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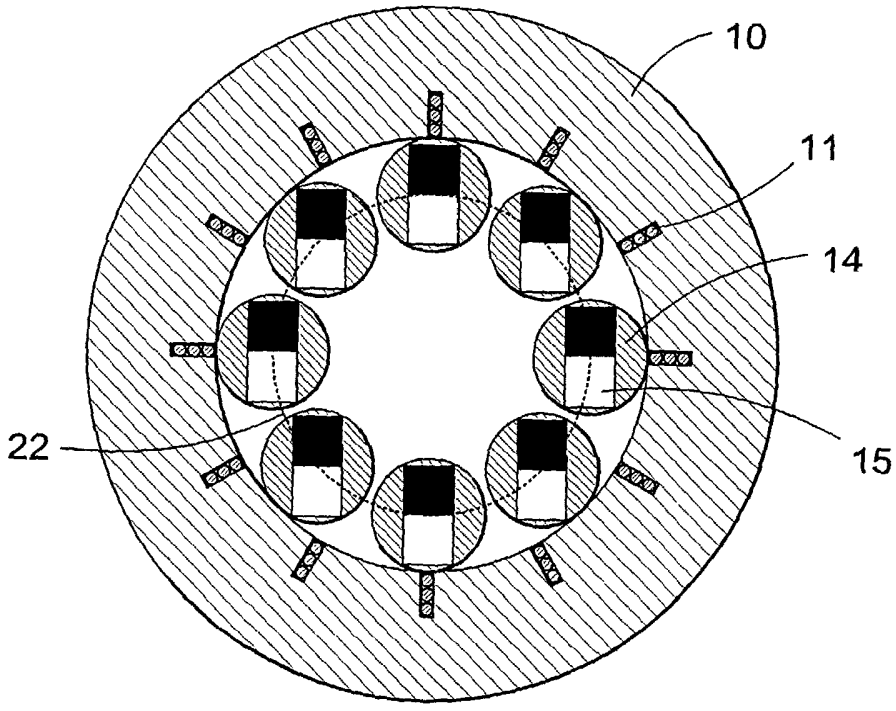
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(54) Title: ELECTRICAL MACHINE



(57) Abstract: The invention relates to an electrical machine having a first magnetic core provided with winding, and a flux-generating device comprising at least two flux-generating variable magnetic flux elements. These are arranged to vary the flux locally so that the local flux variation can be described by a magnetization vector that moves in substantially one plane. The application also relates to a method and a device for controlling magnetic flux in such an electrical machine. The invention also relates to the use of such a machine and a system including such a machine.

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ELECTRICAL MACHINE

Technical field

The present invention relates to an electrical machine comprising a first magnetic core provided with winding, and at least one flux-generating device, the latter comprising at least two flux-generating variable magnetic flux elements. The flux elements are arranged to vary the flux locally in such a way that, seen from a fixed point in the flux-generating device, the local flux variation can be described by a flux vector describing that moves in substantially one plane. The present application also relates to a method and a device for controlling magnetic flux in such an electrical machine.

Background art

In many electrical machines it is of particular interest to adjust the mechanical angular frequency to the electric angular frequency. If a higher frequency is desired, this can be obtained by increasing the number of poles in the machine which, in turn, results in increased diameter and thus a larger and heavier machine. A larger machine is also more expensive. An example of a machine where it is desirable to increase the frequency may be a generator for a wind power plant. A conventional wind-driven generator may, for instance, comprise a transmission box which increases the rotational speed of the wind turbine in order to drive a standard generator for producing a low-voltage alternating current.

One problem with wind power plants is the final assembly, since heavy components must be mounted safely on site. Heavy components place high demands on transport, strength and stability of the construction, thereby incurring increased costs. It is therefore of particular interest to keep down the weight in a wind power plant.

In step-motor applications a strong motor is desired, with precise control of the position of the motor. Today's step-motors can only manage some tens of Nm. Another problem is that the precision is not sufficiently exact and many applications require exact positioning of the motor with the aid of sensors and feedback.

Monophase generators can be used for direct operation for track feeding. Today's generators require a complicated rotor design to enable them to generate singe phase for the tracking supply. The generally low frequency used for track supply is another complicating factor.

In electrical machines it is important to control the flux of the machine in order to obtain an optimal torque and to minimize stray flux and thus losses. If the flux-generating elements of the machine are provided with permanent magnets it is extremely important to make optimal use of the active flux of the magnets.

In machines having several rotating flux-generating magnetic elements, which give a complicated flux image, considerable demands are placed on control of the machine flux. In electrical machines where the rotating flux-generating elements are placed in the air gap of the machine, the greatest active flux is obtained through the machine cores in the position when the magnets of the flux elements are directed perpendicularly to the surface of the cores. The flux then decreases as the magnets are rotated, reaches zero when the magnets are directed along the surface of the core, and then starts to increase again. A flux is thus obtained in the machine which deviates from an ideal sinus-shaped flux wave. Harmonics and other fluctuations in the flux gives rise to torque pulsations and stray fluxes, which result in power stresses and losses. An important feature in this type of electrical machine is to obtain as large an active flux as possible per time unit when the flux is commutated from one rotating flux-generating element to the next.

Patent specification WO 0006 5708 shows an electric generator having a number of separate electrical machines permanently mounted along its periphery. Purely electromagnetically these machines constitute a number of separate, smaller generators with a local flux around each. The machine obtains no common global flux from the smaller generators.

Patent specification SU 1676013 shows an electrical machine in which a number of screening pole motors are placed along the periphery of the machine. The motors are not connected with each other. Each individual motor is provided with a core and a winding. The flux induced in each motor contributes to a total flux directed along the periphery.

Patent specification BE 870 395 shows an electric generator. This generator comprises an outer non-magnetic core provided with a winding and a plurality of internal rotors provided with permanent magnets. The excitation directions of the permanent magnets are kept constant in relation to the direction of the field from the winding and the excitation direction is thus kept constant in relation to the magnetic axis of said winding. The field direction is always constant in relation to the physical direction of the winding. The described functionality of the device shown can be called in question since the alleged

torque transmitting force is probably counteracted by an equivalent reaction force fed back via the magnetic field.

A known concept is the Hallbach cylinder which is used primarily for flux concentration of magnetic fields in air. Embodiments of the Hallbach cylinder also exist in which the flux concentration pulses along a specific axis.

Patent specification FR 22118675 shows a type of motor consisting of a number of motors connected together in a ring to form an arrangement with a single "output shaft". This motor is described as having rotors that generate a toroid-shaped substantially pulsing flux. Each rotor generates a flux that cooperates with the nearest rotor between which a winding is placed. The common flux is connected through all rotors included in the machine. A multiphase machine of this design requires several toroid-shaped fluxes not combined, which are axially separated from each other.

All the publications mentioned above describe monophase machines with two poles. None of them describes a machine with a common, global rotating flux linked between the components. Neither do the shown constructions describe several flux generating components connected to one and the same magnetic core in such a manner that a multiphase system can be obtained. Furthermore, none of them shows the possibility of varying the number of poles in a simple manner with the same mechanical construction thus obtaining, for instance, a variable and flexible frequency by means of simultaneous external switching of the stator winding.

The invention in accordance with the present application relates to providing a compact and flexible electrical machine for a broad power range, which solves the problems mentioned above, and to providing a flux-conducting element that conducts and controls the flux in machines of the type mentioned above with a view to improving the flux image and thus utilizing the machine flux better.

Brief description of the invention

The present application relates to a compact electrical machine with great flexibility as regards the frequency at which alternating current is generated or consumed. Furthermore the invention enables provision of an electrical machine in which the reluctance of the flux-generating flux elements in the machine are varied regularly during operation. This variation in reluctance is utilized to exactly control the movement and positioning of the flux-generating device, thereby offering considerable advantages in many applications, such as step-motor operation. The construction described in the present application also allows

movement of the flux-generating device of the machine in at least two different types of movement, thereby giving a flexible machine with more grades of freedom than conventional machines. This offers entirely new possibilities for designing electromagnetic machines.

The present application also relates to a method and a device for controlling magnetic flux in such an electrical machine. One of the objects is to obtain as large an active flux as possible per time unit from each magnetic flux-generating element. A more uniform reluctance is also obtained over a certain period. The method improves the curve shape of the flux and gives more uniform operation with fewer torque pulsations and stray fluxes, and thus higher efficiency. The number of states of equilibrium per revolution is doubled in a rotating magnetic flux-generating element.

Description of embodiments

In a preferred embodiment the number of poles in the machine is determined by the relative angular difference between the magnetic axes of the flux elements.

In another preferred embodiment the global travelling flux is at least bipolar.

In a preferred embodiment the machine comprises several cores. In another preferred embodiment more than one core is provided with a winding.

In a preferred embodiment said flux elements are arranged between the first and the second cores. In another preferred embodiment said flux elements are arranged to take up forces in several directions.

In a preferred embodiment said flux elements are arranged to rotate in a local rotary movement about their axes of rotation with the same or different directions of rotation. The individual angular velocity of the flux elements in this local rotary movement may be the same or different.

In yet another preferred embodiment the machine comprises means for movement of said flux elements, the axes of rotation of the flux elements following a global rotary movement about said machine shaft. This means for movement may be a toothed wheel, for instance.

In a preferred embodiment the means for movement of said flux elements is arranged so that each flux element in its local rotation obtains varying angular velocity. This feature can be exploited when the machine is operating as either motor or generator. The angular velocity of each flux element will be highest when the flux element passes a pole which gives a higher flux alteration per time

unit. Depending on the variation in angular velocity, a more or less pulse-shaped voltage with increased peak value is obtained for a generator.

In another preferred embodiment the axes of rotation of the flux elements are peripherally displaced in relation to each other.

In a preferred embodiment the flux elements comprise permanent magnets. The permanent magnets may be made of one of the following materials: Steel, AlNiCo, Ba, Sr-ferrites, Sm(Fe,Co), SmCo, SmFeN, NdFeB and nanocomposite permanent magnets.

In another preferred embodiment of the machine in accordance with the present application the flux elements in the machine are excited asynchronously. In this embodiment each of the flux elements is provided with a squirrel cage winding. In two more preferred embodiments the magnetic flux elements may comprise field windings or may be made of soft magnetic material. In a further preferred embodiment the machine also comprises means for varying the magnetic flux of the magnetic flux mechanically or magnetically.

In a preferred embodiment the magnetic flux elements are arranged so that their time variations are correlated.

The excitation directions of the flux elements may be varied around the periphery of the machine. The machine may be either monophase or multiphase.

In a preferred embodiment the invention can be used as step-motor. This construction gives considerably stronger step-motors than those in current use which can only manage some tens of Nm. To obtain the desired features of a step-motor the design of the motor is optimized to obtain a high starting torque. The design in accordance with the present invention enables production of very large step-motors. A step-motor in accordance with the present invention can be used in applications that currently require a large motor with analogue feedback control. An advantage with a step-motor in accordance with the present invention is that it does not necessarily consume power in stationary loaded position as conventional step-motors do for the most part. The invention described in the present application provides step-motors having great precision in all sizes.

In a preferred embodiment the machine comprises several cores. One or more cores are arranged to rotate in one embodiment. In another embodiment more than one core is provided with a winding.

In a preferred embodiment said flux elements are arranged between the first and the second cores.

The excitation directions of the flux elements may be varied around the periphery of the machine. The flux elements can transmit movement and/or absorb forces in several directions, such as a radially directed force.

In a preferred embodiment the present invention relates to at least one electrical machine comprising a magnetic core as well as at least one winding and at least one machine shaft. The rotor of the machine comprises at least one or more magnetic flux elements arranged radially displaced in relation to said machine shaft. The flux elements are connected to said machine shaft. The flux elements generate a substantially axially directed flux in said core. Said flux elements are arranged to rotate in a local rotary movement about their axes of rotation with the same or different directions of rotation. The individual angular velocity and direction of rotation of the flux elements in this local rotary movement may be the same or different.

In a preferred embodiment the core of the machine is arranged so that the machine flux is connected via the flux elements.

In yet another preferred embodiment the machine comprises means for movement of said flux elements such that the axes of rotation of the flux elements follow a global rotary movement about said machine shaft. This means for movement may be a toothed transmission gear, for instance.

In another preferred embodiment said winding is circular and is placed in the core. The winding surrounds the axis of rotation of the machine in another embodiment.

In yet another preferred embodiment the machine core is shaped as a cylinder with a peripheral groove. The winding and the magnetic flux elements may be arranged in this groove.

If the machine comprises two or more magnetic flux elements the core may, in a preferred embodiment, comprise a first and a second cylinder which are placed concentrically in relation to each other. In another preferred embodiment the winding is arranged between the first and second cylinders of the core. In yet another preferred embodiment the flux in the machine is connected via flux elements placed between the cylinders of the core.

In yet another preferred embodiment the axis of rotation of the rotor coincides with that of the machine shaft.

In another preferred embodiment the core is arranged coaxially in relation to the rotor.

In a further preferred embodiment the machine core is divided into magnetically separated circuits.

In another preferred embodiment the core is sectioned into circle sectors. This can be obtained, for instance by radial cuts in the core.

The flux elements can transmit movement and/or absorb forces in several directions, e.g. a radially directed force.

In yet another preferred embodiment the axes of rotation of the magnetic flux elements are peripherally displaced in relation to each other.

In a preferred embodiment the flux elements comprise permanent magnets. The permanent magnets may, for instance, be made of one of the following materials: Steel, AlNiCo, Ba, Sr-ferrites, Sm(Fe,Co), SmCo, SmFeN, NdFeB and nanocomposite permanent magnets.

In yet another preferred embodiment of the machine in accordance with the application the flux elements in the machine are excited asynchronously. In this embodiment each of the flux elements is provided with a squirrel cage winding.

In two more preferred embodiments the flux elements may comprise field windings or may be made of soft magnetic material. In a further preferred embodiment the machine also comprises means for varying the magnetic flux of the magnetic flux mechanically or magnetically.

The application also relates to a method and a device for controlling magnetic flux in an electrical machine. The invention is particularly intended for use in electrical machines comprising a flux-generating device with at least two rotating magnetic flux-generating elements. The flux from said magnetic flux-generating elements is superposed to a resultant global flux for the machine. One of the aims of the invention is to obtain as large an active flux as possible per time unit from each magnetic flux-generating element. A more uniform reluctance is also obtained over a certain period. The method improves the curve shape of the flux and gives more uniform operation with fewer torque pulsations and stray fluxes, and thus higher efficiency. The number of states of equilibrium per revolution is doubled in a rotating magnetic flux-generating element.

The machine in which the present invention is intended to be used comprises at least two rotating flux-generating elements. The flux-generating elements are arranged to rotate in a local rotary movement about their axes of rotation. The local flux elements generate a global magnetic flux in the machine cores.

The machine in which the invention is intended to be used may be either a rotating or a linear electrical machine. In the case of a rotating electrical machine this may be a motor, step-motor, pulse generator, wind-power generator or frequency converter, for instance. In the case of a linear machine it may be a motor, step-motor, generator, pulse generator or generator for a wave-power plant, for instance.

Brief description of the drawings

Figure 1 shows a basic layout sketch of the machine in accordance with the invention having an external core provided with winding.

Figure 2 shows the flux path in a machine as illustrated in Figure 1.

Figure 3 shows a basic layout sketch of the machine in accordance with the invention having an internal core provided with winding.

Figure 4 shows a basic layout sketch of an embodiment having double cores.

Figure 5 shows a another embodiment of the invention with double cores provided with windings, and in which the flux elements are provided with squirrel cage windings for asynchronous operation.

Figure 6 shows a view in perspective of a preferred embodiment of the machine described in the application.

Figure 7 shows the means for movement of the flux elements, arranged so that the local rotation of the flux elements 14 in the machine is effected with varying angular velocity during the rotation.

Figure 8 shows a preferred embodiment where the machine is used as generator in a wind power plant.

Figure 9 shows the magnetic flux in the machine in a preferred embodiment, in this case a bipolar machine.

Figure 10 shows the magnetic flux in the machine in yet another preferred embodiment, in this case a four-polar machine.

Figure 11 shows the magnetic flux of the machine in a preferred embodiment, in this case a multipolar machine.

Figure 12 shows the operating principle for a step-motor designed in accordance with the present invention.

Figure 13 shows the fundamental principle of frequency conversion in an electrical machine in accordance with the present invention.

Figure 14 shows frequency conversion in a preferred embodiment of an electrical machine in accordance with the present invention.

Figure 15 shows one embodiment of a flux element.
The flux elements can transmit movement and/or absorb forces in several directions, e.g. a radially directed force.

Figure 16 shows a basic layout sketch of a preferred embodiment of the invention.

Figure 17 shows a preferred embodiment where the machine is used as generator in a wind power plant.

Figure 18 shows the path of the magnetic flux from one magnetic flux-generating element to the next.

Figure 19 shows the path of the magnetic flux when the flux-generating elements have been rotated a quarter of a revolution from the position shown in Figure 1.

Figure 20 shows the path of the magnetic flux when the flux-generating elements have been rotated half a revolution from the position shown in Figure 1.

Figures 21 and 22 shows an embodiment of the invention in which the magnetic flux elements are directed so that passive flux conductors are required as feedback conductors.

Detailed description of preferred embodiments

Figure 1 shows a basic layout sketch of a preferred embodiment of the invention described in the present application. A core 10, in this embodiment an external core in the form of a hollow cylinder, provided with a winding 11, surrounds a machine shaft and a number of magnetic flux elements 14, shown here with circular cross section. The flux elements 14, provided with permanent magnets 15, are arranged between the core and a support device 22, preferably of non-magnetic material, which may consist of a gear rim. The excitation directions of the permanent magnets are arranged in various ways. The movements of the flux elements are correlated.

In Figure 2 the flux lines 19 indicate the flux path in a machine as illustrated in Figure 1.

Figure 3 shows a basic layout sketch of another preferred embodiment of the invention described in the present application. The machine comprises a core 10, in this embodiment an internal, homogenous core, provided with a winding 11. It also comprises a machine shaft and a number of magnetic flux elements 14. The flux elements 14, provided with permanent magnets 15, are arranged between the core and a support device 22, preferably of non-magnetic material. The excitation directions of the permanent magnets may be arranged in various ways. The movements of the flux elements are correlated.

Figure 4 shows another preferred embodiment of the machine described in the present application. A first core 10, provided with winding, surrounds a second core 12 (not provided with winding) which may be arranged to rotate. A number of flux elements 14 are arranged between the first and the second cores. The flux elements are provided with permanent magnets 15. The movements of the flux elements are correlated.

Figure 5 shows another preferred embodiment of the invention. The machine comprises a first core 10 and a second core 12, provided with windings

11 and 13, and also a number of flux elements 14 arranged between them. The core windings 11 and 13 may be arranged in several ways. The cores may be wound individually and the windings may then be connected in series or in parallel, or may be galvanically isolated. The cores may also be wound with a single common winding, this then being wound across the air gap 21. In the embodiment shown the flux elements are provided with squirrel cage winding 17 and are excited asynchronously. The movements of the flux elements are correlated.

Figure 6 shows a view in perspective of a preferred embodiment of the machine in accordance with the present application. The machine comprises a first core 10, in this embodiment in the form of a hollow cylinder, provided with a winding 11. In this embodiment it also comprises an inner core 12 arranged to rotate with a machine shaft. Between the first and second cores are one or more rotating magnetic flux elements 14. Said rotating flux elements are in this embodiment caused to rotate via individual gear rims or some other device with equivalent function driven by a corresponding device on the inner core. The element is thus caused to rotate about its own axis while simultaneously moving around the periphery of the inner core. The movements of the flux elements are correlated.

In Figure 7 the means for movement of the flux elements is arranged so that the local rotation of the flux elements 14 in the machine is effected with varying angular velocity. The angular velocity of each flux element will be highest when the flux element passes a pole, which gives a higher flux change per time unit, in turn inducing a higher voltage. The figure shows that driving of the flux element is obtained with the aid of an elliptical toothed wheel. Within the scope of the claims this effect is obtained in other ways, such as by the use of other non-circular shapes for the same purpose.

Figure 8 shows a preferred embodiment where the machine is used as generator in a wind power plant. The turbine vane 20 of the wind power plant is connected to the machine shaft which, in turn, is connected via a support 22 to a number of magnetic flux elements 14. Each of the flux elements 14 is arranged to rotate about its own axis. At the same time the flux elements move in a circular path about the machine shaft. In this embodiment the machine comprises a first core 10 provided with a first winding 11 and a second core 12 provided with a second winding 13. In this embodiment the first core is in the form of a hollow cylinder and surrounds the second core, also in the form of a hollow cylinder. Said flux elements 14 are provided with permanent magnets and are arranged between the first and second cores. The turbine vane is driven around, which

causes the flux elements 14 to move in a circular movement around the machine shaft and in a rotary motion, each about its own axis. The movements of the flux elements are correlated. These movements give rise to a rotating flux wave which induces an alternating voltage in each of the windings 11 and 13.

Figure 9 is a flux image illustrating the magnetic flux in the machine in a preferred embodiment. The flux elements are provided with permanent magnets 15. In this embodiment the machine is bipolar. The machine comprises a first core with a winding and a second core, as well as a number of flux elements 14 the excitation directions of which are the same. The movements of the flux elements are correlated and the flux from the flux elements therefore cooperates to form a global rotating bipolar flux in the machine. This is indicated in the figure by flux lines 19.

Figure 10 is a flux image illustrating the magnetic flux in the machine in another preferred embodiment. The flux elements are provided with permanent magnets 15. The excitation directions of the magnets in this embodiment are different and a multipolar machine is therefore obtained, in this case a four-polar machine. The movements of the flux elements are correlated and the flux from the flux elements thus cooperates to form a global rotating four-polar flux in the machine, as indicated in the figure by flux lines 19.

Figure 11a is a flux image illustrating the magnetic flux of the machine in a preferred embodiment. The flux elements are provided with permanent magnets 15. The excitation directions of the magnets in this embodiment are different and a multipolar machine is therefore obtained. The movements of the flux elements are correlated and the flux from the flux elements thus cooperates to form a global rotating multipolar flux in the machine, as indicated in the figure by flux lines 19.

Figure 11b shows the same embodiment as Figure 11a but at a different point in time when the magnets have assumed a different position.

The designs illustrated in Figures 10 and 11 are substantially identical, the relative excitation directions of the magnets being the only feature that differs.

Figure 12 shows the operating principle for a step-motor in accordance with the present invention. Figure 12a shows an example in which the flux elements 14 provided with permanent magnets 15 have assumed the position in which the flux elements of the magnetic circuit connects has lowest reluctance. The magnets are forced out of their positions by means of a magnetic field generated in the windings 11, 13. The figure shows two cores provided with windings but one of the cores may be constructed without a winding in a step-motor application. In order to initiate turning of the magnets the winding 11 is

somewhat asymmetrical. An asymmetrical current pulse determines in which direction the motor shall be turned one step. Due to the special design of the core the air gap increases during the actual transition phase, as is shown in Fig. 12b. This means that the magnets with less resistance are turned until they reach their next position, whereupon the reluctance again increases ensuring that the magnets are retained in this new position. The machine shaft of the motor has thus been turned one step. This step has high angular accuracy, which is exploited in order to turn the motor shaft with high precision. The step-motor can be constructed in such a way that no power need be supplied to retain the rotor in a locked position provided the load in question is less than a certain predetermined torque.

Figure 13a shows the fundamental principle of frequency conversion in a frequency converter in accordance with the present invention. A number of flux elements 14 are placed between a first fixed core 10 and a second fixed core 12, with a distance d between their centres, and provided with permanent magnets 15 arranged with alternating excitation directions. The permanent magnets 15 give rise to a flux in the first and second cores, respectively. In Figure 13b all the flux elements have been rotated a part of a turn in counter clockwise direction in the figure. The flux image in each core has thus changed and the flux pattern is therefore displaced in one direction in the first core and in the opposite direction in the second core. If a velocity v is simultaneously applied to the set of flux elements the flux pattern in the first core will acquire the velocity f_R*2d + v in one direction whereas the flux pattern in the second core will acquire the velocity f_R*2d - v in the other direction, where f_R is the rotation frequency of the flux elements. The flux wave obtained has thus a higher velocity in the first core than in the second one. The wave length, on the other hand, remains unchanged. The voltage variation induced in the first core thus acquires a frequency that differs from the frequency of the voltage variation induced in the second core. The frequency ratio between the induced voltages will be $f_1 : f_R = (f_R + v/2d) : (f_R - v2/d)$ where f_1 is the frequency in the first winding and f_2 is the frequency in the second winding. The flux-generating elements have thus created global travelling flux waves having the same wave length but with different velocity in each core.

Figure 14 shows a preferred embodiment of an electrical machine in accordance with the present invention. This comprises a first core 10 provided with a first winding 11 and a second core 12 provided with a winding 13, and also a number of flux elements 14 arranged between the first and second cores. The flux elements are provided with permanent magnets and arranged to rotate about their own axes. A machine shaft is also included which is connected to the flux

elements 14. When the flux elements 14 are caused to move, partly in a circular movement with the angular velocity w about the machine shaft, and partly in a rotary movement about their own axes with the angular velocity w_{prim} a rotary flux wave is obtained in the first and second cores. In accordance with the same principle the flux wave in the first core 10 acquires the angular velocity w_{prim} + w, whereas the flux wave in the second core 12 acquires the angular velocity w_{prim} - w. Different frequencies are thus obtained in the two windings 11 and 13, respectively. Selection of the number of flux elements and of respective angular velocities w and w_{prim} enables an optional frequency ratio to be obtained between the two windings. The frequency ratio between the induced voltages will be $f_0 : f_1 = (w_{prim}+1/2Nw) : (w_{prim}-1/2Nw)$, where N is the number of flux elements, f_0 is the frequency in the outer winding and f_1 is the frequency in the inner winding.

Figure 15 shows one embodiment of a flux element. The flux element may be of optional shape. A flux element having cylindrical shape is illustrated in the figure but other shapes are feasible within the scope of the appended claims, such as a tapering shape. The element in this embodiment is made out of permanently magnetic material 31, soft magnetic material 32 and non-magnetic material 33.

Figure 16 shows a basic layout sketch of a preferred embodiment of the invention as described in the present application. The machine comprises a core 10 and a winding 11 surrounding a machine shaft. It also comprises a number of magnetic flux elements 14, shown here with circular cross section. The flux elements 14, provided with permanent magnets 15, are arranged in the core. The excitation directions of the permanent magnets may be arranged in different ways. The movements of the flux elements are correlated.

Figure 17 shows a preferred embodiment where the machine is used as generator in a wind power plant. The turbine vane 20 of the wind power plant is connected to the machine shaft which, in turn, is connected to a number of magnetic flux elements 14. Each of the flux elements 14 is arranged to rotate about its own axis. At the same time the flux elements move in a circular path about the machine shaft. In this embodiment the machine comprises a core 10 and a winding 11. In this embodiment the core is shaped as a cylinder with a peripheral groove. Said magnetic flux elements 14 are provided with permanent magnets 15 and arranged in this groove. The turbine vane is driven around which causes the flux elements 14 to move with a circular movement about the machine shaft and in a rotary movement each about its own axis. The movements of the

flux elements are correlated. These movements give rise to a flux which induces a voltage the winding 11.

Figure 18 shows two cores 10, 12 and two flux-generating elements 14 comprising permanent magnets 15. Passive magnetic flux-conducting elements 1 are also shown arranged between the flux-generating elements 14. In the position illustrated in this figure the flux-generating elements 14 are directed so that the flux from the permanent magnets 15 is directed perpendicularly to the cores 10, 12. The magnetic flux, indicated by flux lines 19, is connected via the first core 10 and the second core 12. In Figure 18b the flux-generating device is provided with a passive flux-conducting part 3. The flux can then be connected through only one core 10 and the passive flux-conducting part 3, and the second core 12 is superfluous.

Figure 19 shows the path 19 of the magnetic flux when the flux-generating elements have been rotated a quarter of a revolution from the position shown in Figure 1. The flux is returned via two magnetic flux-conducting elements 1. Said magnetic flux-conducting elements 1 are provided with an aluminium plate 2. This prevents the flux from being conducted through the passive flux-conducting part 3, and it is instead conducted from a flux-generating element 14 via a flux-conducting element 1 to the core 10 and a second flux-conducting element, back to the flux-generating element 14. The frequency of the electrical machine will be doubled in comparison with a machine without said flux-conducting elements. This is because in a machine without the flux-conducting elements 1 the magnetic flux is zero when the magnetic flux-generating elements have assumed the position shown in the figure.

Figure 20 shows the path 19 of the magnetic flux when the flux-generating elements 14 have been rotated half a revolution from the position shown in Figure 1. The magnetic flux is now returned through the cores 10 and 12. The figure shows an embodiment where both the magnetic flux-generating elements and the passive magnetic flux-conducting elements are arranged on a support device 22.

Figure 21 shows an embodiment of the invention in which the magnetic flux-generating elements 14 are directed so that passive flux-conducting elements 1 are required as feedback conductors. The machine also comprises a second core 12 and a support device 22. In the figure the flux is connected around the winding via the quadrangular passive flux-conducting elements 1 which are fitted in the flux-generating device.

Figure 22 shows the same embodiment of the invention as the preceding figure except that the magnetic flux-generating elements 14 have been turned 90

degrees from the position shown in the preceding figure. In this position the flux is connected only through the flux-generating elements 14 and the passive flux-conducting elements 1. A reduction in the pulsing torque caused by the varying reluctance is thus achieved.

The invention is naturally not limited to the above embodiments exemplified but can be designed as modifications within the scope of the inventive concept defined in the appended claims.

CLAIMS

1. An electrical machine comprising a first magnetic core (10) provided with winding, and at least one flux-generating device, said flux-generating device comprising at least two flux-generating variable magnetic flux elements (14), arranged to vary the flux locally in such a way that a magnetization vector describing the local flux variation moves in substantially one plane, from a fixed point in the flux-generating device, **characterized** in that the flux from the flux elements (14) is superposed to a global, substantially travelling flux in the magnetic parts of the machine.

2. An electrical machine as claimed in claim 1, **characterized** in that the magnetic flux elements (14) are arranged to rotate in a local rotary movement.

3. An electrical machine as claimed in claim 1 or claim 2, also comprising at least one machine shaft, **characterized** in that said magnetic flux elements (14) are connected to said machine shaft.

4. An electrical machine as claimed in claim 3, **characterized** in that said flux-generating variable magnetic flux elements (14) are arranged radially displaced in relation to said machine shaft.

5. An electrical machine as claimed in any one of the preceding claims, **characterized** in that the machine comprises a second core (12).

6. An electrical machine as claimed in claim 5, **characterized** in that the machine comprises more than two cores.

7. An electrical machine as claimed in any one of claims 5-6, **characterized** in that at least two cores are provided with windings.

8. An electrical machine as claimed in any one of claim 5-7, **characterized** in that said magnetic flux elements (14) are arranged between two cores.

9. An electrical machine as claimed in any one of claims 2-8, **characterized** in that the magnetic flux elements (14) are arranged to rotate in said local rotary movement with different directions of rotation.

10. An electrical machine as claimed in any of claims 2-9, **characterized** in that the magnetic flux elements (14) are arranged to rotate in said local rotary movement with varying angular velocity.

11. An electrical machine as claimed in any one of claims 3-10, **characterized** in that the axis of rotation of said flux-generating device coincides with the machine shaft.

12. An electrical machine as claimed in any one of the preceding claims, **characterized** in that said first core (10) surrounds the flux-generating device.

13. An electrical machine as claimed in any one of claims 1-12, **characterized** in that said first core (10) is surrounded by the flux-generating device.

14. An electrical machine as claimed in any one of the preceding claims, **characterized** in that said first core (10) is arranged coaxially in relation to the flux-generating device.

15. An electrical machine as claimed in any one of claims 5-14, **characterized** in that said second core (12) is arranged coaxially in relation to the flux-generating device.

16. An electrical machine as claimed in any one of claims 5-15, **characterized** in that said second core (12) surrounds the first core (10).

17. An electrical machine as claimed in any one of claims 5-15, **characterized** in that said second core (12) is surrounded by the first core (10).

18. An electrical machine as claimed in any one of claims 5-17, **characterized** in that at least one core is arranged to rotate.

19. An electrical machine as claimed in claim 18, **characterized** in that said magnetic flux elements (14) are connected to the machine shaft via a rotating core.

20. An electrical machine as claimed in claim 1, **characterized** in that said magnetic flux elements (14) generate a substantially axially directed flux in said first core (10).

21. An electrical machine as claimed in claim 20, **characterized** in that said first core (10) is arranged to connect the machine flux via said magnetic flux elements (14).

22. An electrical machine as claimed in any one of claims 20-21, **characterized** in that said winding (11) is circular and is placed in the first core (10).

23. An electrical machine as claimed in any one of claims 20-22, **characterized** in that said winding (11) surrounds the axis of rotation of the machine.

24. An electrical machine as claimed in any one of claims 20-23, **characterized** in that said first core (10) is shaped as a cylinder with a peripheral groove.

25. An electrical machine as claimed in claim 24, **characterized** in that said winding (11) is arranged in said groove.

26. An electrical machine as claimed in claim 24 or claim 25, **characterized** in that said magnetic flux elements (14) are arranged in said groove.

27. An electrical machine as claimed in any one of claims 20-26, **characterized** in that said core (10) is arranged to connect the machine flux via said magnetic flux elements (14).

28. An electrical machine as claimed in any one of claims 20-27, **characterized** in that said first core (10) comprises a first and a second cylinder which are placed concentrically in relation to each other.

29. An electrical machine as claimed in claim 28, **characterized** in that said winding (11) is arranged between the first and second cylinders of the core.

30. An electrical machine as claimed in any one of claims 20-29, **characterized** in that said core (10) is divided into magnetically separated circuits.

31. An electrical machine as claimed in claim 30, **characterized** in that said core (10) is sectioned into circle sectors.

32. An electrical machine as claimed in any one of the preceding claims, **characterized** in that said magnetic flux elements (14) are local.

33. An electrical machine as claimed in any one of the preceding claims, **characterized** in that said global travelling flux is at least bipolar.

34. An electrical machine as claimed in any one of the preceding claims, **characterized** in that the axes of rotation of said magnetic flux elements (14) are peripherally displaced in relation to each other.

35. An electrical machine as claimed in any one of the preceding claims, **characterized** in that the reluctance for a specific flux element (14) varies regularly during operation.

36. An electrical machine as claimed in any one of the preceding claims, **characterized** in that said magnetic flux elements (14) comprise permanent magnets.

37. An electrical machine as claimed in claim 36, **characterized** in that the permanent magnets are made of one of the following materials: Steel, AlNiCo, Ba, Sr-ferrites, Sm(Fe,Co), SmCo, SmFeN, NdFeB and nanocomposite permanent magnets.

38. An electrical machine as claimed in any one of claims 1-35, **characterized** in that said magnetic flux elements (14) comprise a squirrel cage winding.

39. An electrical machine as claimed in any one of claims 1-35, **characterized** in that said magnetic flux elements (14) comprise a field winding.

40. An electrical machine as claimed in any one of claims 1-35, **characterized** in that said magnetic flux elements (14) comprise soft magnetic material.

41. An electrical machine as claimed in any one of the preceding claims, **characterized** in that the machine comprises means for varying the magnetic flux of the magnetic flux elements (14) mechanically.

42. An electrical machine as claimed in any one claims 1-40, **characterized** in that the machine comprises means for varying the magnetic flux of the magnetic flux elements (14) electromagnetically.

43. An electrical machine as claimed in any one of the preceding claims, **characterized** in that said magnetic flux elements (14) are arranged so that their time variations are correlated with each other.

44. An electrical machine as claimed in any one of the preceding claims, **characterized** in that the machine is multiphase.

45. An electrical machine as claimed in any one of claims 1-43, **characterized** in that the machine is monophase.

46. An electrical machine as claimed in any one of the preceding claims, **characterized** in that the winding (11, 13) of the machine comprises an insulated conductor for low voltage.

47. An electrical machine as claimed in any one of claims 1-45, **characterized** in that the winding (11, 13) of the machine comprises an insulated cable for high voltage.

48. An electrical machine as claimed in any one of the preceding claims, **characterized** in that said magnetic flux elements (14) are arranged to absorb forces in more than one direction.

49. An electrical machine as claimed in any one of the preceding claims, **characterized** in that said magnetic flux elements (14) are arranged to absorb radial forces.

50. An electrical machine as claimed in any one of the preceding claims, **characterized** in that the machine comprises means for movement of said magnetic flux elements (14) so that the axes of rotation of the magnetic flux elements follow a global translation movement.

51. An electrical machine as claimed in claim 50, **characterized** in that the global translation movement is a rotary movement about said machine shaft.

52. An electrical machine as claimed in claim 50, **characterized** in that the global translation movement is a linear translation movement.

53. An electrical machine as claimed in any one of claims 50-52, **characterized** in that the means for movement is arranged so that the local rotation of said magnetic flux elements (14) is achieved with varying angular velocity.

54. An electrical machine as claimed in any one of claims 50-53, **characterized** in that the number of poles is determined by the relative angular difference between the magnetic axes of the flux elements (14).

55. A method of controlling magnetic flux in an electrical machine as claimed in any one of claims 50-54, **characterized** in that during part of a revolution in the local rotary movement of the magnetic flux-generating elements (14), the magnetic flux is conducted via passive magnetic flux-conducting elements (1) that follow said global translation movement.

56. A method of controlling flux as claimed in claim 55, wherein passive flux-conducting parts (3) that follow said translation movement are included in said flux-generating device, **characterized** in that during part of a revolution in the rotary movement of the magnetic flux-generating elements, the flux is returned through said passive flux-conducting part.

57. A method of controlling flux as claimed in claim 55, **characterized** in that during part of a revolution in the rotary movement of the magnetic flux-generating elements, the flux is returned through said second core (12).

58. A method of controlling flux as claimed in claim 56 or claim 57, **characterized** in that said magnetic flux-generating elements (14) are arranged having the same excitation direction as said first core (10).

59. A method of controlling flux as claimed in claim 58, **characterized** in that said passive magnetic flux-conducting elements (1) are arranged so that each individual flux line is conducted through substantially all magnetic flux-generating elements (14) during part of a revolution in the rotary movement of the magnetic flux-generating elements.

60. A method of controlling flux as claimed in claim 58, **characterized** in that each individual flux line is conducted through only one magnetic flux-generating element (14) and at least one passive magnetic flux-conducting element (1) during part of a revolution in the rotary movement of the magnetic flux-generating elements.

61. A method of controlling flux as claimed in claim 56 or claim 57, **characterized** in that said magnetic flux-generating elements (14) are arranged with alternating excitation direction in relation to said first core (10).

62. A method of controlling flux as claimed in claim 61, **characterized** in that said passive magnetic flux-conducting element (1) is arranged so that each individual flux line is conducted through substantially only one magnetic flux-generating element (14) during part of a revolution in the rotary movement of the magnetic flux-generating elements.

63. A method of controlling flux as claimed in claim 61, **characterized** in that each individual flux line is conducted through substantially at least two magnetic flux-generating elements (14) during part of a revolution in the rotary movement of the magnetic flux-generating elements.

64. A method of controlling flux as claimed in any one of claims 55-63, **characterized** in that said passive magnetic flux-conducting elements (1) are arranged between said magnetic flux-generating elements (14).

65. A method of controlling flux as claimed in any one of claims 55-63, **characterized** in that said passive magnetic flux-conducting elements (1) are

arranged in the space between the magnetic flux-generating elements (14) and a core.

66. A device for controlling flux in an electrical machine as claimed in any one of claims 50-54, **characterized** in that the passive magnetic flux-conducting elements (1) are arranged to follow said translation movement and to conduct magnetic flux from the magnetic flux-generating elements during part of a revolution in the rotary movement.

67. A device as claimed in claim 66, **characterized** in that passive flux-conducting parts (3) that follow said translation movement are included in said flux-generating device, so that the flux is returned through said passive flux-conducting parts during part of a revolution in the rotary movement of the magnetic flux-generating elements.

68. A device as claimed in claim 66, **characterized** in that during part of a revolution in the rotary movement of the magnetic flux-generating elements, the flux is returned through said second core (12).

69. A device as claimed in claims 66-68, **characterized** in that said magnetic flux-generating elements (14) are arranged having the same excitation direction as said first core (10).

70. A device as claimed in claim 69, **characterized** in that said passive magnetic flux-conducting elements (1) are arranged so that each individual flux line is conducted through substantially all magnetic flux-generating elements (14) during part of a revolution in the rotary movement of the magnetic flux-generating elements (14).

71. A device as claimed in claims 66-68, **characterized** in that said magnetic flux-generating elements (14) are arranged with alternating excitation direction in relation to said first core (10).

72. A device as claimed in claim 71, **characterized** in that said passive magnetic flux-conducting elements (1) are arranged so that each individual flux line is conducted through substantially only one magnetic flux-generating element (14) during part of a revolution in the rotary movement of the magnetic flux-generating elements (14).

73. A device as claimed in claim 71, **characterized** in that said passive magnetic flux-conducting elements (1) are arranged so that each individual flux line is conducted through substantially at least two magnetic flux-generating elements (14) during part of a revolution in the rotary movement of the magnetic flux-generating elements (14).

74. A device as claimed in any one of claims 66-73, **characterized** in that said passive magnetic flux-conducting elements (1) are arranged between said magnetic flux-generating elements (14).

75. A device as claimed in any one of claims 66-73, **characterized** in that said passive magnetic flux-conducting elements are arranged in the space between the magnetic flux-generating elements (14) and a core.

76. A device as claimed in any one of claims 66-75, **characterized** in that said passive magnetic flux-conducting elements (1) are made of soft magnetic material.

77. A device as claimed in any one of claims 66-75, **characterized** in that said passive magnetic flux-conducting elements (1) comprise non-magnetic material.

78. A device as claimed in claim 77, **characterized** in that said non-magnetic material is aluminium.

79. A device as claimed in claim 78, **characterized** in that said passive magnetic flux-conducting elements are provided with an aluminium plate (2).

80. A device as claimed in any one of claims 66-79, **characterized** in that said passive magnetic flux-conducting elements (1) have a lens-shaped cross-section.

81. A device as claimed in any one of claims 66-79, **characterized** in that said passive magnetic flux-conducting elements (1) have a substantially quadrangular cross section.

82. A device as claimed in any one of claims 66-81, that includes a support means (22), **characterized** in that said passive magnetic flux-conducting elements (1) are included in said support means (22).

83. A device as claimed in any one of claims 66-82, **characterized** in that said passive magnetic flux-conducting elements (1) are arranged to absorb a force.

84. A rotating electrical machine comprising a device as claimed in any one of claims 66-83.

85. A linear electrical machine comprising a device as claimed in any one of claims 66-83.

86. An electrical machine as claimed in any one of the preceding claims, **characterized** in that the machine comprises a communication unit.

87. The use of an electrical machine as claimed in any one of the preceding claims in a frequency converter.

88. The use of an electrical machine as claimed in any one of the preceding claims for converting one number of phases to another number of phases.

89. The use of an electrical machine as claimed in any one of claims 1-65 as generator.

90. The use of a machine as claimed in claim 89 in a wind power plant.

91. The use of an electrical machine as claimed in any one of claims 1-65 as motor.

92. The use of a machine as claimed in claim 91 as a step-motor.

93. The use of an electrical machine as claimed in any one of claims 1-65 in a synchronous compensator.

94. A system comprising an electrical machine as claimed in any one of claims 1-65.

Fig. 1

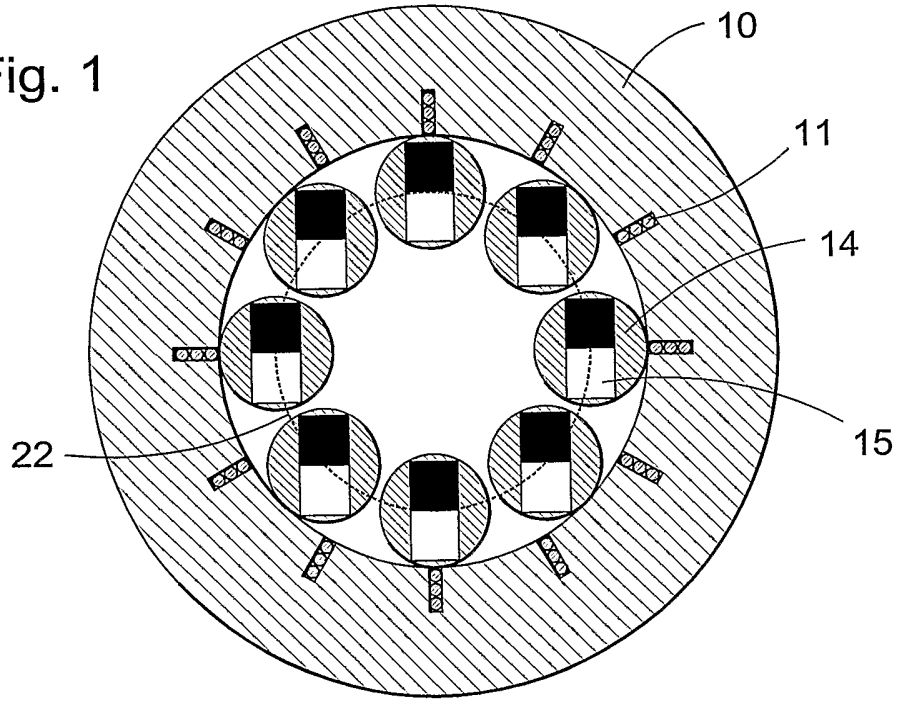


Fig. 2

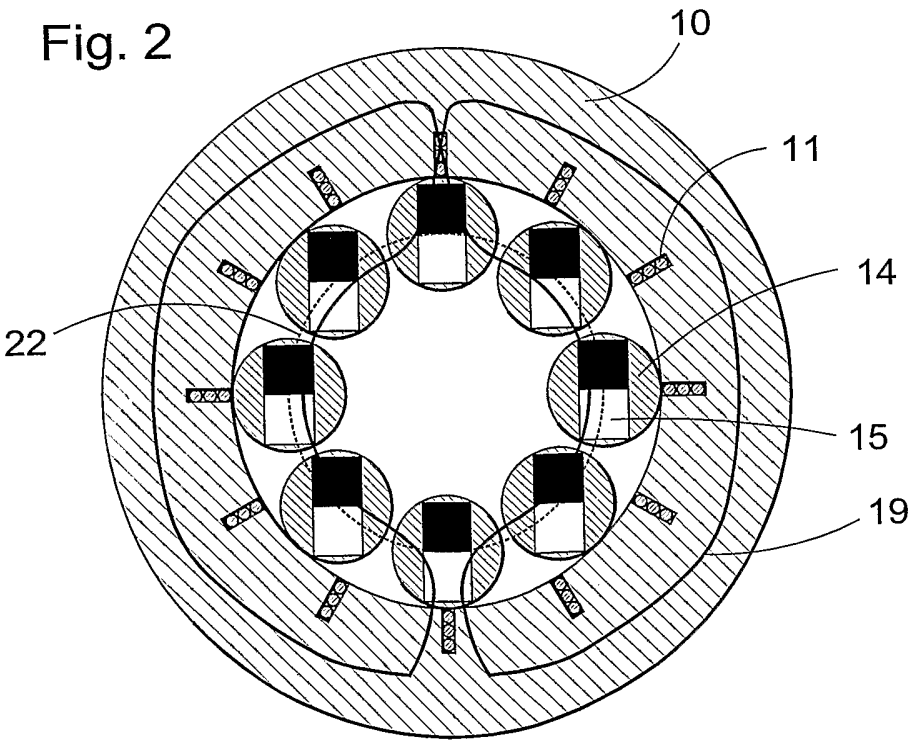


Fig. 3

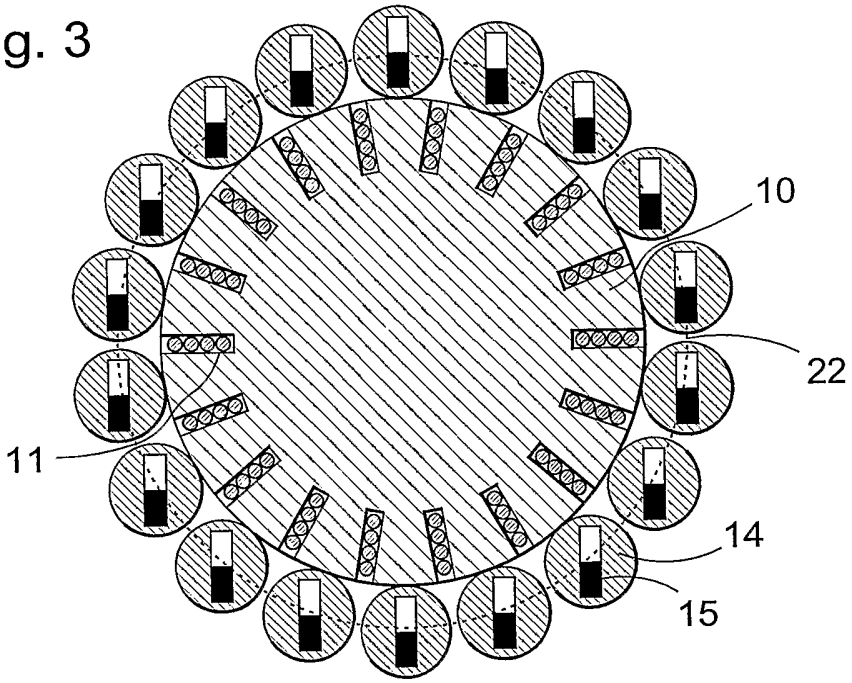


Fig. 4

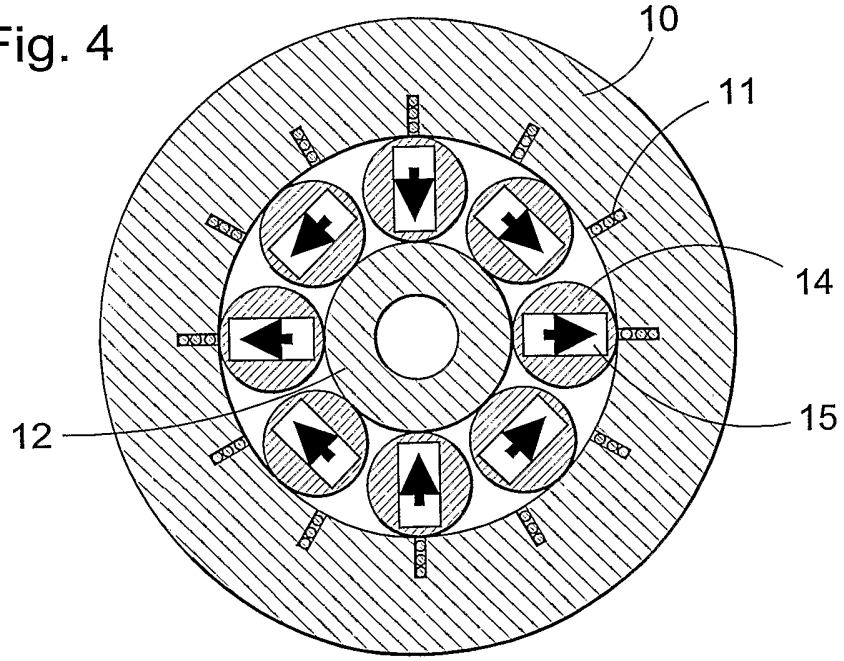


Fig. 5

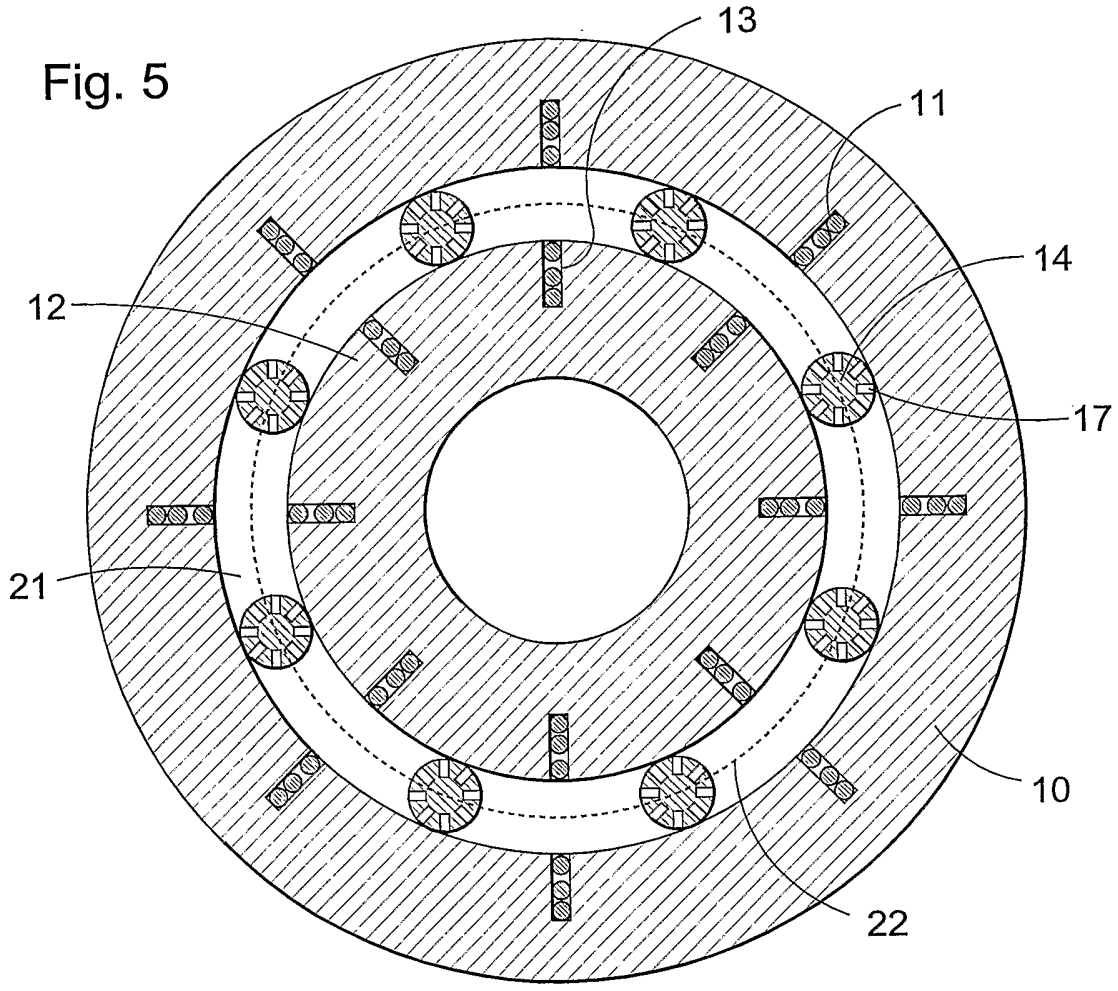


Fig. 6

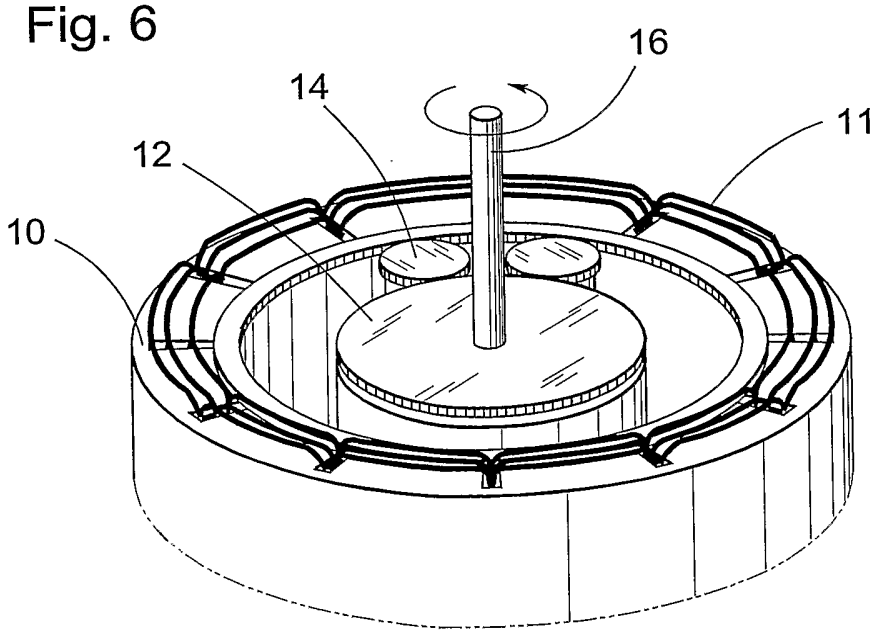


Fig. 7

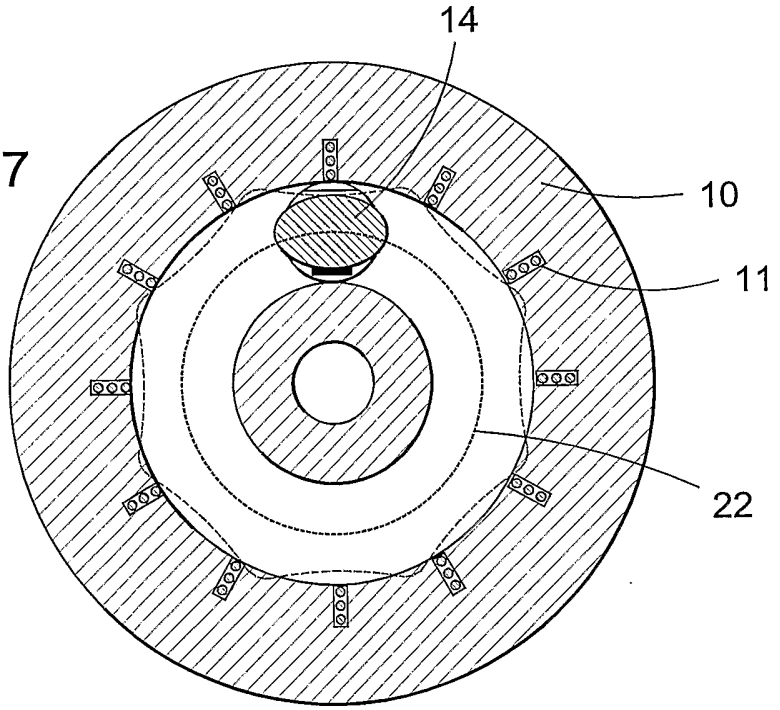


Fig. 8

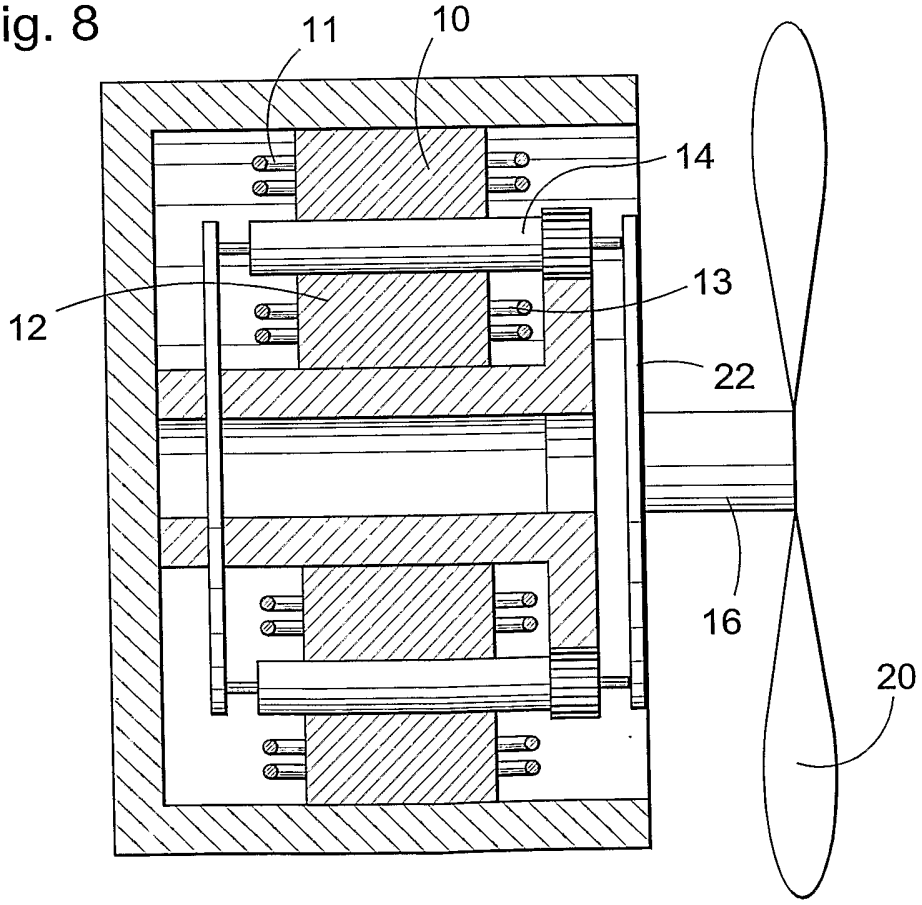


Fig. 9

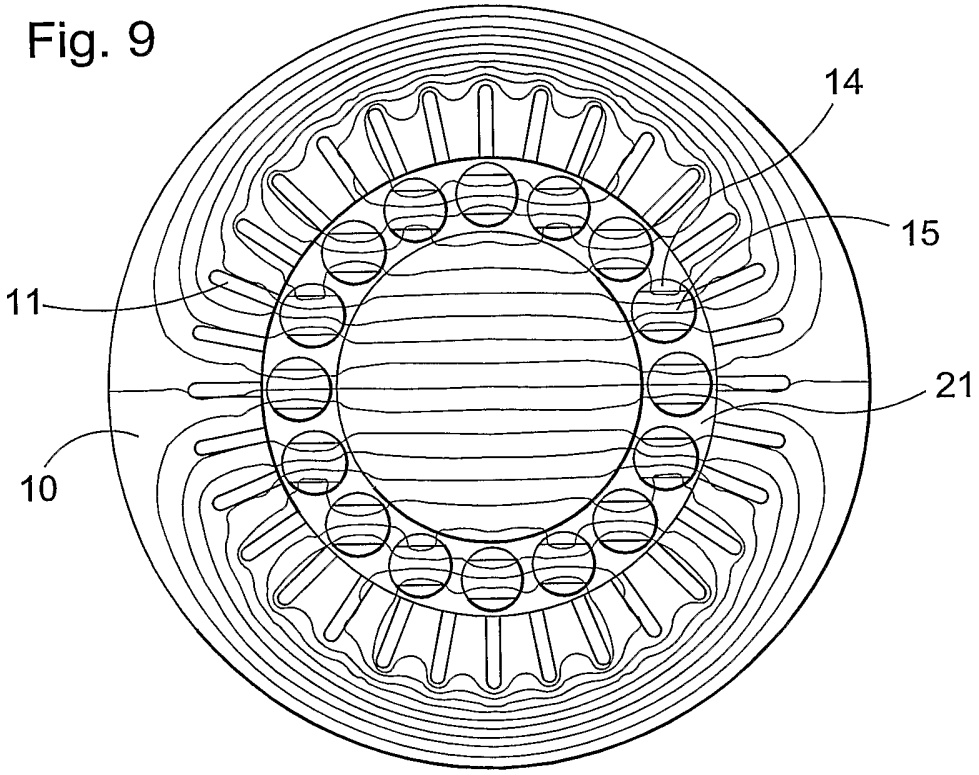


Fig. 10

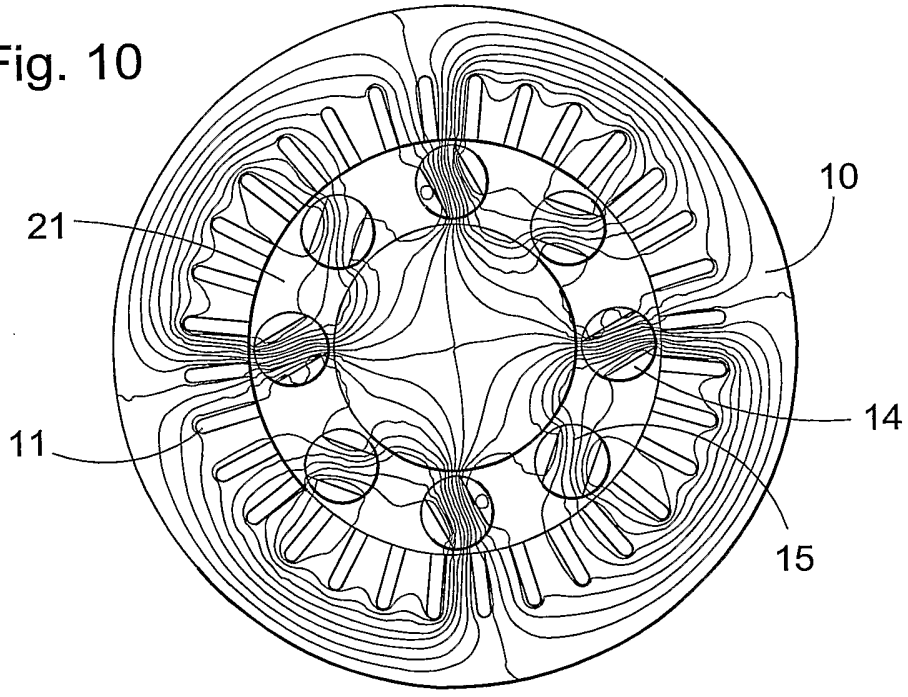


Fig. 11a

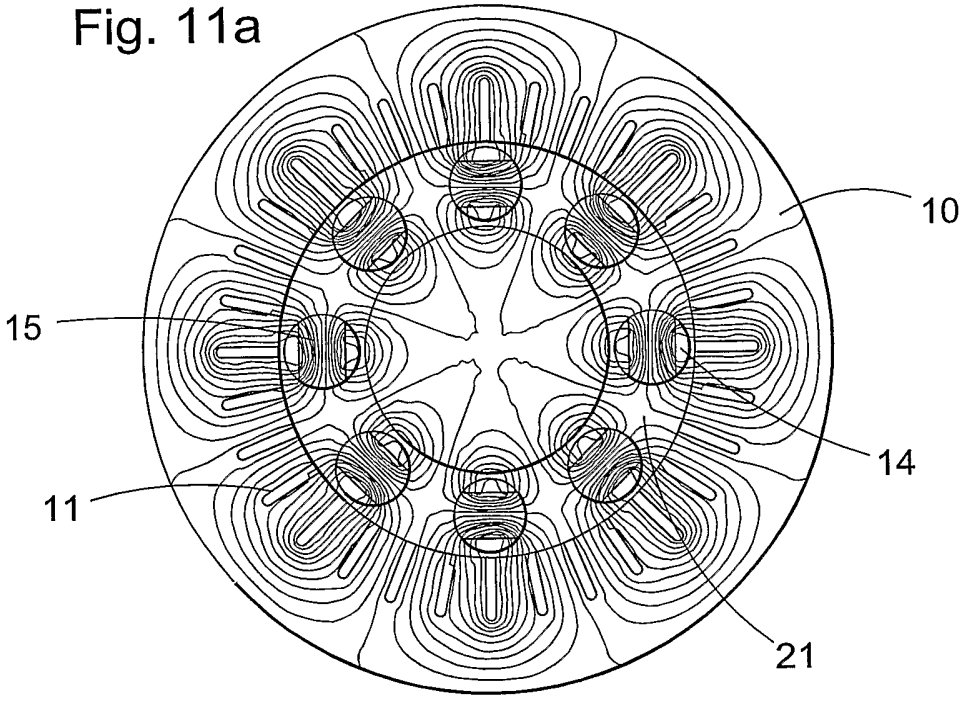


Fig. 11b

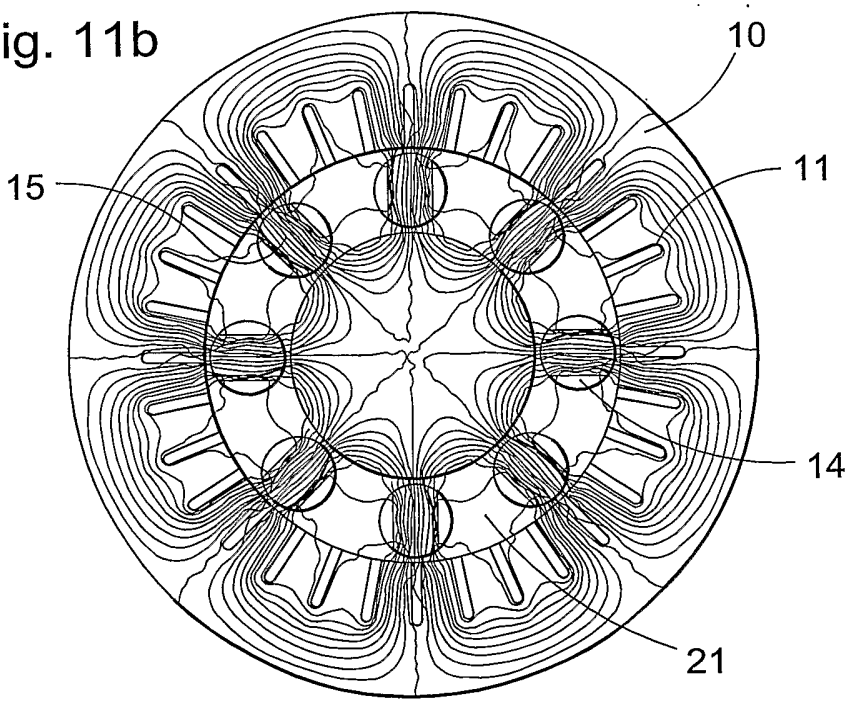


Fig. 12a

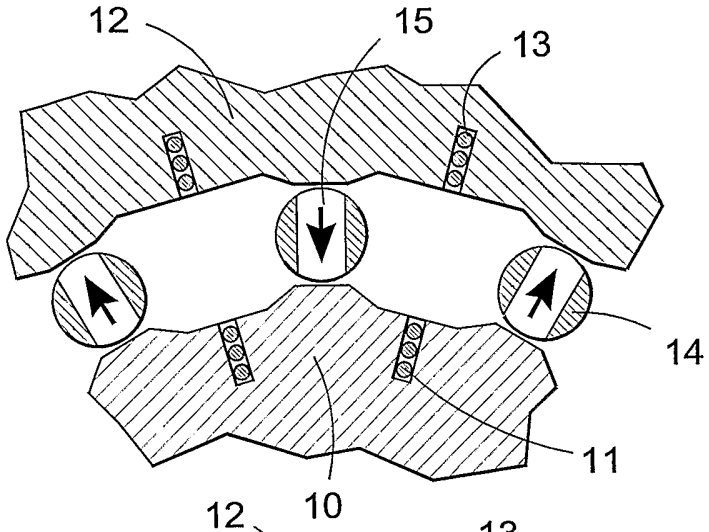


Fig. 12b

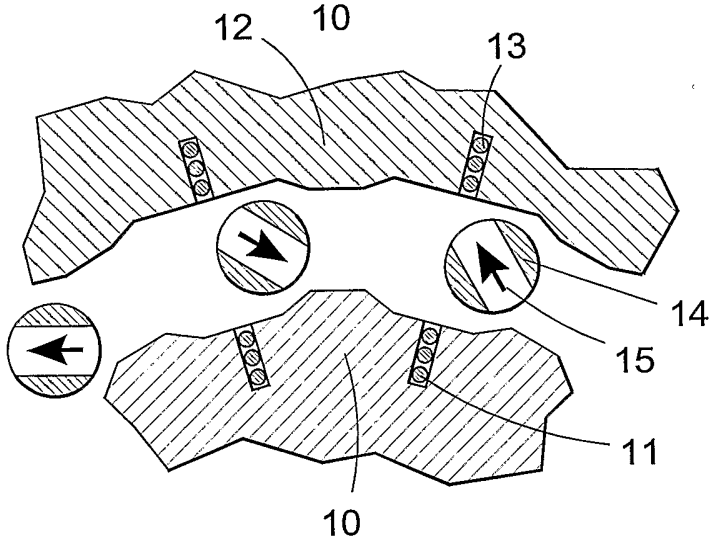


Fig. 13a

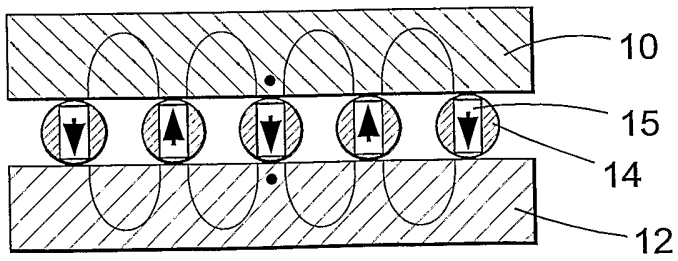


Fig. 13b

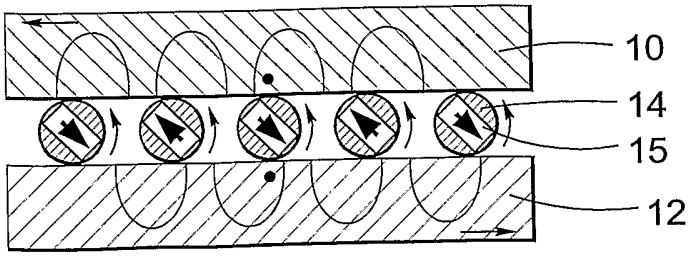
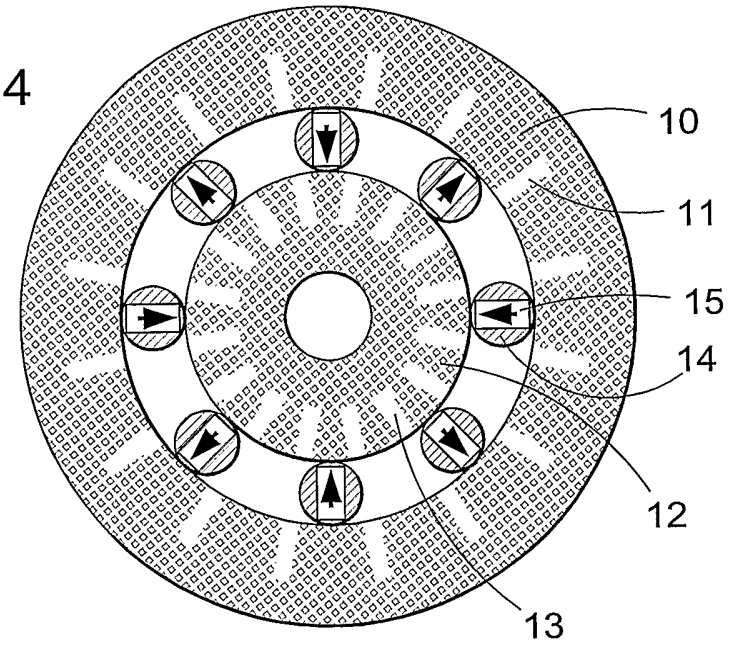


Fig. 14



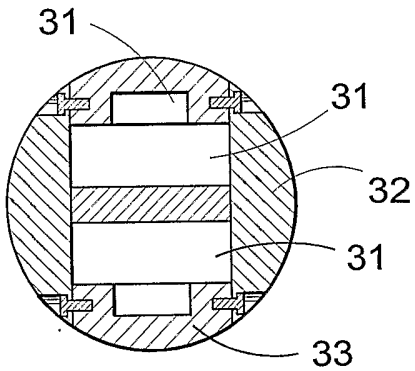


Fig. 15

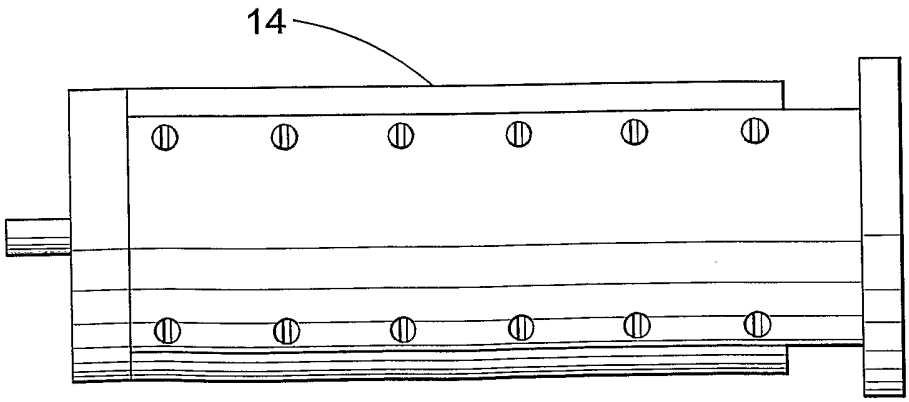


Fig. 16

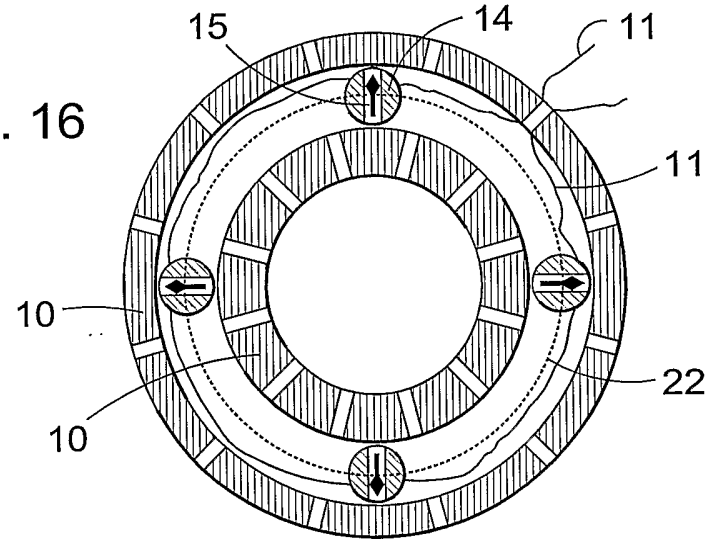
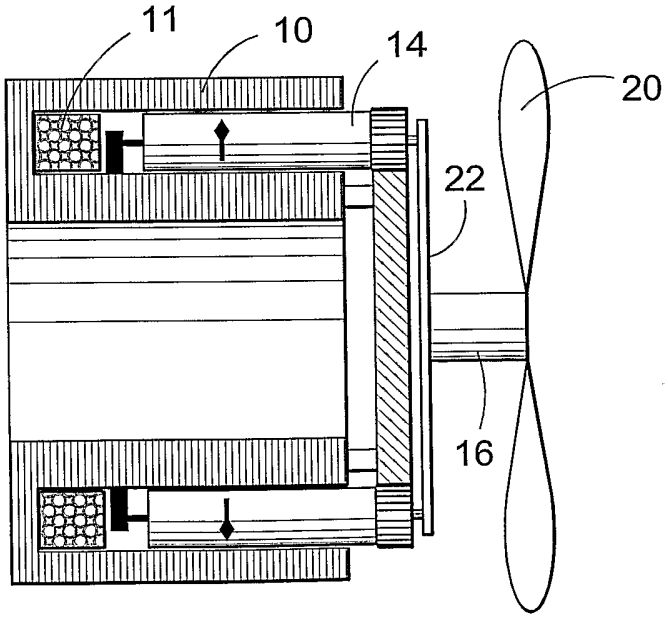


Fig. 17



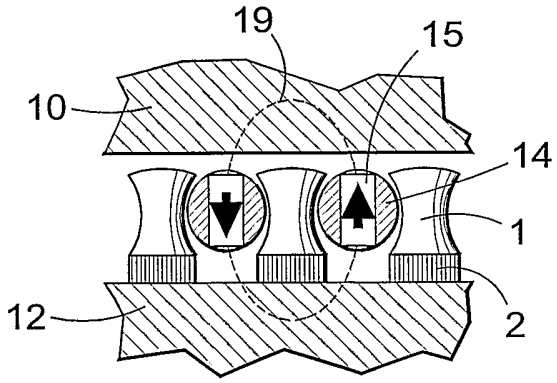


Fig. 18a

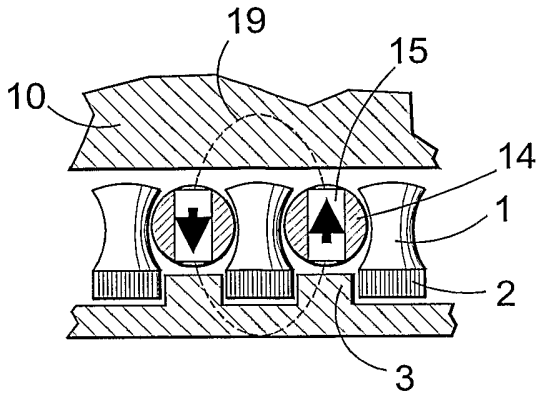


Fig. 18b

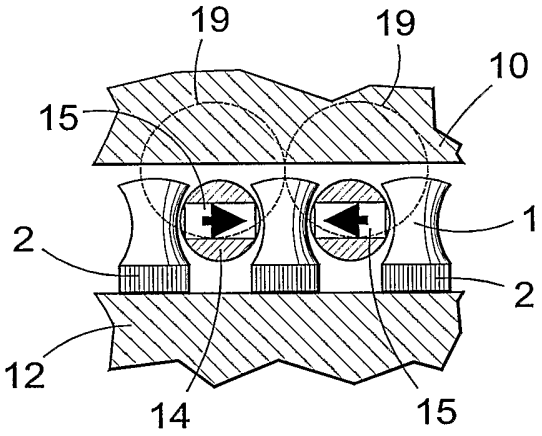


Fig. 19

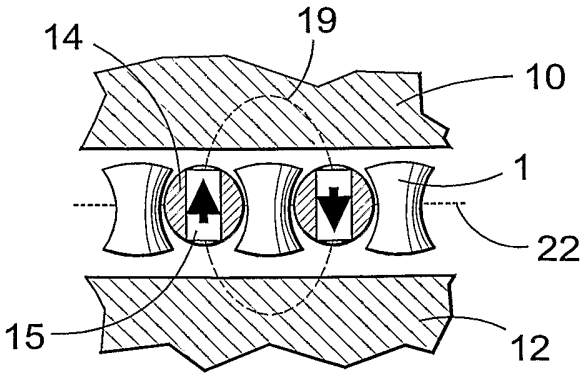


Fig. 20

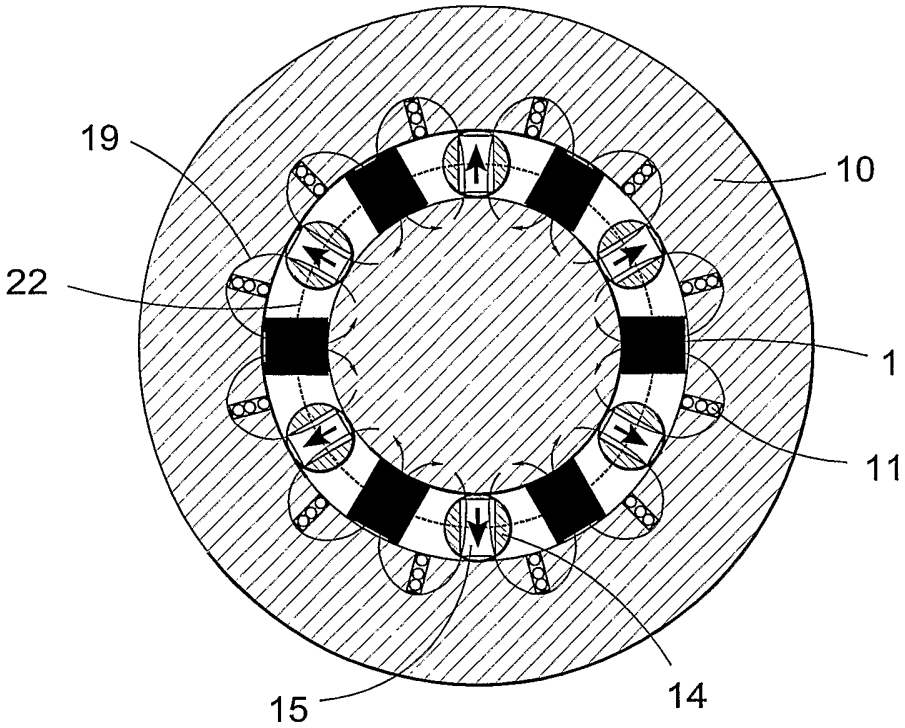


Fig. 21

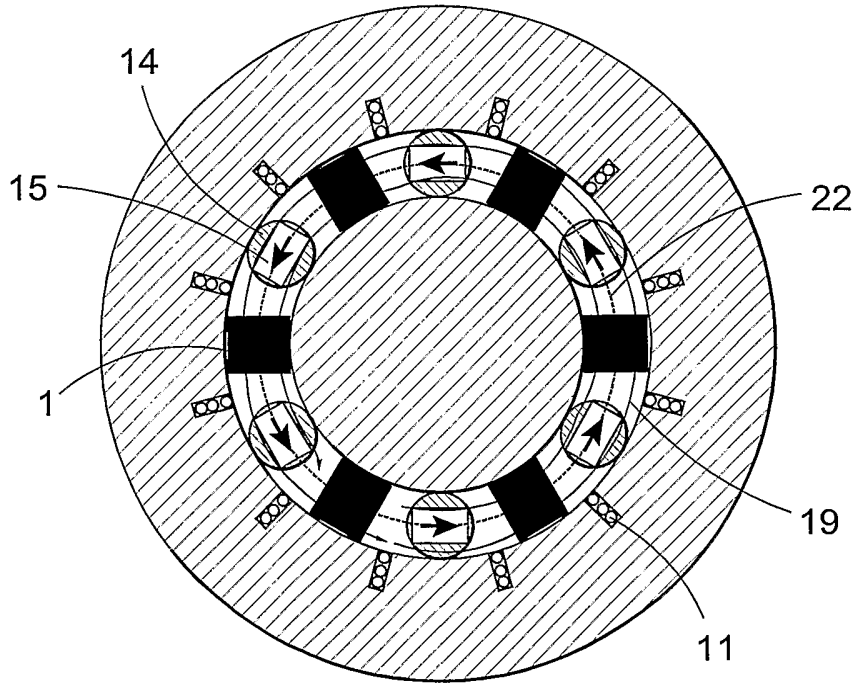


Fig. 22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00902

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H02K 16/00, H02K 21/12, H02K 37/10, H02K 41/06, H02K 47/18
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)

IPC7: H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2271025 A (IAN BRODERICJ PITT-STEELE), 30 March 1994 (30.03.94), page 2, line 7 - page 3, line 10; page 9, line 10 - page 12, line 33	1-24
A	WO 0021183 A1 (ROBERT BOSCH GMBH), 13 April 2000 (13.04.00), page 3, line 30 - page 6, line 27	1-94
A	US 4734621 A (YONNET, J.P. ET AL), 29 March 1988 (29.03.88), column 1, line 54 - line 68; column 2, line 26 - column 3, line 27	1-94
A	US 4752706 A (MESZAROS, L.G.), 21 June 1988 (21.06.88), abstract	1-94

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"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
18 July 2002	26 -07- 2002
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Håkan Sandh/mj Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00902

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 2346052 A1 (SCHEPKE, WILHELM FRIEDRICH), 27 March 1975 (27.03.75), page 4, line 4 - line 25 -- --------	1-94

INTERNATIONAL SEARCH REPORT

Information on patent family members

06/07/02

International application No.
PCT/SE 02/00902

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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WO 0021183 A1	13/04/00	CZ 20011212 A	15/08/01
		DE 19845914 A,C	13/04/00
		EP 1119895 A	01/08/01
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		FR 2592520 A,B	03/07/87
		JP 63066936 A	25/03/88
US 4752706 A	21/06/88	CA 1191535 A	06/08/85
DE 2346052 A1	27/03/75	NONE	