(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 273 813 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
31.05.2006 Bulletin 2006/22

(51) Int Cl.:
F16C 32/04 (2006.01) *F16C 39/06* (2006.01)

(21) Application number: **02009027.0**

(22) Date of filing: **23.04.2002**

(54) **Stator core for a magnetic bearing and method of manufacturing the same**

Statorkern für ein Magnetlager und Verfahren zu seiner Herstellung

Noyau statorique pour un palier magnétique et son procédé de fabrication

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR

(30) Priority: **02.07.2001 JP 2001201030**

(43) Date of publication of application:
08.01.2003 Bulletin 2003/02

(60) Divisional application:
03029453.2 / 1 411 255

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Description

BACKGROUND OF THE INVENTION

Technical field of the invention

[0001] The present invention relates to a structure of a magnetic bearing that supports a rotor without making contact, particularly a stator core for a homo-polar type of magnetic bearing, and a method of manufacturing it.

Prior art

[0002] A turbo compressor can be made larger in capacity and smaller in size than a reciprocating or screw compressor, and can be easily made to an oil-free type. Therefore, turbo compressors are used often as general-purpose compressors in applications such as a compressed air source for factories, a source of air for separation, and other various processes.

[0003] Conventionally, gas bearings, sliding bearings and magnetic bearings have been used to support a high-speed rotating shaft of a high-speed motor that is connected directly to and drives a turbo compressor. In particular, a homo-polar magnetic bearing can be used to support a rotor (rotating shaft) in a contact free manner that rotates to form the high speed shaft of a high speed motor by passing magnetic flux through the shaft to produce an electromagnetic sucking force which causes the shaft to float, this being one type of radial magnetic bearing for use with shafts that rotate at a high speed (for instance, 100,000 min^{-1} or more) .

[0004] Figs. 1A and 1B show typical schematic viewes of a conventional homo-polar magnetic bearing. In these figures, a homo-polar magnetic bearing 1 is composed of a rotor 3 that is arranged at the axial center of a casing 2 and parallel to it in the axial direction and can rotate at a high speed, U-shaped stator cores 4 installed inside the casing 2 with gaps between the outer surface of the rotor 3, and coils 5 that are placed around the toothed ends of the stator cores 4.

[0005] In addition, a plurality of stator cores (4 cores in Figs. 1A and 1B) are disposed equally spaced in the circumferential direction with gaps between the outer surface of the rotor 3. Although not illustrated, stator cores 4 are arranged in the axial direction of the rotor 3 in at least 2 locations with a predetermined distance between them. Consequently, the rotor can rotate stably at a high speed. A stator core 4 is made of laminated steel sheets each of which is manufactured with an insulating adhesive material applied to its surface to bond to an adjacent thin steel sheet, and these are bonded one after another to obtain a predetermined length. As shown in Figs. 1A and 1B, the direction A in which the laminated steel sheets 4 (lamination) are bonded is arranged to be perpendicular to the axial direction Z of the rotor 3.

[0006] As described above, in the homo-polar magnetic bearing 1, since the toothed ends of the stator cores 4 that surround the rotor 3 are close to each other in the axial direction and as the coils 5 produce the N and S poles of an electro magnet, the homo-polar magnetic bearing 1 can float the shaft in a contact free manner and support the rotor 3 by the sucking force of the toothed ends located opposite each other. Therefore, the direction of this homo-polar magnetic field is parallel to the centerline of the rotor and on the outer surface of the rotor 3 as shown by the dashed arrow lines in Fig. 1B.

[0007] Fig. 1C is a schematic view that shows a conventional process for assembling laminated steel sheets to form a conventional stator core. Normally, the stator core 4 of the homo-polar magnetic bearing 1 is manufactured by making thin rectangular steel sheets 4a coated with an insulating material, by a method such as punching, and assembling these punched steel sheets 4a one after another, to produce a laminated stator core 4.

[0008] However, when the inner surfaces of the aforementioned stator cores 4 (laminated steel sheets) are cut by a rotary cutting process, a large cutting load is applied to the edges of the laminated steel sheets 4a in a lateral direction, so the tips of the laminated steel sheets 4a are bent, and the insulating material is crushed in the direction of rotation by the above-mentioned bending load, which is a practical problem. Consequently, the steel sheets contact each other resulting in an increase in the eddy currents in the stator unit, so another problem occurs due to the reduced levitation force applied to the rotor 3, poor rotating characteristics, etc. Still another problem is that the laminated material is peeled away by the edge of the cutting tool. Even if the above-mentioned process of cutting in a lathe is replaced by using a vertical boring machine etc. to cut the inner surfaces of laminated steel sheets, because there are gaps between adjacent steel sheets, there is the additional problems that smooth cutting and true roundness cannot be easily ensured.

[0009] On the other hand, the inventors of the present invention have proposed the homo-polar magnetic bearing apparatus configured as shown in Figs. 2 and 3, with the aim of improving the characteristics of conventional homo polar magnetic bearings (JP 2001 271 836).

[0010] According to this magnetic bearing apparatus, adjacent N poles or S poles are connected together in the circumferential direction, or are located close to each other with a small gap between them. The homo-polar magnetic bearing with this configuration has the advantage that it is capable of greatly reducing the production of eddy currents and the heat and eddy current losses generated in the rotor.

[0011] However, if the stator cores 4 of the homo-polar magnetic bearing shown in Figs. 2 and 3 are produced using laminated steel sheets with small eddy current losses, as shown in Fig. 1, the laminated steel sheets become so thin in the peripheral web 4b that they fail, crush or peel when processed, which is a practical disadvantage.

[0012] More explicitly, in the homo-polar magnetic bearing with the structure shown in Figs. 2 and 3, the stator cores 4 are connected together circumferentially or located close to each other, so the distribution of magnetic flux in the rotor is more uniform and losses can be reduced. Conversely, however, if stator cores 4 in which the tips are connected together are formed with a conventional laminated structure, the laminated steel sheets are so small in the portions where adjacent magnetic poles are connected together that the laminated structure may collapse when the cores are machined, therefore, it is very difficult to machine the cores without detaching, crushing or peeling the laminations.

[0013] Another problem in a conventional apparatus is that amorphous materials cannot be used because they are difficult to laminate, despite the advantages of having a high electrical resistance and permeability, so the choice of electromagnetic sheet steel is restricted.

[0014] Next, the structure of a conventional homo-polar radial magnetic bearing is described in more detail than before by referring to Figs. 4 and 5. Fig. 4a is a front view of a conventional homo-polar radial magnetic bearing, and Fig. 4b is the corresponding side sectional elevation. Fig. 5 is an isometric view of the stator core of a conventional homo-polar radial magnetic bearing.

[0015] The homo-polar radial magnetic bearing 1 is provided with a casing 2, a plurality of electromagnetic components 13 and a rotating shaft 3. The rotating shaft 3 is made of a material which is magnetic at least on the surface thereof, with an outer diameter of D1 and a length determined by the rotor. The rotor 3 is disposed coaxially with the centerline of the casing 2, parallel thereto in the longitudinal direction, and is supported so that it can rotate freely. The plurality of electromagnetic components 13 support the rotor 3 so that it can rotate freely, and are arranged around the rotor 3. For instance, four electromagnetic components are connected together to form a set, and sets of electromagnetic components 13 support the rotor 3 at 2 locations. At each supporting location, 4 electromagnetic components are equally spaced around the rotor.

[0016] The electromagnetic components 13 are provided with stator cores 80 and coils 5. The stator core 80 is provided with two yokes 6 and 8 and a stem portion 7 as shown in Fig. 5. A yoke 6 or 8 is a column-shaped portion one end of which is opposite the outer surface of the rotor 3 with a gap between them that induces a magnetic pole on the surface 9. The two yokes 6, 8 are arranged axially with a predetermined spacing between each other. The stem portion 7 is a magnetic structure between the other ends of the two yokes 6, 8 connecting the yokes together. The stator core 80 is a thick U-shaped unit comprised of the two yokes 6, 8 and the stem portion 7 without gaps, and is installed in a recess on the inner periphery of the casing 2.

[0017] The coil 5 is a bundle of wire. The wire is wound in several layers around the yokes 6, 8 with an air gap between the coil and yoke. The coil 5 is a block with the same shape as the section of the yoke 6 or 8 with an air gap between the coil and yoke.

[0018] The structure of the stator core 80 is described in further detail referring to Fig. 5. The stator core 80 is made of laminated steel sheets, consisting of a plurality of magnetic steel sheets 81 and an insulating material. The magnetic steel sheet 81 is a thin steel sheet with a thickness T, shaped in the aforementioned U shape. The insulating material is a non-conducting material and is applied between the plurality of magnetic steel sheets 81. When the stator core 80 is assembled as an electromagnetic component, it is laminated in the circumferential direction of the rotor. The magnetic steel sheet 81 of the illustrated stator core 80 is rectangular in shape with a width W1 and a height H1, provided with a slot W2 wide and H2 in height, on the side forming the magnetic pole surface 9. The stator core 80 is made of a plurality of laminated magnetic steel sheets 81 with a predetermined length of L1.

[0019] In another type of electromagnetic component, the width of a stator core 80 near the magnetic pole surface 9 is extended circumferentially in the direction of the outer surface of the rotor, and comes in close contact with the magnetic pole surfaces of the adjacent electromagnetic components of the stator core.

[0020] According to still another type of electromagnetic component, the width of a stator core 80 near the magnetic pole surface 9 is extended circumferentially in the direction of the outer surface of the rotor, and is integrated with the magnetic pole surface of an adjacent electromagnetic component of the stator core 80.

[0021] When the aforementioned stator core for a magnetic bearing is manufactured, thin sheet steel with a thickness T is punched using dies, to produce U-shaped magnetic steel sheets.

[0022] Next, the magnetic pole surface 9 of the stator core for a magnetic bearing must be machined into a circular arc using a lathe etc.; at this time, the rotation causes a cutting load that acts laterally on the edges of the laminated steel sheets, so the tips of the electromagnetic steel sheets are bent; due to this bending, the insulation material is crushed in the direction of rotation, often resulting in adjacent electromagnetic steel sheets coming in contact with each other. The problem encountered when this happens is that large eddy currents are produced in the electromagnetic steel sheets.

[0023] Another problem that the laminated steel sheets become separated during cutting, may occur.

[0024] There is also another problem that if a vertical boring machine is used instead of a lathe, differences are produced at the edges between adjacent laminated steel sheets, and a true, smooth circle cannot be ensured.

[0025] With the type of stator core for a magnetic bearing in which the magnetic pole surface of the stator core is extended over the outer surface of the rotor, since the laminated steel sheets in the extended portions become very thin, they may cause problems by becoming detached, crushed or peeled during machining.

[0026] JP-2000-205260A and JP-2001-271836 A disclose an arrangement of stator cores and a rotor for a homo-polar magnetic bearing according to the preamble of claim 1.

[0027] JP-2000 031135 A discloses an arrangement of stators cores for a homo-polar magnetic bearing comprising U-shaped laminated sheets, wherein the sheets are cut cores that are fabricated by winding a continuous steal sheet into a rectangular shape and by cutting the rectangle into two equal portions. Each core is shaped into a letter "U" of which the center side is open when viewed from the side of the rotor. Four stator cores are provided which are disposed with equal distances around a rotor, wherein the stator cores have distances one to another.

SUMMARY OF THE INVENTION

[0028] It is the object of the invention to provide an easy to manufacture stator core for a magnetic bearing in which the generation of eddy currents is kept to the minimum. It is a further object of the invention to provide a method of manufacturing cores for a magnetic bearing which can avoid the laminated steel sheets becoming detached, crushed or peeled and can be efficiently cut and processed.

[0029] This object is solved by the features of claims 1, 3 and 4 respectively.

[0030] Using a configuration according to claim 1, the production of eddy currents can be drastically reduced, thereby the rotor losses, due to the heat generated by the eddy currents can be greatly reduced. Because the stator core is composed of laminated steel sheets with a U shape such that the center side is open when viewed from the center live side extending in axial direction of the rotor, even the protrusions that are in contact with each other can be integrated into one body together with the coils. The laminated steel in the protrusions is an integral part of the same steel sheet as that in the location of the coils, so a laminated structure can withstand processing work without becoming collapsed, and also avoiding becoming detached, crushed or peeled, thereby the sheet can be efficiently cut and processed.

[0031] Since the protrusions contact each other the generation of eddy currents can be reduced significantly, thus heat and losses due to eddy currents produced in the rotor can be greatly reduced. In addition, since the protrusions contact each other at the plane portions, the stator cores can be easily located and the inner periphery can be precisely cut and processed.

[0032] Moreover, because the cores can be processed after being formed and cut, even an amorphous material etc. that cannot be easily laminated can be used.

[0033] According to a preferred embodiment of the present invention, the aforementioned U-shaped laminated steel cores are manufactured from a continuous steel sheet coated with an insulation material that is wound into a rectangular shape and then cut into equal parts.

[0034] Using this configuration, such stator cores have protruding portions composed of adjacent N and S poles extending circumferentially so as to be in contact with each other and are composed of U-shaped laminated steel sheets with an insulating material between the laminations and the U shape is such that the center side is open when viewed from the side of the shaft, the cores can be processed quickly and efficiently by processing the outer shape and cutting the inside of the cut cores .

[0035] In addition, the cut cores are wound into a rectangular shape with a center opening of predetermined dimensions and can be formed quickly and easily. Moreover, by dividing this wound rectangular shape, into two equal parts with a cutting machine, U-shaped laminated steel sheets each of which is isolated with an insulating material can be easily fabricated. Furthermore, high-cost punching dies need not be used, but simple and compact wrapping dies can be used to manufacture the cut cores, so the manufacturing costs can be reduced, laminating work can be omitted, and therefore, productivity can be improved. In addition, the scrap material that might otherwise be produced from the center parts of steel sheets during punching work when using punching dies can be avoided, therefore, the yield of steel sheets can be improved drastically.

[0036] Using a method according to claim 3, cutting the inside of a plurality of cut cores can be completed in one operation, and the cores can be machined with an excellent concentricity. In addition, the inner surfaces of the ends of the teeth can be cut in the direction of the sheet laminations and in the plane of the laminations during rotation, without imposing a biasing or bending load, therefore, the cut surfaces of the steel sheets remain smooth and regular without the insulating material becoming crushed, broken or peeled, so that a satisfactory excellent roundness can be preserved.

[0037] According to using a method according to claim 4, cutting the inner surface is required twice, however, the number of machining steps can be reduced. In addition, when the inner periphery of the toothed ends is cut during rotation, the cutting work can be carried out in the direction of the lamination and in the horizontal plane of the steel sheets on the inner periphery of the toothed ends, without producing a bias load or deflection, therefore, the cut edges of the steel sheets can be kept smooth without any irregularity at the edge of each cut, and the peripheries of the cores can be kept smooth and truly circular without any collapsing, tearing or peeling of the insulating material.

[0038] Other objects and advantages of the present invention are revealed in the following paragraphs referring to the attached drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0039]

Figs. 1A through 1C are schematic viewes showing the configuration of a conventional homo-polar magnetic bearing.

Figs. 2A and 2B show the configuration of the homo-polar magnetic bearing related to the prior application.

Fig. 3 is an isometric view of the stator cores shown in Fig. 2.

Figs. 4a and 4b are the front plan view and side elevation of a conventional homo-polar radial magnetic bearing.

Fig. 5 is an isometric drawing showing conventional stator cores for a homo-polar radial magnetic bearing.

Figs. 6A through 6C show the stator cores for a magnetic bearing.

Figs. 7A through 7C illustrate an embodiment of the stator cores.

Figs. 8A and 8B are schematic viewes of the embodiment of the stator cores based on the present invention.

Fig. 9 shows a method of manufacturing stator cores

Fig. 10 is another view showing the method of manufacturing stator cores.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0040] Preferred embodiments of the present invention are described below referring to the drawings. Common portions shown in each drawing are identified with the same numbers, and no duplicate descriptions are given.

[0041] Figs. 6A and 6B show stator cores for a magnetic bearing. As shown in the figures, the magnetic bearing incorporates stator cores for a homo-polar magnetic bearing, like that shown in Fig. 13, wherein the toothed ends of the stator cores 10 form N poles and S poles adjacent to each other in the axial direction, and surround a rotor 3.

[0042] In the stator cores for a magnetic bearing the stator cores 10 are provided with protrusions 11 extending in the circumferential direction from adjacent N and S poles so as to be in contact with or in close proximity to each other.

[0043] Fig. 6C typically shows the method of manufacturing U-shaped laminated steel sheets for the stator cores 10. In Fig. 6C, U-shaped laminated steel sheets for the cut cores 12 are manufactured by wrapping a continuous steel sheet 12a coated with an insulation material into a rectangular shape, forming it and cutting it in equal parts.

[0044] Therefore, the stator cores 10 according to the present invention are composed of U-shaped laminated steel sheets interleaved with insulating material, and with the center sides open when viewed from the centerline.

[0045] Figs. 7A through 7C show an embodiment of stator cores. In the figures, Fig. 7A is an isometric view showing the arrangement of 4 stator cores 10 for the case in which the number of magnetic poles is 4, Fig. 7B is an illustration of one of the cores after it has been machined on the outside, and Fig. 7C is a plan view of the arrangement off the 4 stator cores 10. In each view, broken lines represent the cutting surfaces on the cut cores 12.

[0046] In the embodiment shown in Figs. 7A through 7C, protrusions 11 extend circumferentially, and come in point contact (more accurately in 3 dimensions, line contact) with each other at point A on a planes. However, the protrusions can also be made to be in close proximity to each other with a small gap, instead of a point contact. Also, the present embodiment is not limited only to a case with 4 magnetic poles, in other words, 3 or 5 or more poles can be incorporated.

[0047] The aforementioned configuration can greatly reduce the production of eddy currents because there is no gap or only a very small gap between the protrusions 11, thereby heat and losses due to eddy currents generated in the rotor can be greatly reduced.

[0048] Figs. 8A and 8B show an embodiment of the stator cores according to the present invention. Fig. 8A shows one of the four stator cores 10 after it has been machined on the outside, and Fig. 8B is a plan view showing the arrangement of the four stator cores 10. In each drawing, broken lines indicate where the cut cores 12 are cut to form the stator core.

[0049] In the embodiment shown in Figs. 8A and 8B, the protrusions 11 are extended in the circumferential direction and come in contact with each other at the point A in the plan view. Also in this embodiment, the number of magnetic poles is not limited only to 4, but 3 or 5 poles can be incorporated.

[0050] Because there are no gaps between protrusions 11 in this configuration, the generation of eddy currents can be reduced significantly, thus heat and losses due to eddy currents produced in the rotor can be greatly reduced. In addition, since the protrusions contact each other in that planes, the core can be easily located and the inner periphery can be precisely cut and processed.

[0051] The stator cores 10 shown in Figs. 6 ~ 8 are formed from laminated steel sheets shaped like the letter _U,_ of which the center side is open when viewed from the side of the shaft, therefore, the protrusions 11 contact each other or are located close to each other and the cut cores can be integrated into one body together with coils. Consequently, the laminated steel sheets in the protruding tips (protrusions 11) are the same steel sheets as those where the coils are located, so the layers of laminations prevent the sheets from collapsing during processing, and also detachment, crushing or peeling of the laminations can be avoided, and the cores can be efficiently cut and processed.

[0052] Because the cores can be machined after being formed from the cut cores, even an amorphous material that cannot be easily laminated can be used in practice.

(Manufacturing method 1)

[0053] Fig. 9 shows the method of manufacturing stator cores according to the present invention. This method of the present invention consists of an outside machining step (A), a coil assembling step (B), a core assembling step (C) and an inside cutting step (D).

[0054] In the outside machining step (A), a cut core 12 manufactured by winding a continuous steel sheet 12a coated with an insulating material into a rectangular shape, that has been formed and then cut into equal parts, beforehand, is machined on the outside thereof leaving the protrusions 11.

[0055] In the coil assembling step (B), a coil 5 is installed on the cut core 10 the outside of which has been machined. In the core assembling step (C), a plurality (4 in this example) of cut cores 10 are arranged in the prescribed positions. In the inside cutting step (D), the inside of the plurality of cut cores 10 that have been placed in position is cut, thereby the stator cores 10 are completed.

[0056] By virtue of the manufacturing method shown in Fig. 9, the inside of the plurality of cut cores 10 can be completed at one time, and the cut surfaces can be made very accurate and concentric. When the inner periphery of each toothed end is cut, the cutting tool moves in the direction of the lamination and in the plane of the layers of laminations on the inner periphery of the toothed ends, so no eccentric loading or bending takes place, the layers of steel sheets remain laminated without any irregularities due to cutting, the insulating material is prevented from being crushed or torn or otherwise peeled off, and this ensures that the inner surface is smooth and truly circular.

(Manufacturing method 2)

[0057] Fig. 10 shows another method of manufacturing stator cores according to the present invention. The manufacturing method shown in Fig. 10 according to the present invention incorporates an inside cutting step (E), an outside machining step (F) and a coil assembling step (G).

[0058] In the inside cutting step (E), cut cores 12 that have been manufactured by winding a continuous steel sheet 12a coated with an insulating material into a rectangular shape, and the rectangle has been formed and then cut into two equal parts beforehand, a plurality (4 in this example) of cut cores 12 are assembled in the required positions and the inside thereof is cut.

[0059] In the outside machining step (F), the outside and inside surfaces of the plurality of cut cores 10 are machined, leaving protrusions 11 on the outside of the cut cores 10. In the coil assembling step (G), coils 5 are installed on the plurality of cut cores 10 of which the outside has been machined, thus the manufacturing of the stator cores 10 is completed.

[0060] Although the manufacturing method in Fig. 10 requires the inside surface to be cut twice, the number of machining processes can be reduced. In addition, when the inner periphery of the toothed ends is cut and processed by rotating the cores, the cutting work can be carried out both in the direction of laminating and in the plane of the layers of laminations on the inner surface of toothed ends, without producing an eccentric load or bending force, so the cut edges of the steel sheets remain smooth and free from roughness, and the insulating material is prevented from being peeled off due to crushing or tearing, thereby ensuring that the inner surface is smooth and truly circular.

[0061] In the aforementioned embodiments, a radial bearing was taken as an example, however, applicable bearings in practice are not limited only to this example, and the present invention can also be applied to a thrust bearing. In addition, although the descriptions were given assuming a structure for supporting a rotating rotor, the invention is not limited only to this example, but for instance, the present invention can also be applied to a guide for a linear motion drive. A biasing magnet may also be included as part of a stator core.

[0062] The above-mentioned stator cores for a magnetic bearing and the method of manufacturing them offer the following advantages.

1. Since the laminated steel sheets of a cut core are bonded satisfactorily, protrusions of a magnetic pole can also be fabricated in a laminated structure.
2. Protrusions are joined together magnetically but are isolated electrically, so losses can be reduced without degrading the characteristics of the bearing. That is, using cut cores, the protrusions of magnetic poles can also be made of laminated steel sheets, resulting in a reduction of iron losses.
3. A wider selection of types of electromagnetic steel sheets becomes possible, and amorphous materials that are difficult to laminate can also be used for the magnetic poles.

[0063] Therefore, the stator core for a magnetic bearing and the method of manufacturing it according to the present invention can be composed of laminated steel sheets even if the stator cores are provided with protrusions extending in the circumferential direction; in addition, laminated steel sheets can be prevented from becoming detached, crushed or peeled, so they can be efficiently cut and machined; furthermore, an amorphous material that is difficult to laminate can be used as a raw material; consequently, the cost of manufacturing and machining the stator cores can be reduced, while the eddy currents generated in the stator unit can also be greatly reduced, which are excellent advantages in practice.

[0064] The present invention provides stator cores for a magnetic bearing constructed in such a way that the utilization of materials is high, the work pieces can be machined with a high accuracy, and eddy currents are reduced to a minimum.

[0065] Although the present invention has been described referring to a preferred embodiment, it should be understood that the scope of rights included in the present invention is not restricted only to this embodiment. Conversely, the scope of rights of the present invention should include all improvements, modifications and equivalent entities that belong to the scope of the attached claims.

Claims

1. Arrangement of stator cores and a rotor for a homopolar magnetic bearing,
said stator cores (10) surrounding said rotor (3), each of said stator cores (10) having two toothed ends forming an N pole and an S pole adjacent to each other in an axial direction of said rotor (3), and
each of said stator cores (10) comprising U-shaped laminated sheets which are laminated one upon the other and shaped into a letter "U" of which the center side is open when viewed from the center line side extending in axial direction of said rotor (3),
each of said toothed ends including two protrusions (11) extending in opposite circumferential directions of said rotor,
characterized in that
each of said protrusions (11) is an integral part of the respective steel sheet and has a plane portion so that the plane portions of the protrusions (11) of the stator cores (10) are in contact with the plane portions of the protrusions (11) of adjacent stator cores (10),
the sheets are steel sheets laminated in radial direction and interleaved with an insulating material.

2. The arrangement specified in claim 1,
characterized in that
the U-shaped laminated steel sheets are cut cores (12) that are fabricated by winding a continuous steel sheet (12a) coated with an insulating material into a rectangular shape, and forming and cutting the rectangle into two equal portions.

3. A method of manufacturing an arrangement of stator cores according to claim 1 or 2, comprising:

    a forming step wherein cut cores (12) are fabricated by winding a continuous steel sheet coated with an insulating material into a rectangular shape, and forming and cutting the rectangular into two equal portions,
    a coil assembling step (B) wherein coils are installed on the cut cores (12),
    a core assembling step (C) wherein a plurality of the cut cores are positioned at prescribed locations, and
    an inside cutting step (D) wherein the insides of the toothed ends of the plurality of cut cores (12) are cut at the assembled locations, wherein
    the forming step includes an outside machining step (A) wherein the outsides of the cut cores (12) are machined and protrusions (11) at the toothed ends are left unmachined, and
    the coil assembling step (B) includes installing the coils on the cut cores (12) of which the outsides have been machined.

4. A method of manufacturing an arrangement of stator cores according to claim 1 or 2 comprising:

    an inside cutting step (E) wherein a plurality of cut cores (12) that have been fabricated by winding a continuous steel sheet coated with an insulating material into a rectangular shape, and forming and cutting the rectangle into two equal portions are positioned at prescribed locations and the insides of the toothed ends of the cut cores are cut, and
    a coil assembling step (G) wherein coils are installed onto the plurality of cut cores wherein
    an outside machining step (F) is provided wherein the outside of the plurality of cut cores are machined but protrusions (11) at the toothed ends are left unmachined, and
    the coil assembling step (G) includes installing coils onto the plurality of cut cores of which the outsides have been machined.

Patentansprüche

1. Anordnung von Statorkernen und einem Rotor für ein homopolares Magnetlager,
wobei die Statorkerne (10) den Rotor (3) umgeben,
wobei jeder der Statorkeme (10) zwei gezahnte Enden hat, die einen N-Pol und einen S-Pol benachbart zueinander in einer axialen Richtung des Rotors (3) ausbilden, und
wobei jeder der Statorkerne (10) U-förmige geschichtete Bleche aufweist, welche eines auf dem anderen geschichtet sind und in Form des Buchstaben U" ausgebildet sind, von welchem die mittlere Seite offen ist, gesehen von der Mittelllinienseite, die sich in axialer Richtung des Rotors (3) erstreckt,
wobei jedes der gezahnten Enden zwei Auskragungen (11) umfasst, die sich in entgegengesetzten Umfangsrichtungen des Rotors erstrecken,
dadurch gekennzeichnet, dass
jede der Auskragungen (11) ein integraler Teil des jeweiligen Stahlbleches ist und einen ebenen Bereich hat, so dass die ebenen Bereiche der Auskragungen (11) der Statorkeme (10) in Kontakt mit den ebenen Bereichen der Auskragungen (11) von benachbarten Statorkemen (10) sind,
wobei die Bleche Stahlbleche sind, die in radialer Richtung geschichtet sind und mit einem isolierenden Material dazwischen ausgebildet sind.

2. Die Anordnung nach Anspruch 1,

dadurch gekennzeichnet, dass
die U-förmigen geschichteten Stahlbleche geschnittene Kerne (12) sind, die durch Wickeln eines fortlaufenden Stahlbleches (12a), das mit einem isolierenden Material beschichtet ist, in einer rechteckigen Form, und durch Ausbilden und Schneiden des Rechteckes in zwei gleiche Abschnitte hergestellt sind.

3. Ein Verfahren zum Herstellen einer Anordnung von Statorkernen gemäß Anspruch 1 oder 2, welches aufweist:

   einen Ausbildungsschritt, wobei geschnittene Kerne (12) durch Wickeln eines fortlaufenden Stahlbleches, das mit einem isolierenden Material beschichtet ist, in einer rechteckigen Form, und Ausbilden und Schneiden des Rechteckes in zwei gleiche Abschnitte hergestellt werden,
   einen Spulenaufbauschritt (B), wobei Spulen an den geschnittenen Kernen (12) installiert werden,
   einen Kernaufbauschritt (C), wobei eine Mehrzahl von geschnittenen Kernen an vorgeschriebenen Stellen positioniert werden, und
   einen Innenschneideschritt (D), wobei die Innenseiten der gezahnten Enden der Mehrzahl von geschnittenen Kernen (12) an den aufgebauten Stellen geschnitten werden, wobei
   der Ausbildungsschritt einen Außenbearbeitungsschritt (A) umfasst, wobei die Außenseiten der geschnittenen Kerne (12) bearbeitet werden und Auskragungen (11) an den gezahnten Enden unbearbeitet belassen werden, und
   der Spulenaufbauschritt (B) ein Installieren der Spulen auf den geschnittenen Kernen (12), von welchen die Außenseiten bearbeitet worden sind, umfasst.

4. Ein Verfahren zum Herstellen einer Anordnung von Statorkemen gemäß Anspruch 1 oder 2, welches aufweist:

   einen Innenschneideschritt (E), wobei eine Mehrzahl von geschnittenen Kernen (12) die durch Wikkeln eines fortlaufenden Stahlbleches, das mit einem isolierenden Material beschichtet ist, in einer rechtekkigen Form, und Ausbilden und Schneiden des Rechteckes in zwei gleiche Abschnitte hergestellt wurden, an vorgeschriebenen Stellen positioniert werden und die Innenseiten der gezahnten Enden der geschnittenen Kerne geschnitten werden, und
   einen Spulenaufbauschritt (G), wobei Spulen auf der Mehrzahl von geschnittenen Kernen installiert werden, wobei
   ein Außenbearbeitungsschritt (F) vorgesehen ist, wobei die Außenseite der Mehrzahl von geschnittenen Kemen bearbeitet wird, aber Auskragungen (11) an den gezahnten Enden unbearbeitet belassen werden, und
   der Spulenaufbauschritt (G) ein Installieren von Spulen auf der Mehrzahl von geschnittenen Kemen, von welchen die Außenseiten bearbeitet worden sind, umfasst.

Revendications

1. Agencement de noyaux statoriques et d'un rotor pour un palier magnétique homopolaire,
   lesdits noyaux statoriques (10) entourant ledit rotor (3), chacun desdits noyaux statoriques (10) comprenant deux extrémités à dents formant un pôle N et un pôle S adjacents l'un à l'autre dans une direction axiale dudit rotor (3), et
   chacun desdits noyaux statoriques (10) comprenant des feuilles en acier stratifiées en U qui sont stratifiées l'une sur l'autre et formées en U dont le côté central est ouvert quand il est vu depuis le côté de la ligne centrale s'étendant dans la direction axiale dudit rotor (3),
   chacune desdites extrémités à dents comprenant deux protubérances (11) s'étendant dans des directions circonférentielles opposées dudit rotor,
   caractérisé en ce que :

   chacune desdites protubérances (11) fait partie intégrante de la feuille d'acier respective et comporte une partie plane de telle sorte que les parties planes des protubérances (11) des noyaux statoriques (10) sont en contact avec les parties planes des protubérances (11) des noyaux statoriques (10) adjacents,
   les feuilles sont des feuilles d'acier stratifiées dans une direction radiale et intercalées avec un matériau isolant.

2. Agencement selon la revendication 1, **caractérisé en ce que** :

   les feuilles d'acier stratifiées en U sont des noyaux découpés (12) qui sont fabriqués en enroulant une feuille d'acier continue (12a) revêtue d'un matériau isolant en forme rectangulaire, et en formant et découpant le rectangle en deux parties égales.

3. Procédé de fabrication d'un agencement de noyaux statoriques selon la revendication 1 ou 2, comprenant :

   une étape de formation dans laquelle les noyaux découpés (12) sont fabriqués en enroulant une feuille d'acier continue revêtue d'un matériau isolant en forme rectangulaire, et en formant et

découpant le rectangle en deux parties égales, une étape d'assemblage de bobine (B) dans laquelle les bobines sont installées sur les noyaux découpés (12),
une étape d'assemblage de noyau (C) dans laquelle une pluralité des noyaux découpés sont positionnés en des endroits prescrits, et
une étape de découpe intérieure (D) dans laquelle les parties intérieures des extrémités à dents de la pluralité de noyaux découpés (12) sont découpées aux emplacements assemblés, dans lequel :

l'étape de formation comprend une étape d'usinage extérieur (A) dans laquelle les parties extérieures des noyaux découpés (12) sont usinées et les protubérances (11) sur les extrémités à dents sont laissées non usinées, et
l'étape d'assemblage de bobine (B) comprend l'installation des bobines sur les noyaux découpés (12) dont les parties extérieures ont été usinées.

4. Procédé de fabrication d'un agencement de noyaux statoriques selon la revendication 1 ou 2, comprenant :

une étape de découpe intérieure (E), dans laquelle une pluralité de noyaux découpés (12) qui ont été fabriqués en enroulant une feuille d'acier continue revêtue de matériau isolant dans une forme rectangulaire, et en formant et en découpant le rectangle en deux parties égales sont positionnés en des endroits prescrits et les parties intérieures des extrémités à dents des noyaux découpés sont découpées, et
une étape d'assemblage de bobine (G) dans laquelle les bobines sont installées sur une pluralité de noyaux découpés,
dans lequel :

une étape d'usinage extérieur (F) est prévue, dans laquelle la partie extérieure de la pluralité de noyaux découpés est usinée, mais les protubérances (11) sur les extrémités à dents sont laissées non usinées, et
l'étape d'assemblage de bobine (G) comprend l'installation des bobines sur la pluralité de noyaux découpés dont les parties extérieures ont été usinées.

Fig.1A
PRIOR ART

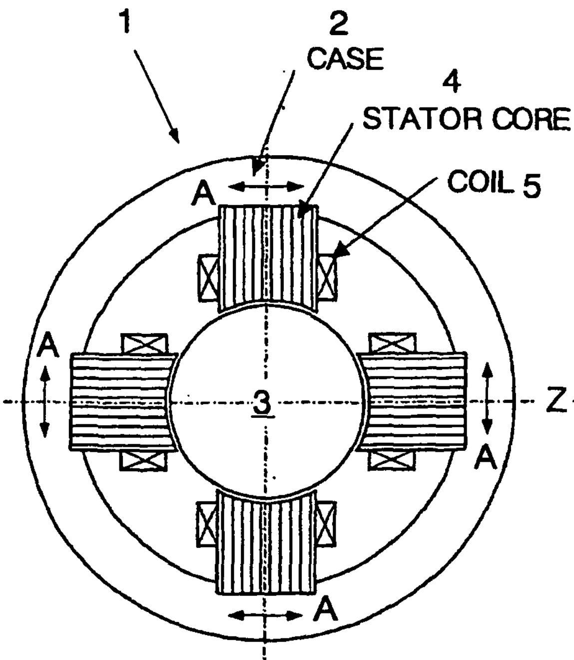


Fig.1B
PRIOR ART

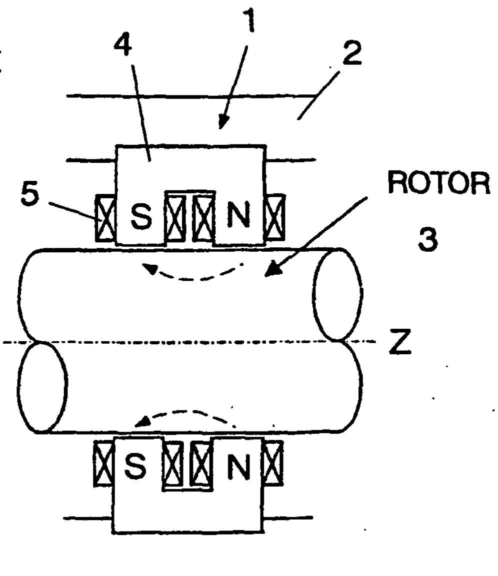


Fig.1C
PRIOR ART

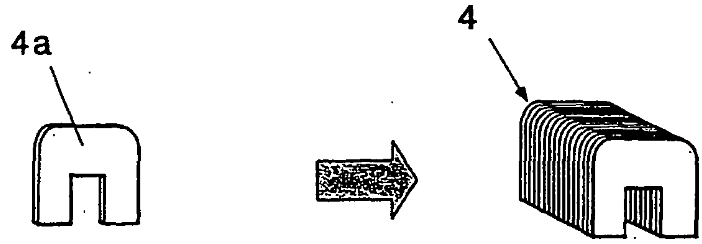


FIG.2A

PRIOR ART

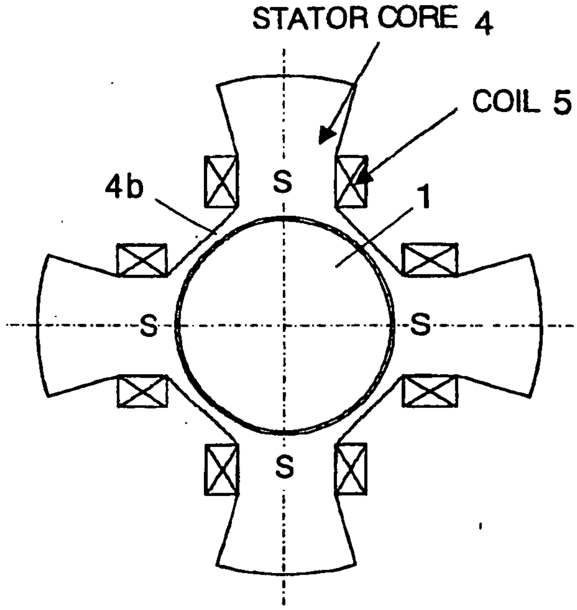


FIG.2B

PRIOR ART

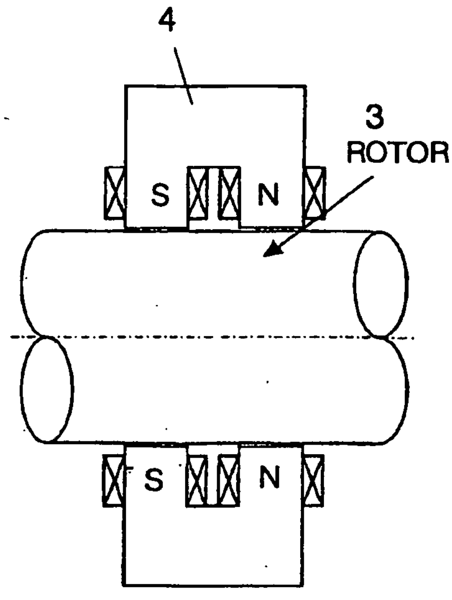


FIG.3

PRIOR ART

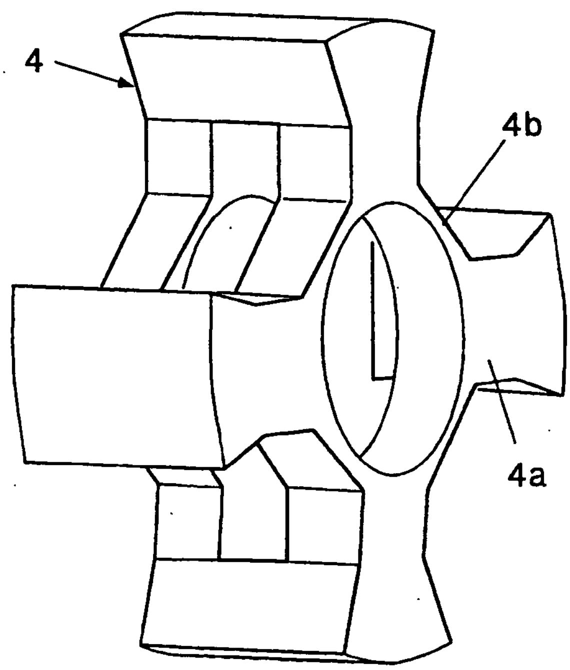


Fig.4a
PRIOR ART

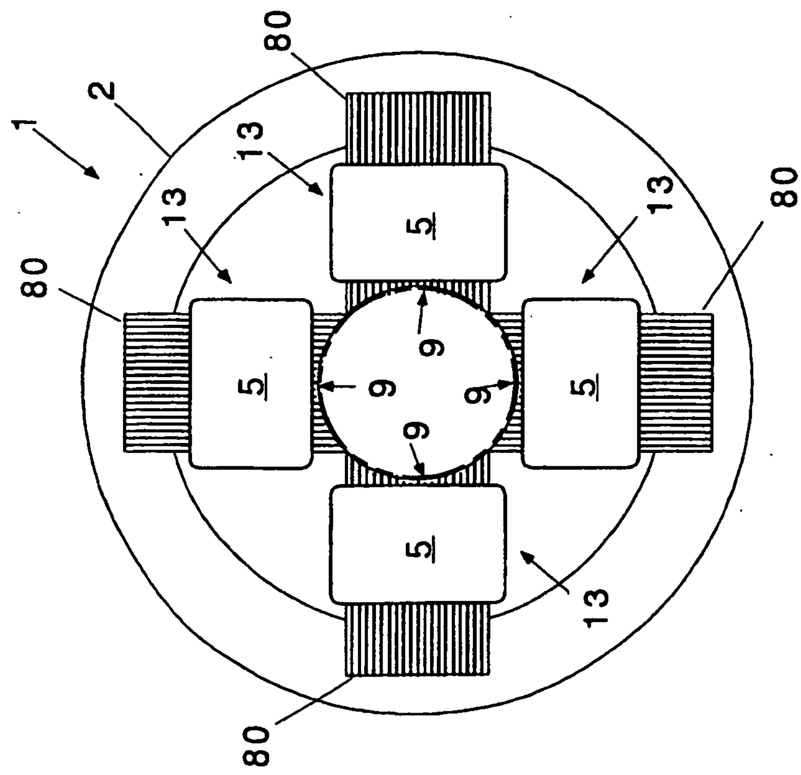


Fig.4b
PRIOR ART

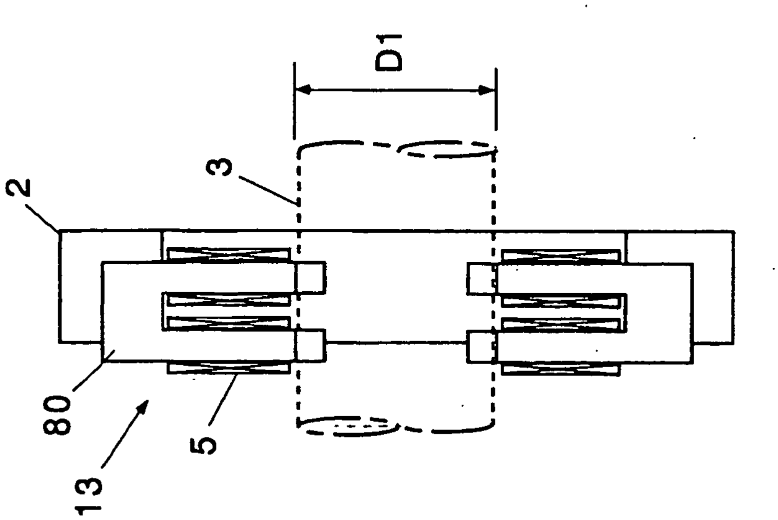


FIG.5
PRIOR ART

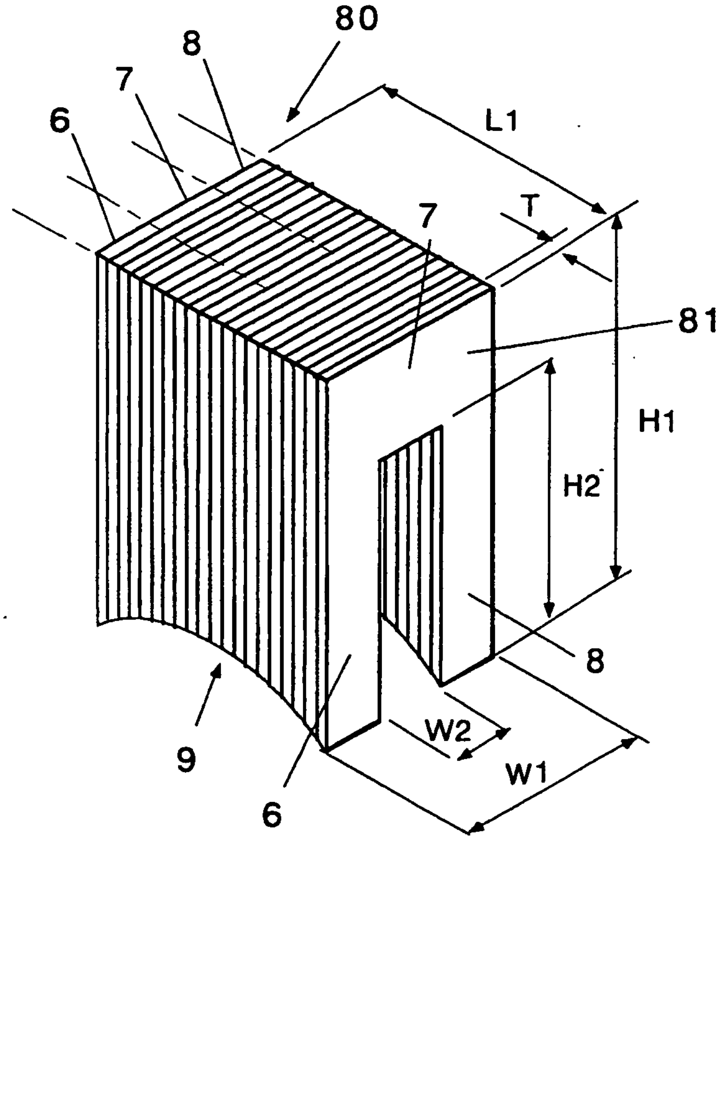


Fig.6A

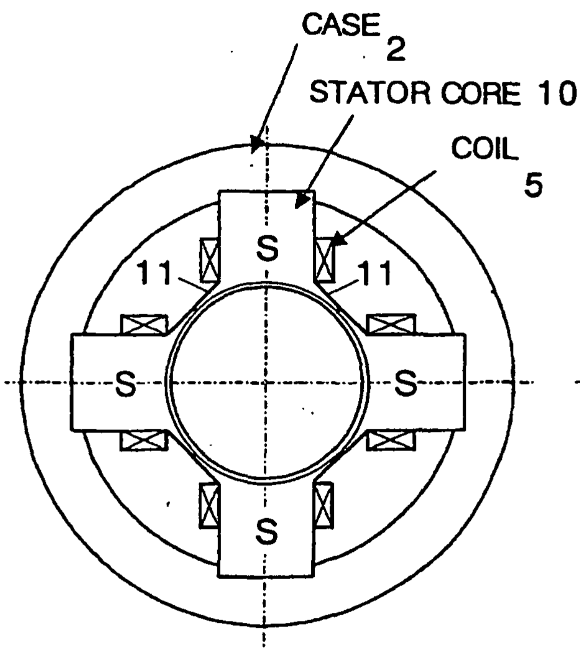


Fig.6B

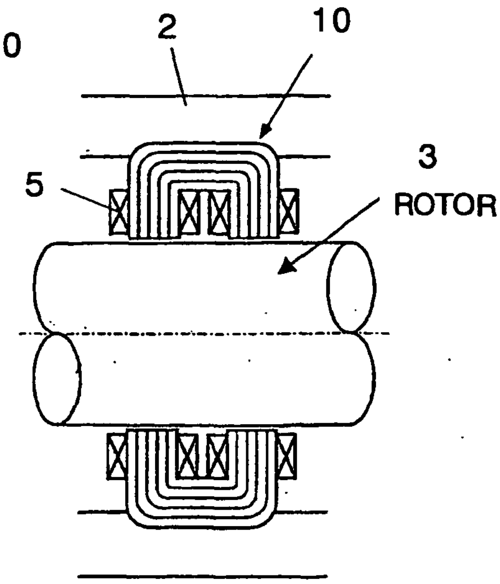


Fig.6C

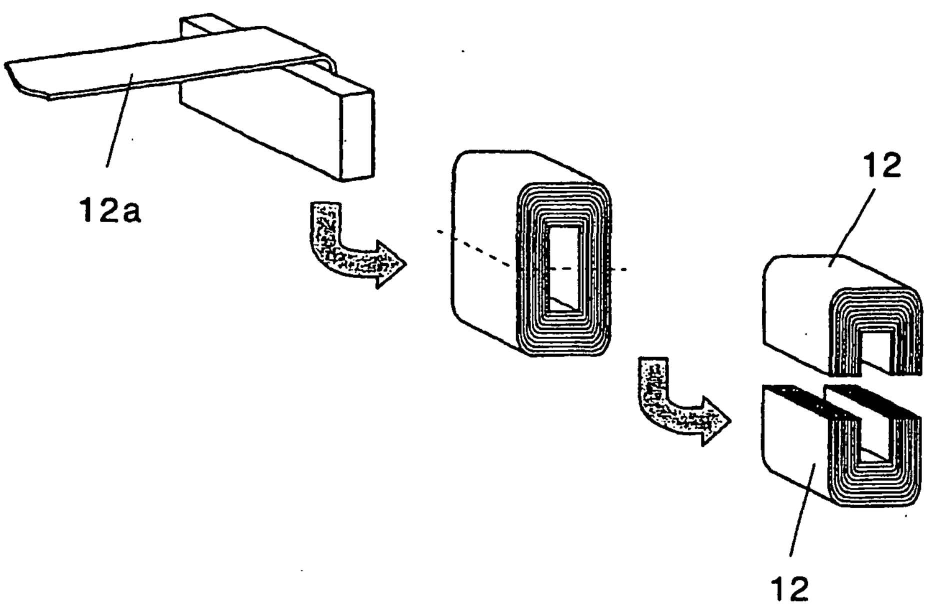


Fig.7A

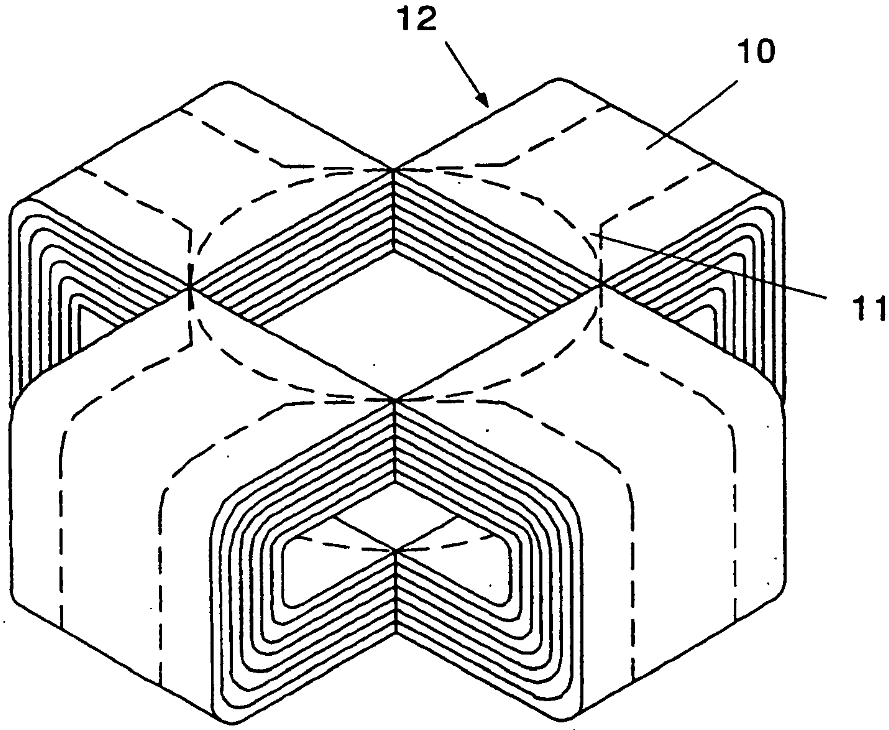


Fig.7B

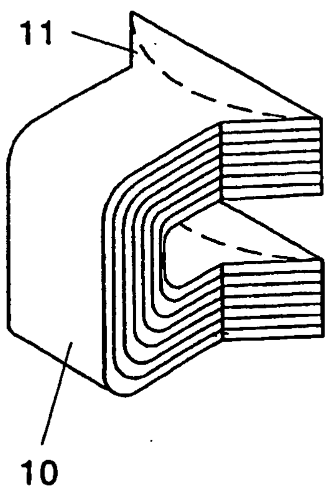


Fig.7C

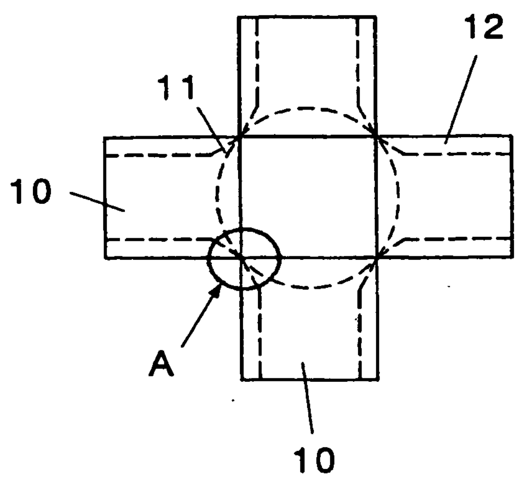


Fig.8A

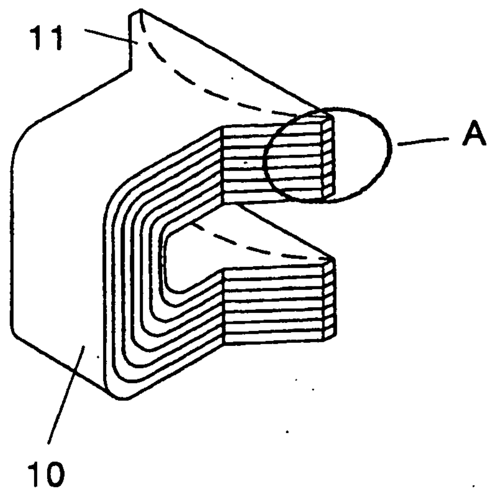


Fig.8B

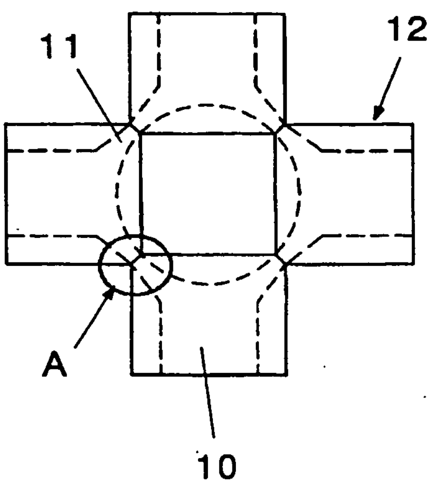


Fig.9

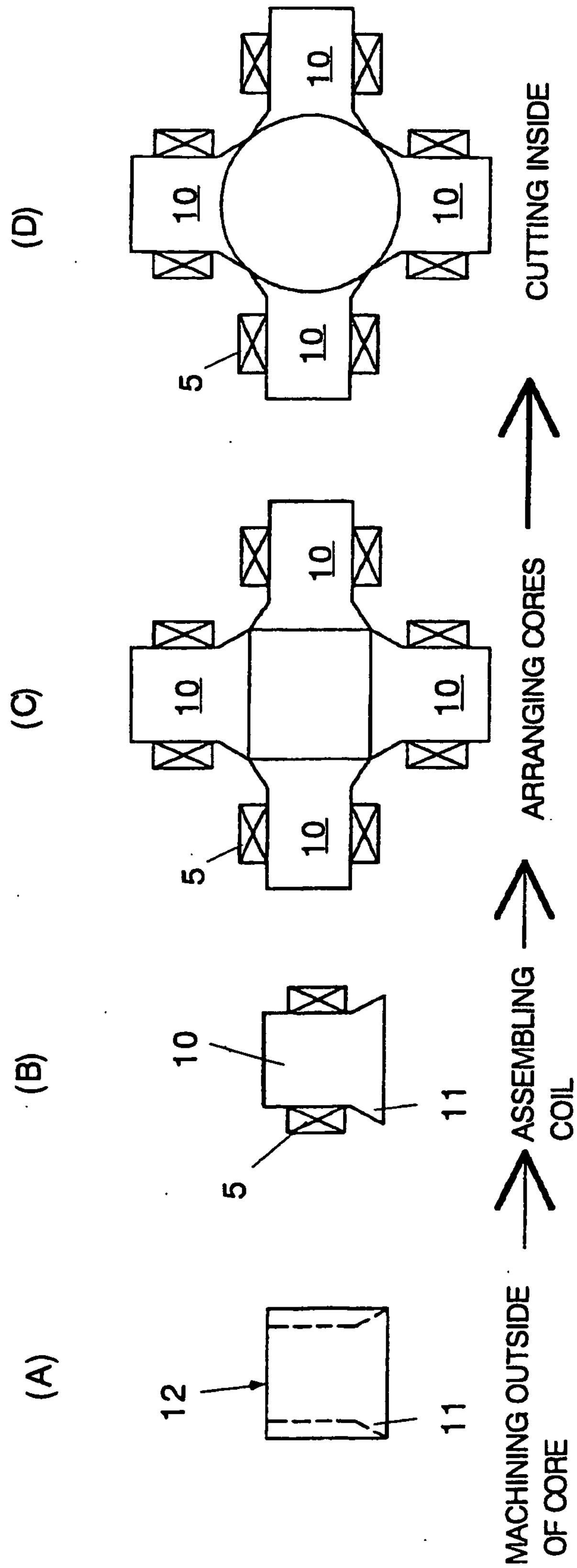
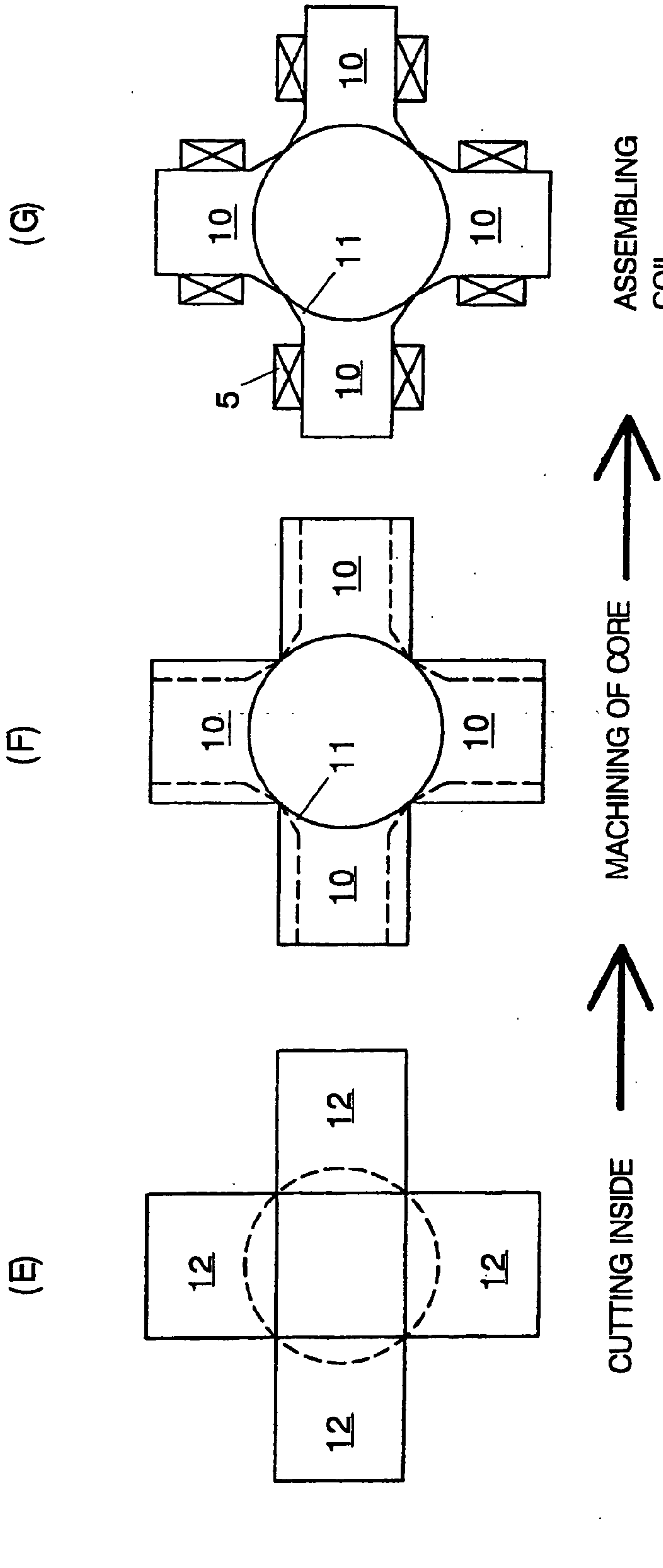

(A)
12
11
MACHINING OUTSIDE OF CORE
(B)
10
5
11
ASSEMBLING COIL
(C)
10
5
ARRANGING CORES
(D)
10
5
CUTTING INSIDE

Fig.10


(E)
(F)
(G)
12
12
12
12
10
10
10
10
11
5
CUTTING INSIDE
MACHINING OF CORE
ASSEMBLING
COIL