motor of claim 29, wherein the tape has a thickness of at least 5mm.
43. The electric motor of claim 29, wherein the tape has a width of no more than 3cm.
44. The electric motor of claim 29, wherein a ribbon layer has a thickness of at no more than 100um.

45. The electric motor of claim 29, wherein a ribbon layer has a thickness of at no more than 50um.
46. The electric motor of claim 29, wherein a ribbon layer has a thickness of at no more than 25um.
47. The electric motor of claim 29, wherein the stator comprises at least 30 stator teeth.
48. The electric motor of claim 29, wherein the stator comprises at least 60 stator teeth.
49. The electric motor of claim 29, wherein the stator comprises at least 120 stator teeth.
50. The electric motor of claim 29, wherein the stator comprises at least 180 stator teeth.
51. The electric motor of claim 29, wherein the formed portions of said tape comprises tape folds having a fold angle of substantially 180 degrees.
52. The electric motor of claim 9, wherein the tape comprises at least 50 ribbon layers.
53. An electric motor comprising a stator magnetic portion consisting essentially of:
    a. a first stator half and second stator half comprising:
        i. a tape formed into stator teeth wherein said tape comprises:
            1. a plurality of ribbon layers;
    b. a return configured between the first and second stator halves.

whereby the edge of the tape is adjacent a rotor and configured to conduct magnetic flux from the rotor.

54. The electric motor of claim 53, wherein the motor is a transverse flux motor.
55. The electric motor of claim 54, wherein the transverse flux motor is an axial type transverse flux motor.
56. The electric motor of claim 53, wherein the tape is a tape loop.
57. The electric motor of claim 53, wherein the tape consists essentially of METGLAS.
58. The electric motor of claim 53, wherein the tape consists essentially of amorphous metal.

59. The electric motor of claim 53, wherein the tape consists essentially of nanocrystalline material.
60. The electric motor of claim 53, wherein the tape comprises at least 50 ribbon layers.
61. The electric motor of claim 53, wherein the tape comprises at least 200 ribbon layers.
62. The electric motor of claim 53, wherein the tape has a thickness of at least 5mm.
63. The electric motor of claim 53, wherein the tape has a width of no more than 3cm.
64. The electric motor of claim 53, wherein a ribbon layer has a thickness of at no more than 100um.
65. The electric motor of claim 53, wherein a ribbon layer has a thickness of at no more than 50um.
66. The electric motor of claim 53, wherein a ribbon layer has a thickness of at no more than 25um.
67. The electric motor of claim 53, wherein the stator comprises at least 30 stator teeth.
68. The electric motor of claim 53, wherein the stator comprises at least 60 stator teeth.
69. The electric motor of claim 53, wherein the stator comprises at least 120 stator teeth.
70. The electric motor of claim 53, wherein the stator comprises at least 180 stator teeth.
71. The electric motor of claim 53, wherein the formed portions of said tape comprises tape folds having a fold angle of substantially 180 degrees.
72. The electric motor of claim 53, wherein the tape comprises at least 50 ribbon layers.
73. The electric motor of claim 53, wherein the first and second stator halves are configured as asymmetric stator halves.
74. The electric motor of claim 60, wherein the first and second stator halves comprise at least one coil entry end.

75. A method of forming a stator portion comprising the steps of:
    a. slitting an magnetic conducting material to form a ribbon;
    b. forming a plurality of ribbon layer one atop another to form a tape having tape edges and ;
    c. folding said tape to form a plurality of stator teeth.
76. The method of claim 75, wherein the magnetic conducing material is amorphous metal.
77. The method of claim 75, wherein the ribbon consists essentially of met-glass.
78. The method of claim 75, wherein the tape consists essentially of met-glass.
79. The method of claim 75, wherein the magnetic conducing material is metglass.
80. The method of claim 75, wherein the stator portion is configured in a transverse flux motor.
81. The method of claim 80, wherein the transverse flux motor is an axial type transverse flux motor.
82. The method of claim 75, wherein the step of forming a plurality of ribbon layer one atop another to form a tape having tape edges tape comprises taking-up the ribbon on a core to form a tape loop.
83. The method of claim 75, wherein the tape comprises at least 50 ribbon layers.
84. The method of claim 75,wherein the tape comprises at least 200 ribbon layers.
85. The method of claim 75wherein the tape has a thickness of at least 5mm.
86. The method of claim 75wherein the tape has a width of no more than 3cm.
87. The method of claim 75, wherein a ribbon layer has a thickness of no more than 100um.
88. The method of claim 57, wherein a ribbon layer has a thickness of no more than 50um.
89. The method of claim 75, wherein a ribbon layer has a thickness of no more than 25um.
90. The method of claim 75, wherein the stator comprises at least 30 stator teeth.
91. The method of claim 75, wherein the stator comprises at least 60 stator teeth.
92. The method of claim 75, wherein the stator comprises at least 120 stator teeth.
93. The method of claim 75, wherein the stator comprises at least 180 stator teeth.

94. The method of claim 75, wherein the formed portions of said tape comprises tape folds having a fold angle of substantially 180 degrees.

95. The method of claim 75, further comprising the step of:

   a. forming two stator halves from separate tapes;

96. The method of claim 95, further comprising the step of:

   a. configuring a first stator half on a first side of a rotor, whereby a tape edge is adjacent said first side of said rotor;

97. The method of claim 98, further comprising the step of:

   a. configuring a second stator half on a second side of the rotor, whereby a second tape edge is adjacent said second side of said rotor;

98. The method of claim 97, further comprising the step of:

   a. configuring a return between said first stator half and said second stator half, whereby the return magnetically couples the first stator half to the second stator half.

99. A **stator magnetic portion consisting of**:

   a. a first stator half comprising a tape comprising:
      i. a first stator half tape edge;
      ii. a plurality of first ribbon layers;
      iii. a plurality of stator teeth comprising;
         1. formed portions of said tape;
   b. a second stator half comprising a tape comprising:
      i. a second stator half tape edge;
      ii. a plurality of second ribbon layers;
      iii. a plurality of stator teeth comprising;
         1. formed portions of said tape;
   c. a return

whereby the first stator half tape edge and second stator half tape edge are configured adjacent to a rotor and configured to conduct a magnetic flux from the rotor through said tape edges.

100. The stator **magnetic portion** of claim 99, wherein the magnetic flux is conducted from a first side of a rotor to the first stator half tape edge, through the

first ribbon layers, from the first stator half tape edge to a return, from the return to the second stator half tape edge, through the second ribbon layer, from the second stator half tape edge back to the second side of the rotor.

101. The stator **magnetic portion** of claim 99, further comprising

a. a return comprising a tape comprising;

i. a first return edge and a second return edge; and

ii. a plurality of ribbon layers.

whereby the magnetic flux is conducted from the first stator half edge to a

102. The stator **magnetic portion** of claim 99, wherein the first and second stator half tape is a tape loop.

103. The stator **magnetic portion** of claim 99, wherein the first and second stator half tape consists essentially of amorphous metal.

104. The stator **magnetic portion** of claim 99, wherein the first and second stator half tape consists essentially of METGLAS.

105. The stator **magnetic portion** of claim 99, wherein the first and second stator half tape consists essentially of nanocrystalline material.

106. The stator **magnetic portion** of claim 99, wherein the first and second stator half tape comprises at least 50 ribbon layers.

107. The stator **magnetic portion** of claim 99, wherein the first and second stator half tape comprises at least 200 ribbon layers.

108. The stator **magnetic portion** of claim 99, wherein the first and second stator half tape has a thickness of at least 5mm.

109. The stator **magnetic portion** of claim 99, wherein the first and second stator half tape has a width of no more than 3cm.

110. The stator **magnetic portion** of claim 99, wherein the first and second ribbon consists essentially of ribbons having a thickness of at no more than 3cm.

111. The stator **magnetic portion** of claim 99, wherein the first and second ribbon consists essentially of ribbons having a thickness of no more than 100um.

112. The stator **magnetic portion** of claim 99, wherein the first and second ribbon consists essentially of ribbons having a thickness of no more than 50um.

113. The stator **magnetic portion** of claim 99, wherein first and second ribbon consists essentially of ribbons having a thickness of no more than 25um.

114. The stator **magnetic portion** of claim 99, wherein the stator comprises at least 30 stator teeth.

115. The stator **magnetic portion** of claim 99, wherein the stator comprises at least 60 stator teeth.

116. The stator **magnetic portion** of claim 99, wherein the stator comprises at least 120 stator teeth.

117. The stator **magnetic portion** of claim 99, wherein the stator comprises at least 180 stator teeth.

118. The stator **magnetic portion** of claim 99, wherein the formed portions of said tape comprises tape folds having a fold angle of substantially 180 degrees.

119. The stator **magnetic portion** of claim 99, whereby the first and second stator halves are configured as asymmetric stator halves.

120. The stator **magnetic portion** of claim 99, whereby the first and second stator halves comprise at least one coil entry end.

121. A polyphase motor comprising:

a. two stator stacks;
b. one coil;
c. one return;

whereby for each additional phase, one stator stack, one coil and one return are added.

122. The polyphase motor of claim 121 wherein the stator stacks and returns comprise a soft metal composite.

123. A polyphase motor comprising:

a. two stator stacks made from soft metal composite incorporating a return;
b. one coil;

whereby for each additional phase, one stator stack and one coil are added.

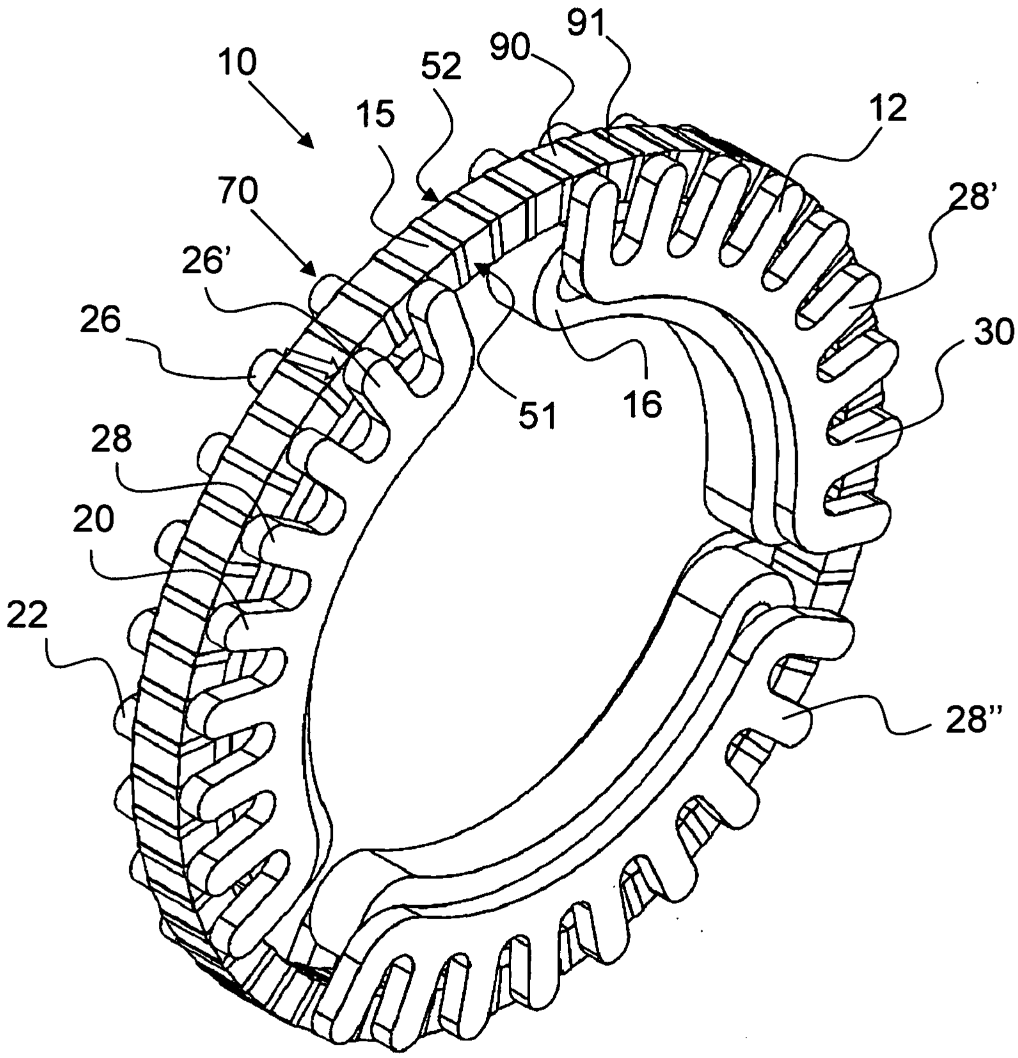

FIG. 1

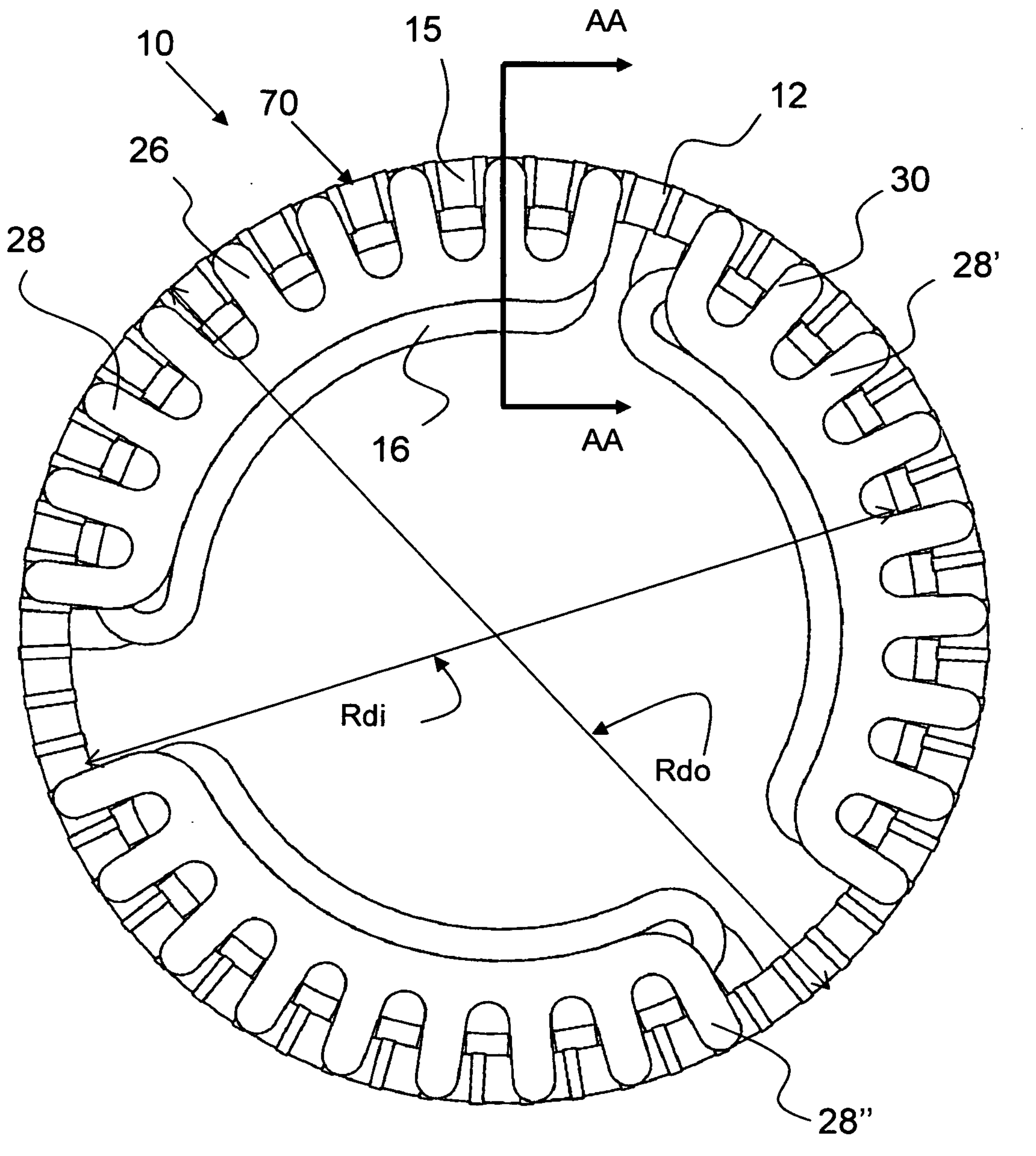

FIG. 2

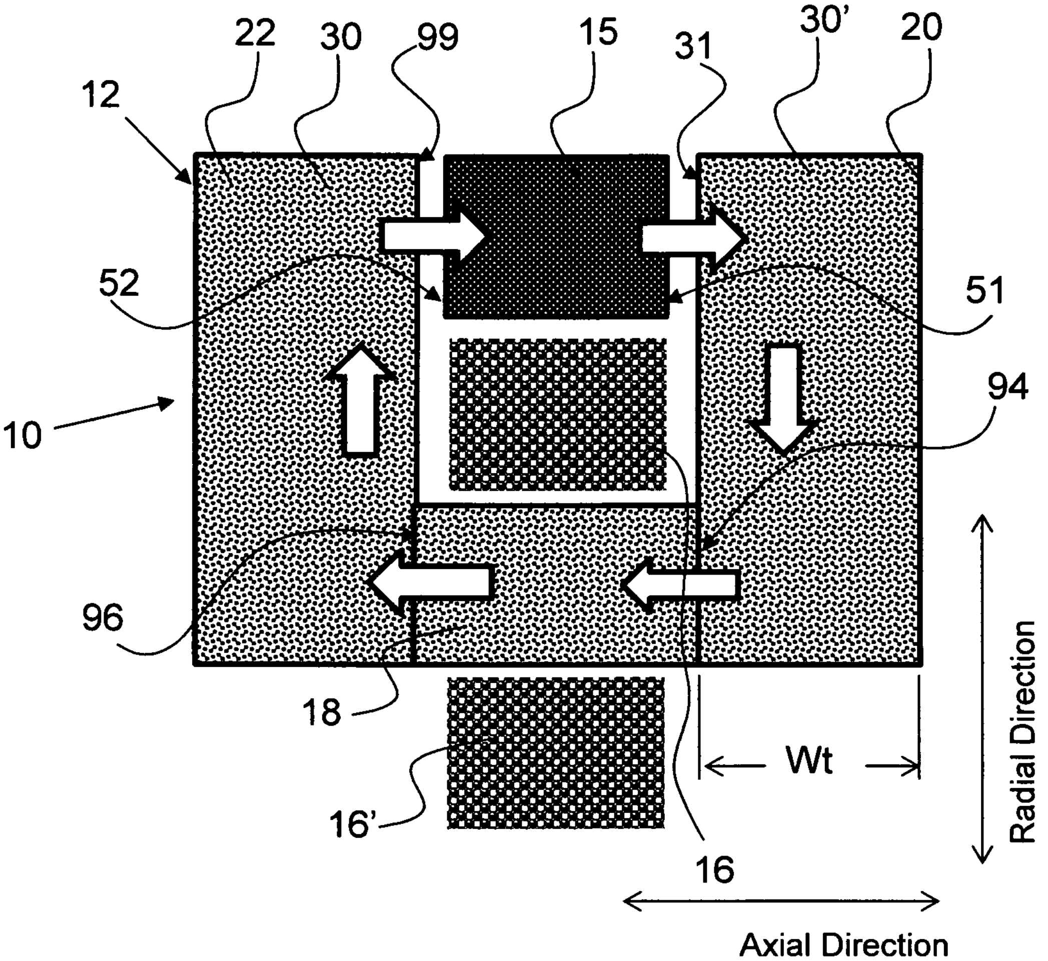
22
30
99
15
31
30'
20
12
52
51
94
10
96
18
Wt
16'
16
Radial Direction
Axial Direction

FIG. 3

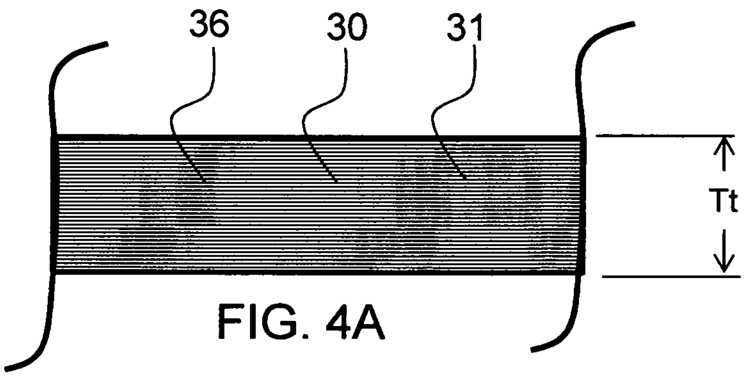

FIG. 4A

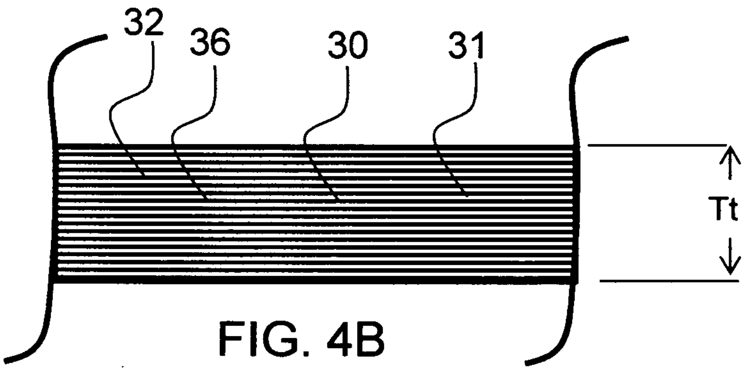

FIG. 4B

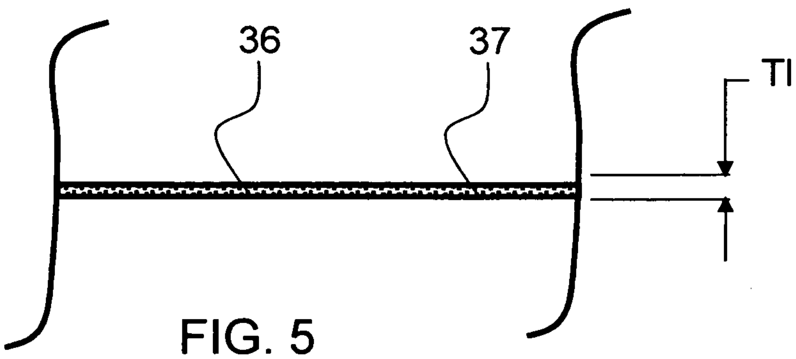

FIG. 5

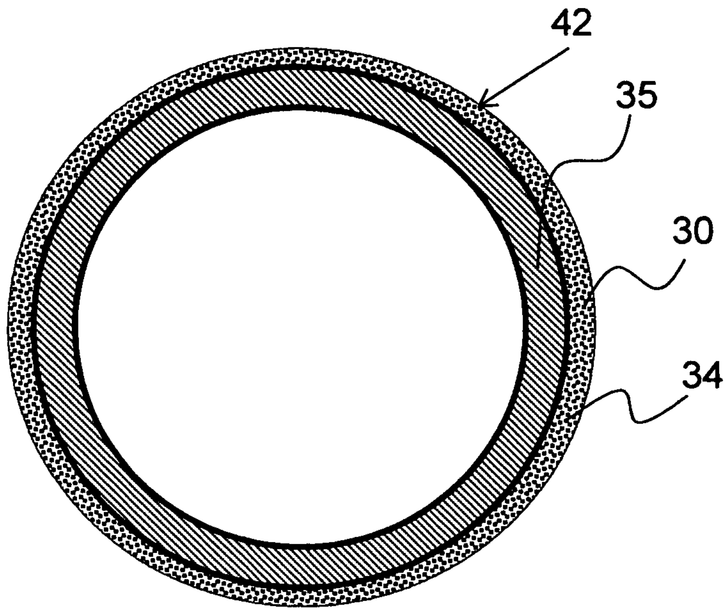

FIG. 6

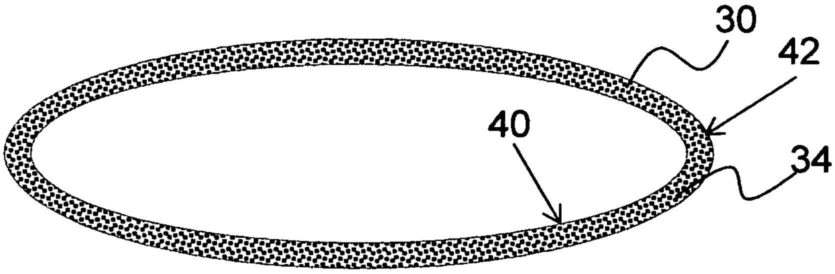

FIG. 7A

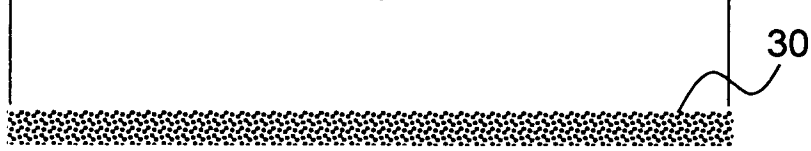

FIG. 7B

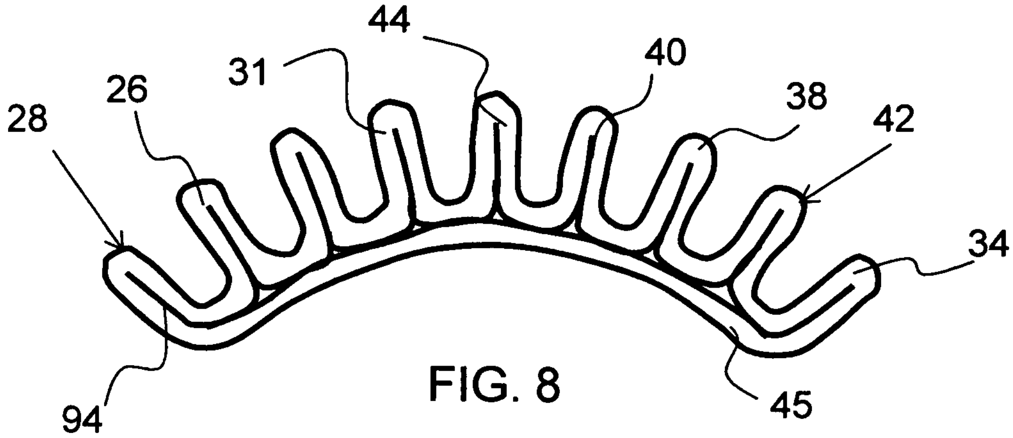

FIG. 8

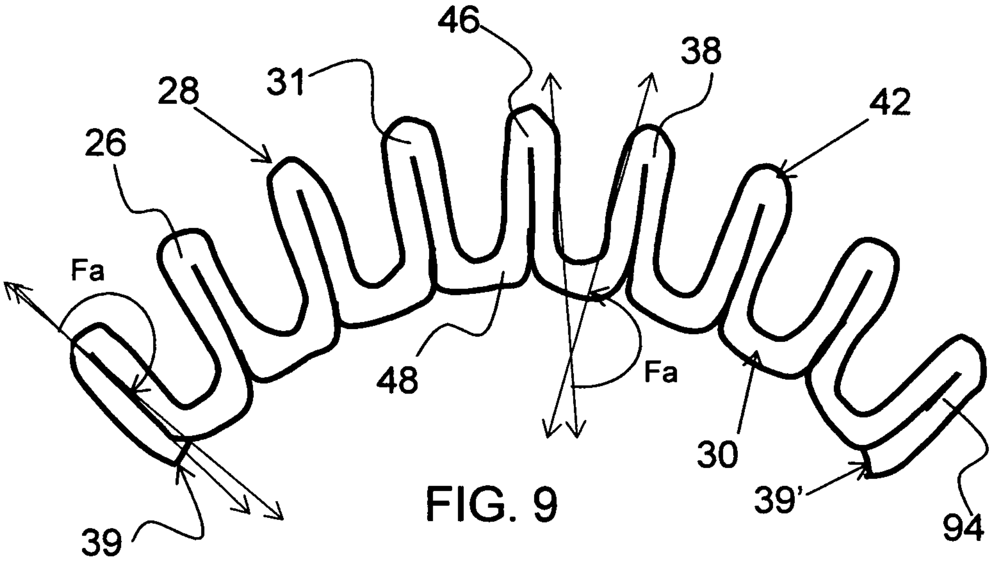

FIG. 9

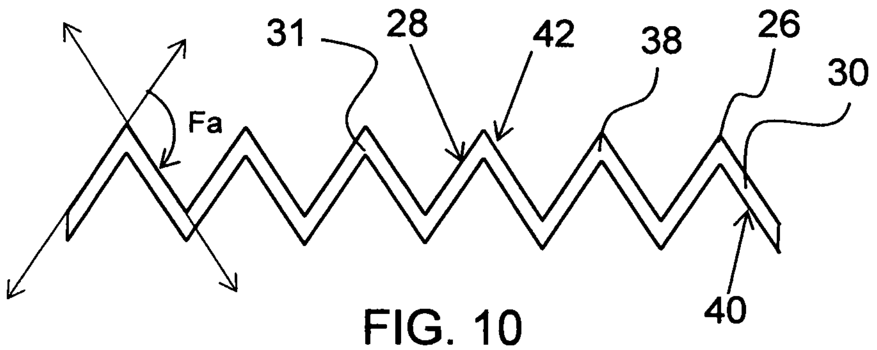

FIG. 10

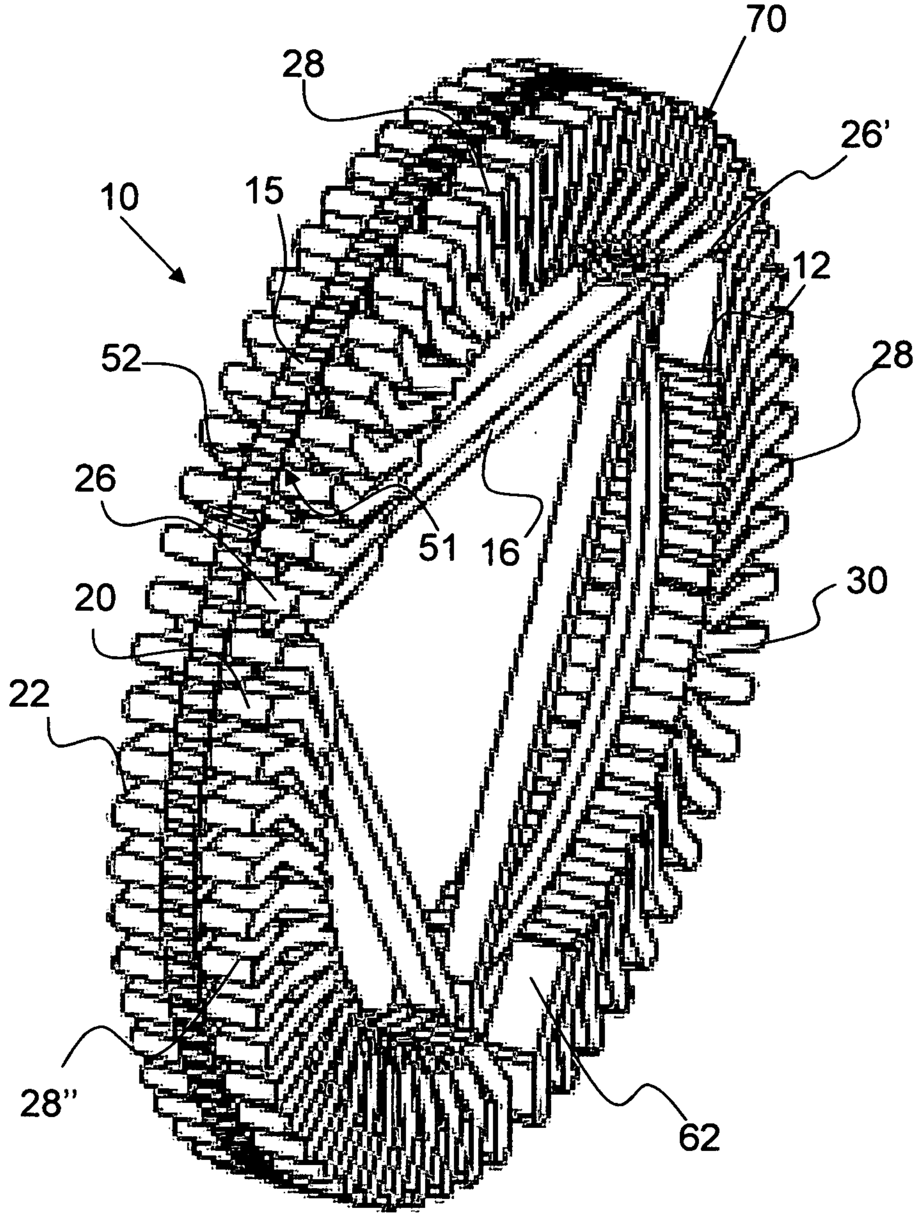

FIG. 11

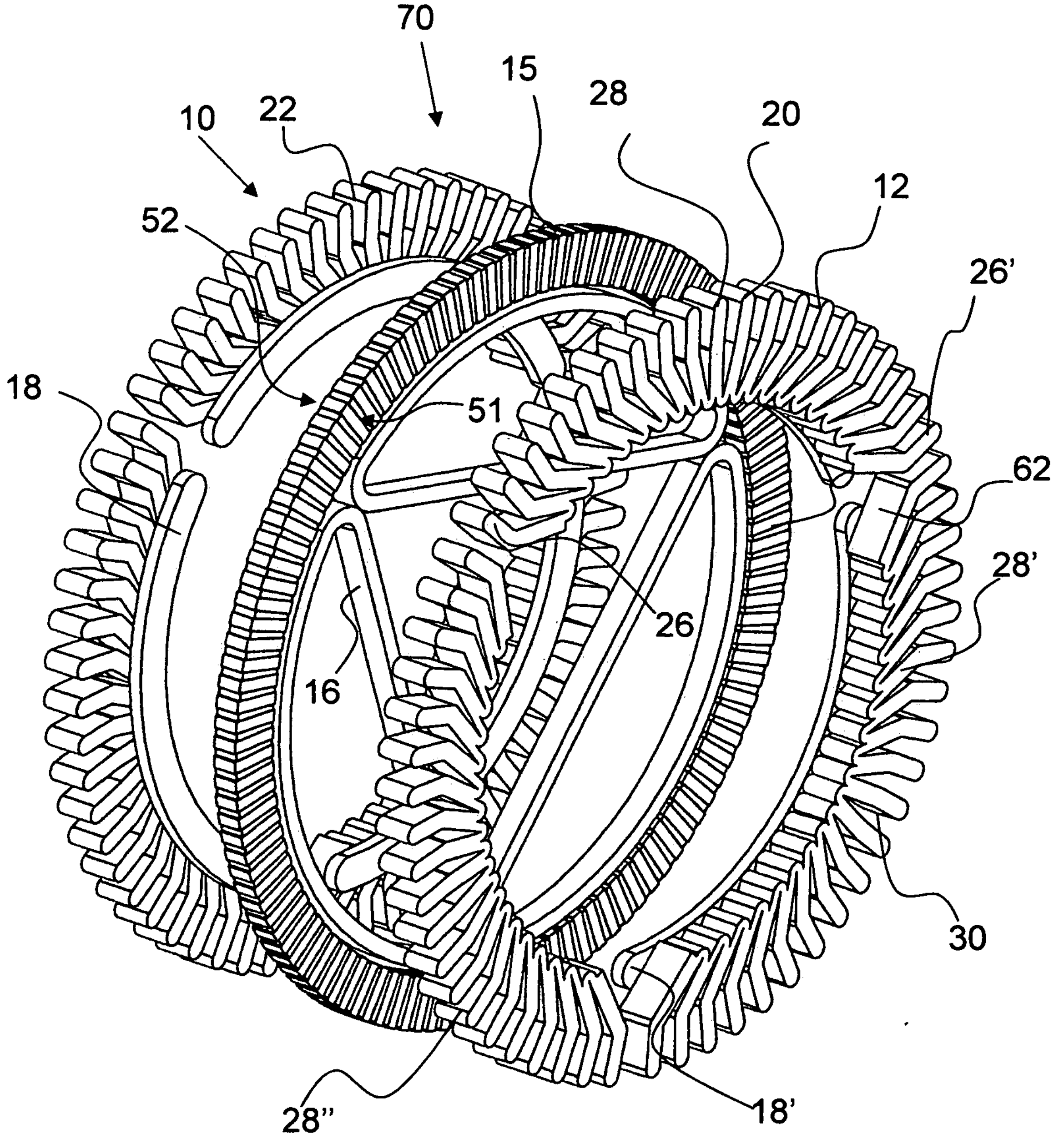

FIG. 12

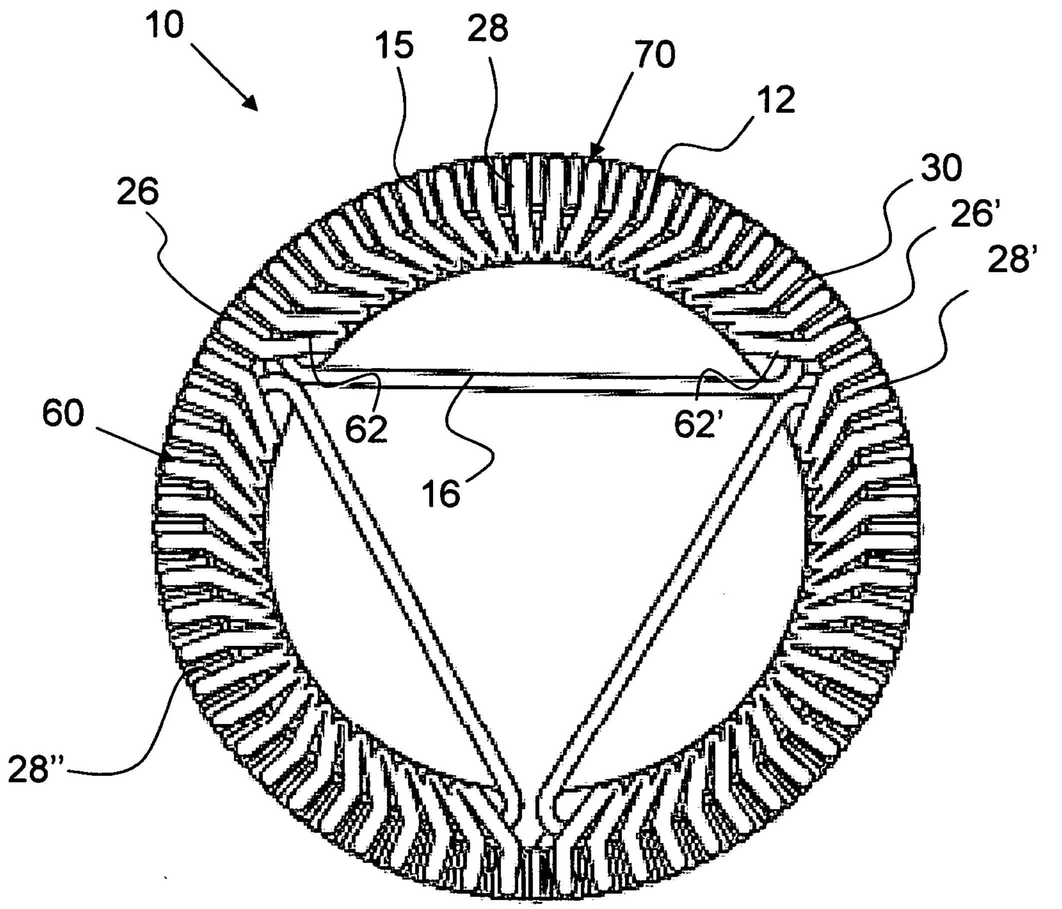

FIG. 13

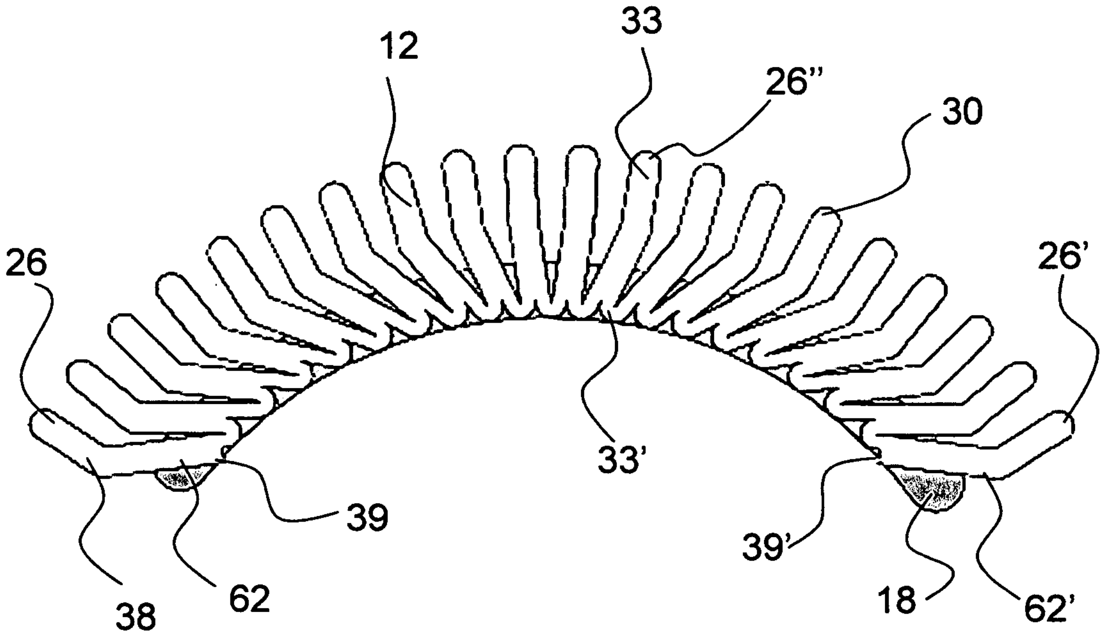

FIG. 14

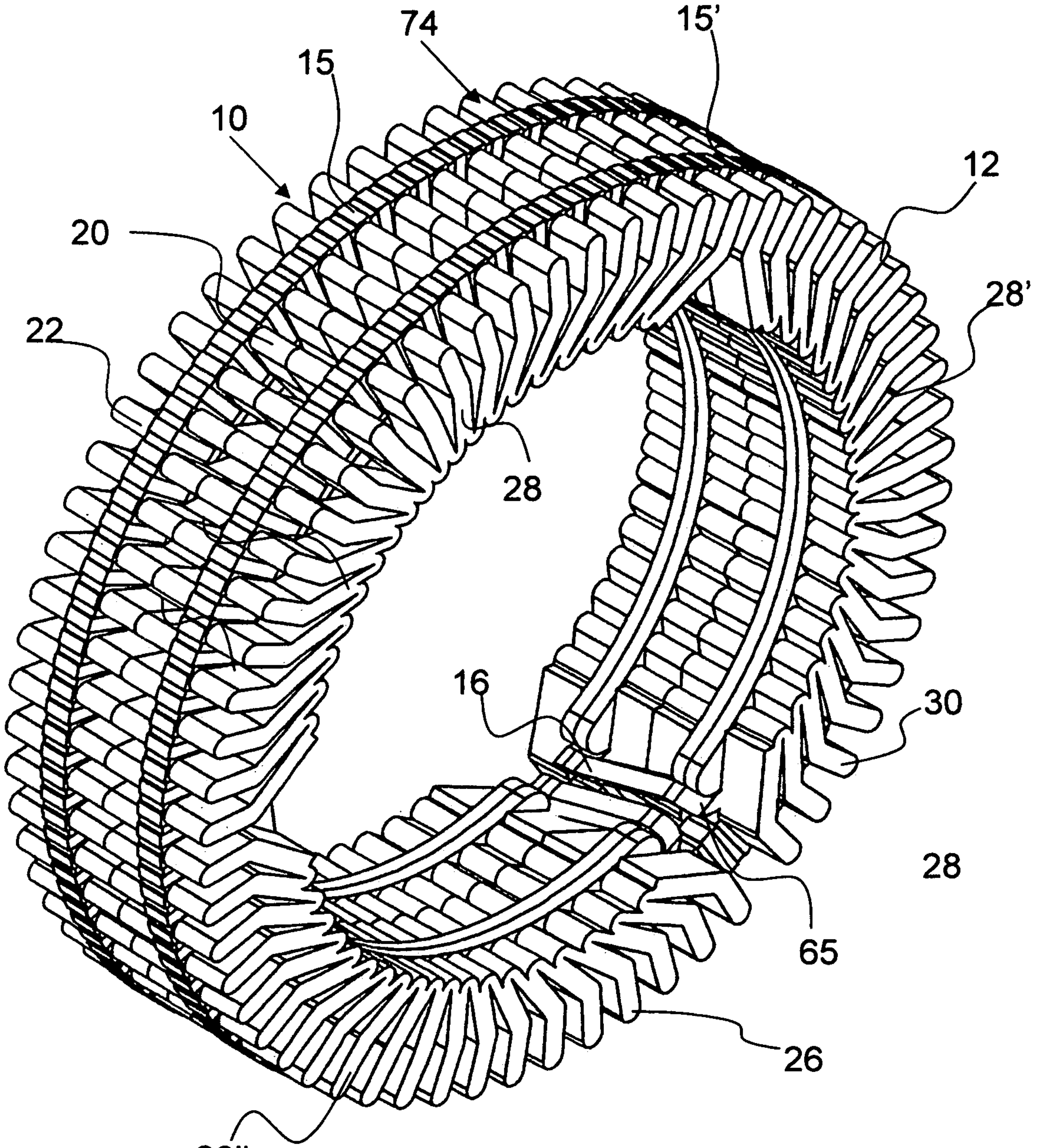

FIG. 15

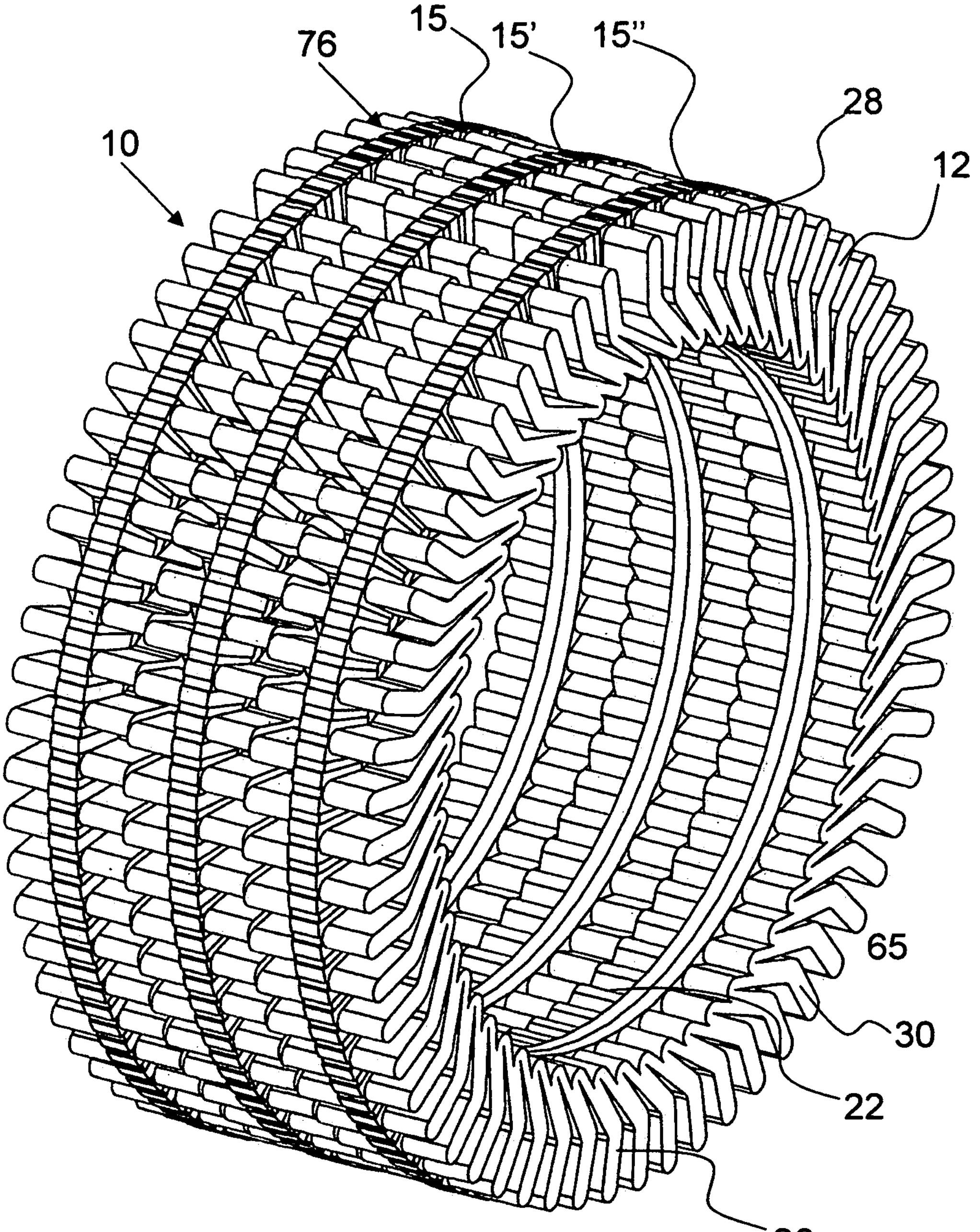

FIG. 16

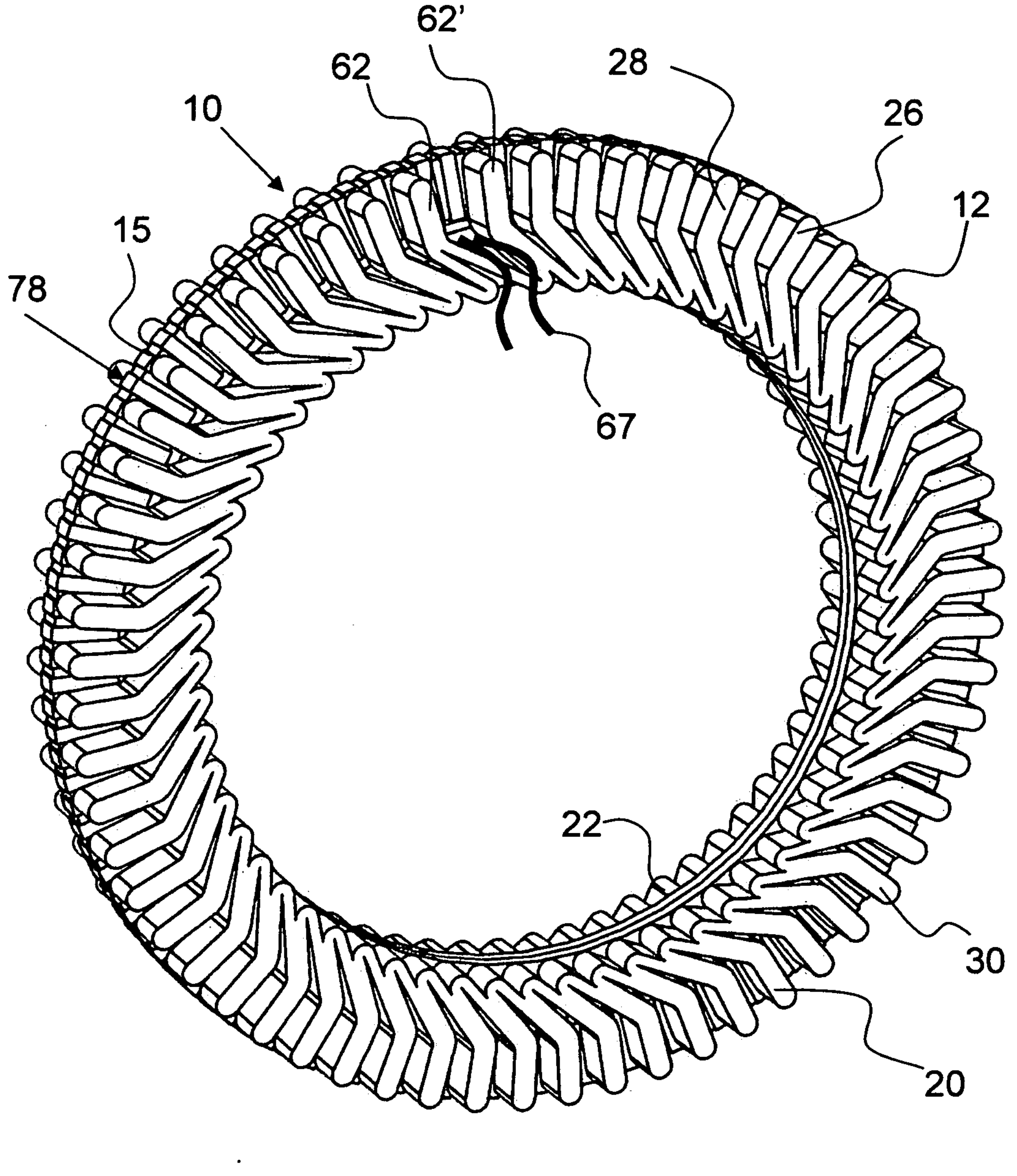

FIG. 17

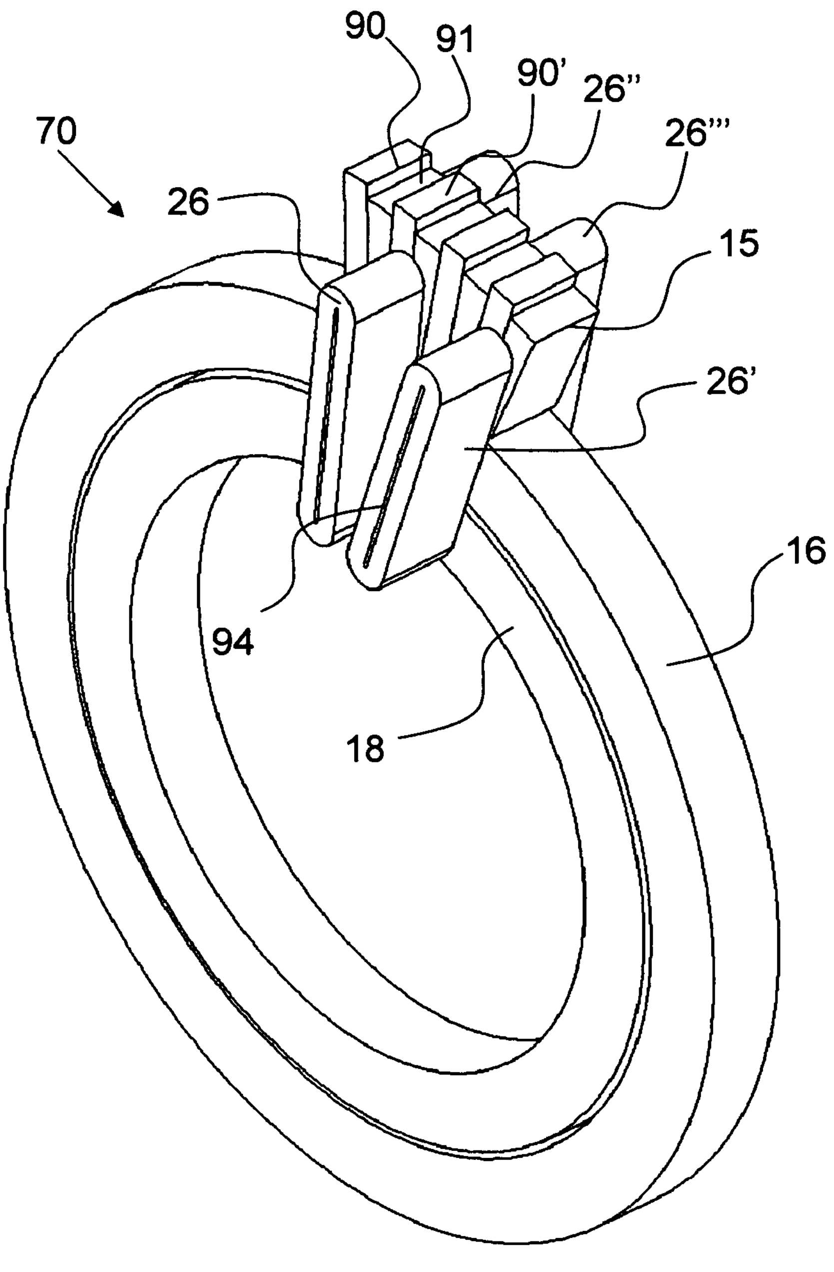

FIG. 18

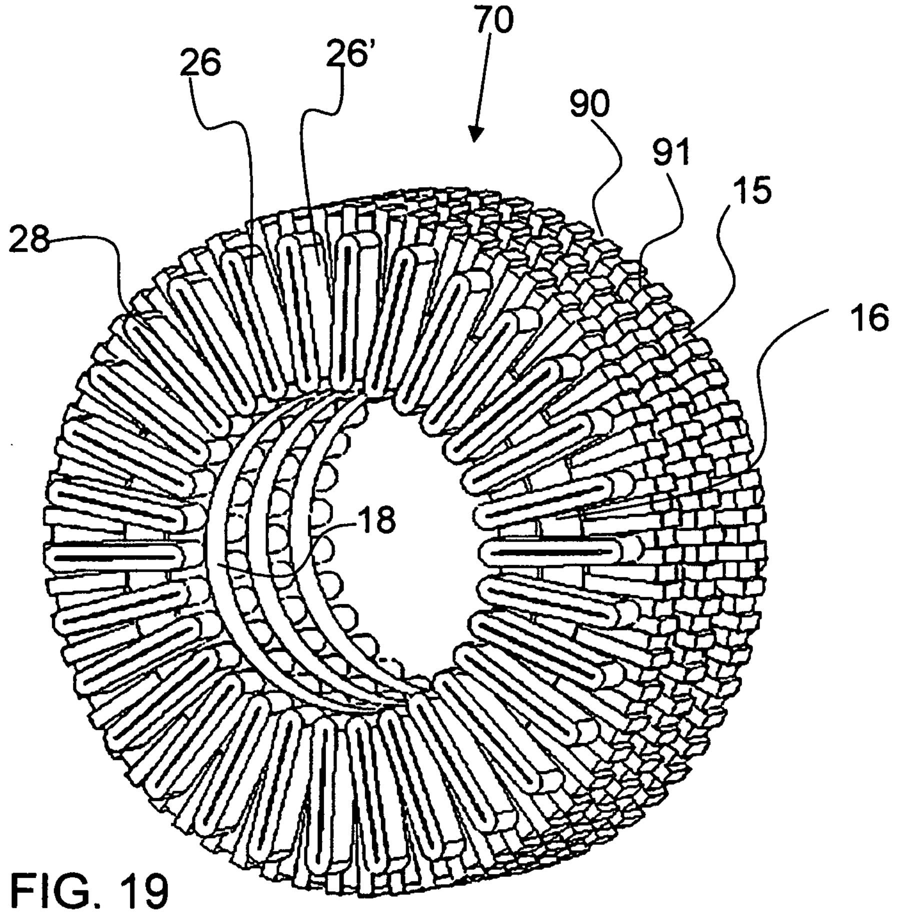
70
26
26'
90
91
15
28
16
18

FIG. 19

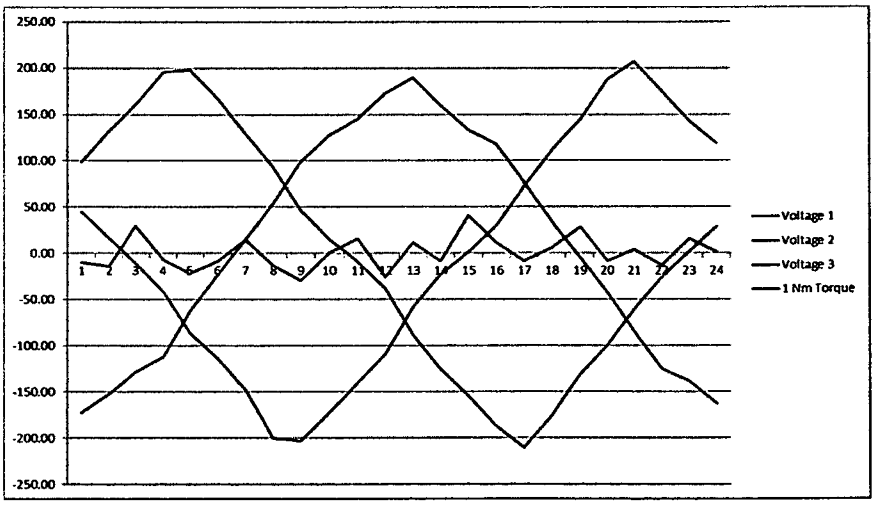
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Voltage 1
Voltage 2
Voltage 3
1 Nm Torque

FIG. 20

3 Phases Direction A					1.5 mm resolution mesh			Amps Peak per phase			OC	Phase angle		File;							
As single phase loop		Ohms	Turns	Amps Peak				0.04			OC	Phase angle							Core losses OFF		
	Degrees	0.502084	100	OC							OC	Phase angle									
Voltage 1	RMS	Voltage 2		Voltage 3		Amps 1		Amps 2		Amps 3		Nm Torqu	Joule loss	1 Input W	2 Input W	2 Input W	Jmag inpo	1 Input Watts			
0.00	0.00	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	-158.45		0.00	0.00	0.00	0.00				
98.45	9693.11	-172.46	29741	44.87	2013	-0.01	0	0.02	0	0.00	0	-133.10		-0.32	-0.99	-0.07	0.00		1		
131.81	17374.73	-152.33	23205	16.28	265	-0.01	0	0.02	0	0.00	0	-15.58		-1.32	-2.65	-0.10	0.00		2		
160.38	25722.72	-128.65	16551	-10.45	109	-0.02	0	0.01	0	0.00	0	149.11		-2.12	-1.96	-0.01	0.04		3		
195.89	38371.76	-112.35	12623	-42.11	1773	-0.02	0	0.01	0	0.00	0	163.67		-3.18	-1.44	-0.07	0.03		4		
198.05	39224.28	-62.92	3959	-86.03	7401	-0.02	0	0.01	0	0.01	0	138.81		-3.88	-0.79	-0.43	0.00		5		
166.89	27853.52	-23.27	542	-114.15	13030	-0.02	0	0.00	0	0.01	0	108.78		-3.34	-0.20	-1.01	0.00		6		
128.89	16611.93	15.02	226	-147.38	21720	-0.01	0	0.00	0	0.01	0	77.66		-2.20	-0.01	-1.72	0.00		7		
93.31	8707.47	54.31	2949	-200.54	40216	-0.01	0	-0.01	0	0.02	0	-15.06		-1.25	-0.13	-3.05	0.00		8		
46.20	2134.24	99.54	9909	-202.84	41145	0.00	0	-0.01	0	0.02	0	-97.06		-0.51	-0.60	-4.07	0.00				
14.98	224.25	127.79	16330	-172.49	29751	0.00	0	-0.01	0	0.02	0	-115.93		-0.11	-1.29	-3.53	0.01				
-9.10	82.80	145.05	21040	-140.52	19746	0.00	0	-0.01	0	0.01	0	-127.62		-0.01	-1.86	-2.46	0.00				
-38.55	1486.17	173.06	29951	-109.03	11888	0.00	0	-0.02	0	0.01	0	-184.88		-0.06	-2.52	-1.56	0.02				
-88.26	7789.91	189.96	36084	-58.86	3464	0.01	0	-0.02	0	0.01	0	-134.90		-0.42	-3.28	-0.73	0.02				
-125.12	15655.34	159.56	25461	-23.03	530	0.01	0	-0.02	0	0.00	0	-50.90		-1.14	-3.06	-0.18	0.01				
-154.40	23837.83	133.18	17736	1.28	2	0.02	0	-0.01	0	0.00	0	125.78		-1.94	-2.16	-0.02	0.00				
-187.28	35073.31	118.11	13950	29.52	871	0.02	0	-0.01	0	0.00	0	167.57		-2.89	-1.59	-0.03	0.03				
-210.45	44288.05	77.11	5946	71.86	5164	0.02	0	-0.01	0	-0.01	0	161.69		-3.94	-0.97	-0.28	0.02				
-175.61	30837.53	34.17	1168	112.10	12566	0.02	0	0.00	0	-0.01	0	134.66		-3.74	-0.33	-0.86	0.00				
-130.75	17094.62	-5.06	26	144.54	20890	0.01	0	0.00	0	-0.01	0	108.75		-2.36	-0.04	-1.65	0.00				
-99.27	9854.20	-42.78	1830	187.67	35222	0.01	0	0.00	0	-0.02	0	9.78		-1.33	-0.07	-2.77	0.00				
-60.74	3689.15	-85.11	7244	206.78	42759	0.01	0	0.01	0	-0.02	0	-45.02		-0.66	-0.42	-3.89	0.01				
-25.78	664.40	-125.34	15711	175.24	30709	0.00	0	0.01	0	-0.02	0	-114.41		-0.20	-1.11	-3.65	0.01				
1.81	3.28	-138.22	19104	143.18	20501	0.00	0	0.01	0	-0.01	0	-121.49		-0.02	-1.74	-2.54	0.00				
28.72	825.01	-162.68	26464	118.95	14148	0.00	0	0.02	0	-0.01	0	-151.04		-0.03	-2.27	-1.73	-0.01		Sheer PSI		0.2
66.94	4481.13	-172.20	29654	74.33	5524	-0.01	0	0.02	0	-0.01	0	-151.46		-0.24	-2.80	-0.95	0.00		Ft-Lbs.		1.2
114.56	13124.05	-171.59	29444	34.33	1179	-0.01	0	0.02	0	0.00	0	-107.96		-0.87	-2.95	-0.31	-0.02		RPM		180
138.97	19313.15	-141.10	19908	7.19	52	-0.01	0	0.01	0	0.00	0	43.72		-1.64	-2.44	-0.05	-0.02		Rad/sec		18.84956
172.25	29668.46	-126.71	16056	-20.73	430	-0.02	0	0.01	0	0.00	0	165.53		-2.43	-1.80	-0.01	-0.01		Power (RMS Volts X		11
201.10	40440.61	-95.81	9179	-55.44	3074	-0.02	0	0.01	0	0.01	0	166.85		-3.48	-1.26	-0.15	0.00		Power J-Mag		3
190.71	36370.10	-49.06	2407	-96.10	9236	-0.02	0	0.00	0	0.01	0	118.54		-3.84	-0.55	-0.58	0.00		Nm times Rad/Sec		31
154.25	23794.13	-10.31	106	-124.67	15541	-0.02	0	0.00	0	0.01	0	107.23		-2.98	-0.10	-1.22	0.00		IXE Power Factor		2.78
116.69	13615.89	27.19	739	-163.50	26731	-0.01	0	0.00	0	0.02	0	40.37		-1.85	-0.02	-2.08	0.00		INST= Power Factor		32853.75
77.36	5984.18	68.21	4652	-211.76	44840	-0.01	0	-0.01	0	0.02	0	-28.94		-0.95	-0.24	-3.54	0.00		Watts loss		0
35.13	1234.12	113.37	12853	-192.88	37201	0.00	0	-0.01	0	0.02	0	-129.58		-0.33	-0.85	-4.10	0.00		Efficiency at speed a		100.0%
6.67	44.46	132.70	17609	-160.65	25809	0.00	0	-0.01	0	0.02	0	-120.14		-0.05	-1.52	-3.14	0.00		AV per torque		6.8
	15495.32		14069.12		15808.23		0.00		0.00		0.00	1.64	#DIV/0!				J-Mag Pov	0.01	Dissipation per Nm		0.00
RMS Volts	124.48	RMS Volts	118.61	RMS Volts	125.73	RMS amps	0.03	RMS amps	0.03	RMS amps	0.03	Nm Torqu	#DIV/0!						Nm per amp		18.1
Phase vol	101%	Phase vol	96%	Phase vol	102%	AVG Volts	122.9			Amps Sur	0.1		#DIV/0!						R/kt^2		0.002

FIG. 21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/000004

A. CLASSIFICATION OF SUBJECT MATTER

H02K 1/06(2006.01)i, H02K 1/12(2006.01)i, H02K 15/02(2006.01)i

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 1/06; H02K 21/24; H02K 3/47; H02K 19/06; H02K 1/18; H02K 1/12; H02K 21/12; H02K 1/02; H02K 1/16; H02K 15/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: motor, stator, tape, ribbon, edge, fold

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2001-292542 A (NISSAN MOTOR CO., LTD.) 19 October 2001 See abstract, paragraphs [0032]-[0036], claim 1 and figures 1-6.	75-79,83-94 1-74,80-82,95-123
A	US 8253299 B1 (NORMAN P. RITTENHOUSE) 28 August 2012 See column 7, line 9 - column 10, line 42 and figures 4-6.	1-123
A	US 2009-0322165 A1 (NORMAN P. RITTENHOUSE) 31 December 2009 See abstract, paragraphs [0052]-[0078] and figures 2a-7a.	1-123
A	US 2008-0272666 A1 (RICHARD HALSTEAD) 06 November 2008 See paragraphs [0031]-[0044] and figures 1-6.	1-123
A	US 2011-0148225 A1 (DAVID G. CALLEY et al.) 23 June 2011 See paragraphs [0071]-[0099] and figures 5A-5E.	1-123
A	JP 2012-023861 A (MITSUBISHI ELECTRIC CORP.) 02 February 2012 See abstract, paragraphs [0009]-[0021] and figures 1-6.	1-123

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 May 2014 (19.05.2014)	**19 May 2014 (19.05.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer
PARK, Hye Lyun
Telephone No. +82-42-481-3463

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2014/000004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2001-292542 A	19/10/2001	None	
US 8253299 B1	28/08/2012	WO 2011-146851 A1	24/11/2011
US 2009-0322165 A1	31/12/2009	US 2009-0195090 A1	06/08/2009
		US 7492074 B1	17/02/2009
		US 7723891 B2	25/05/2010
		US 7868510 B2	11/01/2011
US 2008-0272666 A1	06/11/2008	EP 2201825 A2	30/06/2010
		US 2010-0101074 A1	29/04/2010
		US 7646132 B2	12/01/2010
		US 8261429 B2	11/09/2012
		WO 2008-137398 A2	13/11/2008
US 2011-0148225 A1	23/06/2011	CN102227862 A	26/10/2011
		CN102257708 A	23/11/2011
		CN102257709 A	23/11/2011
		EP 2342800 A2	13/07/2011
		EP 2342802 A2	13/07/2011
		EP 2342803 A2	13/07/2011
		JP 2012-507983 A	29/03/2012
		JP 2012-508549 A	05/04/2012
		JP 2012-508555 A	05/04/2012
		KR 10-2011-0084902 A	26/07/2011
		KR 10-2011-0086063 A	27/07/2011
		KR 10-2011-0093803 A	18/08/2011
		US 2010-0109452 A1	06/05/2010
		US 2010-0109453 A1	06/05/2010
		US 2010-0109462 A1	06/05/2010
		US 2011-0050010 A1	03/03/2011
		US 2011-0062723 A1	17/03/2011
		US 2011-259659 A1	27/10/2011
		US 2011-273035 A1	10/11/2011
		US 2012-001501 A1	05/01/2012
		US 7851965 B2	14/12/2010
		US 7868508 B2	11/01/2011
		US 7923886 B2	12/04/2011
		US 7994678 B2	09/08/2011
		US 8008821 B2	30/08/2011
		US 8030819 B2	04/10/2011
		US 8193679 B2	05/06/2012
		US 8242658 B2	14/08/2012
		WO 2010-062764 A2	03/06/2010
		WO 2010-062764 A3	19/08/2010
		WO 2010-062765 A2	03/06/2010
		WO 2010-062765 A3	19/08/2010
		WO 2010-062766 A2	03/06/2010
		WO 2010-062766 A3	12/08/2010

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2014/000004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2012-023861 A	02/02/2012	None	