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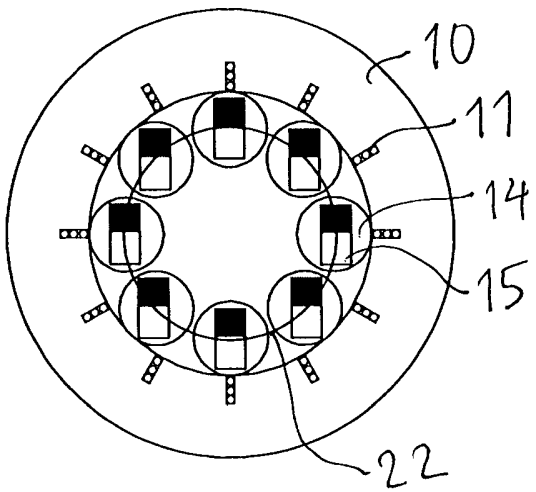
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[Continued on next page]

(54) Title: GENERATOR FOR WIND POWER



(57) Abstract: The invention relates to a generator for wind power comprising a first magnetic core provided with a winding, and at least one flux-generating device having at least two flux-generating magnetic flux elements. These are arranged to vary the flux locally so that the local flux variation can be described by a magnetizing vector that moves in substantially one plane. The flux from the flux elements is superposed to a global flux in the magnetic parts of the generator for wind power. The invention also relates to the use of such a generator for wind power and to a system comprising such a generator for wind power.

WO 02/099954 A1

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GENERATOR FOR WIND POWER

Technical field

The present invention relates to a generator for wind power comprising a rotor and at least one a first magnetic core provided with a winding, as well as at least one shaft. The rotor of the wind-power generator comprises at least two magnetic flux elements arranged to rotate each about its own axis of rotation. The axes of rotation are radially displaced in relation to the shaft of the wind-power generator. The flux elements are connected to said shaft.

Background art

In many electric 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 wind-power generator 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.

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

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.

Both 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 wind-power generator for a broad power range, which solves the problems mentioned above.

Brief description of the invention

The present invention relates to a compact wind-power generator having considerable flexibility as regards the frequency at which alternating current is generated. Furthermore, the construction described in the present application permits movement of the rotor in at least two different types of movement, thus giving a flexible machine with several degrees of freedom and entirely new possibilities for designing the wind-power generator.

The generator for wind power in accordance with the present invention comprises at least two magnetic flux elements displaced radially in relation to the shaft of the wind-power generator. The flux elements in the wind-power generator are connected to the shaft of the wind-power generator. The flux elements are arranged to rotate in a local rotary motion about their axes of rotation. The excitation directions of the magnetic flux elements are constantly varied in relation to the position vector of the flux element in the rotor construction. The local flux

elements generate a global magnetic flux in the cores. By "global magnetic flux" is meant that the flux from each individual flux element cooperates continuously in the construction provided with a winding. The direction of the global magnetic field alters constantly in relation to the relative movement of the flux-generating device.

The global flux described in the invention can be described concisely in the ideal case as a travelling wave with constant amplitude and phase velocity around the magnetic circuit of the machine. This wave has a periodic shape at every instant. In practice elements of pulsing flux also appear, which cause periodically varying velocity and amplitude.

In all the preferred embodiments said cores are made of optional magnetic material. A core may be made, for instance, in the form of a laminated sheet iron core or a compressed powder core of magnetic material.

One or more windings in the invention described in the present application may be wound using insulated cable or insulated conductor for low voltage. The insulated cable is preferably a high or medium voltage cable constructed with an insulating part including at least two semiconducting layers surrounding an insulating layer. The invention in accordance with the present application is intended to be used within an optional power range.

A communication unit consisting of at least one in/out unit with processor may be included in the invention. Measured values from one or more sensors in the rotor or stator are collected in the processor. Signals from the machine can be sent to the processor via the in/out unit. An output signal from the processor may be sent via the in/out unit to some type of control device fitted in the machine. The communication may also be used for sending data from the processor via wires or by means of wireless transmission from the machine for the purpose of control or data collection. The communication unit can be applied on a static part or on some movable part of the invention.

Description of embodiments

In a preferred embodiment of the invention the wind-power generator comprises several cores. In one embodiment one or more cores is/are arranged to rotate. In another embodiment more than one core are provided with windings.

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

In yet another preferred embodiment the wind-power generator comprises means for movement of said flux elements whereupon 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 gear drive, for instance.

Said flux elements are arranged to rotate in a local rotary motion about their axes of rotation with the same or different directions of rotation. The individual angular velocities of the flux elements in this local rotary movement may be the same or may vary in relation to each other. The flux elements can transmit movement and/or absorb forces in several directions, e.g. a radially directed force.

In a preferred embodiment the means for movement of said flux elements is arranged so that each flux element in its local rotation acquires varying angular velocity. The angular velocity of each flux element will be highest when the flux element passes a pole that gives a higher flux change per time unit. Depending on the variation of the angular velocity, a more or less pulse-shaped voltage with increased peak value is obtained for a generator.

In yet 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.

In yet another preferred embodiment of the wind-power generator in accordance with the application the flux elements in the wind-power generator are excited asynchronously. In this embodiment each of the flux elements is provided with a squirrel cage winding. The magnetic flux is rotated mechanically or magnetically.

The excitation directions of the flux elements may be varied around the periphery of the wind-power generator.

Brief description of the drawings

Figure 1 shows a basic layout sketch of the wind-power generator in accordance with the invention, having an external core provided with a winding.

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

Figure 3 shows a basic layout sketch of the wind-power generator in accordance with the invention, having an internal core provided with a winding.

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

Figure 5 shows yet another embodiment of the invention in which the flux elements are provided with squirrel windings for asynchronous operation.

Figure 6 shows a view in perspective of a preferred embodiment of the wind-power generator in accordance with the present 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 wind-power generator is effected with varying angular velocity during the rotation.

Figure 8 shows the wind-power generator in a wind power plant.

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

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

Figures 11a and b show the magnetic flux of the wind-power generator in a preferred embodiment, in this case a multipolar machine.

Figure 12 shows an embodiment of a flux element.

Detailed description of preferred embodiments

Figure 1 shows a basic layout sketch of a preferred embodiment of the wind-power generator of the invention, in accordance with the present application. A core 10, in this case 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, illustrated here with circular cross section. The flux elements 14, provided with permanent magnets 15, are arranged between the core and a support 22, preferably of non-magnetic material, which may consist of a gear rim. The excitation directions of the various permanent magnets can be arranged in various ways. The movements of the flux elements are correlated.

The flux lines 19 in Figure 2 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 in accordance with the present application. The wind-power generator comprises a core 10, in this embodiment an internal, homogeneous core provided with a winding 11. A machine shaft is also included, 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 22, preferably of non-magnetic material. The excitation directions of the permanent magnets may be arranged in various ways in relation to each other. The movements of the flux elements are correlated.

Figure 4 shows yet another preferred embodiment of the wind-power generator in accordance with the present application. A first core 10, provided with a winding, surrounds a second core 12 which may also be provided with a winding (not shown). The core windings may be arranged in several ways. The cores can be wound individually, after which the windings may be connected in series or in parallel, or they may be galvanically isolated. The cores may also be wound with a single common winding which, in that case, is wound over the air gap 21. A number of flux elements 14 are arranged between the first and the second core. The flux elements are provided with permanent magnets 15. The movements of the flux elements are correlated.

Figure 5 shows yet another preferred embodiment of the invention. The wind-power generator comprises a first and a second core, both provided with windings, and a number of flux elements 14 arranged therebetween. The flux elements in this embodiment are provided with squirrel windings 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 wind-power generator in accordance with the present application. The wind-power generator comprises a first core, 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 two 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 elements are thus caused to rotate each 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 wind-power generator 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 the wind-power generator in a wind power plant. The turbine vane 20 of the wind power plant is connected to the shaft of the wind-power generator 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 shaft of the wind-power generator. In this embodiment the wind-power generator 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 which is cylindrical. Said flux elements 14 are provided with permanent magnets 15 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 shaft of the wind-power generator 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 illustrates the magnetic flux in the wind-power generator in a preferred embodiment. The flux elements are provided with permanent magnets 15. In this embodiment the wind-power generator is bipolar. The wind-power generator 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 wind-power generator. This is indicated in the figure by flux lines 19.

Figure 10 illustrates the magnetic flux in the wind-power generator in yet 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 wind-power generator, as can be seen in the figure as flux lines 19.

Figure 11a illustrates the magnetic flux of the wind-power generator 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 wind-power generator, as can be seen in the figure as 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 an embodiment of a flux element. The shape of the flux element is optional. The figure shows a cylindrical flux element but other shapes, such as tapered, are feasible within the scope of the appended claims. In this embodiment the element is constructed out of permanently magnetic material 31, soft magnetic material 32 and non-magnetic material 33.

The invention is of course not limited to the embodiments described above by way of example, but can be modified within the scope of the inventive concept defined in the appended claims.

CLAIMS

1. A generator for wind power comprising a first magnetic core (10) provided with a 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 manner that from a fixed point in the flux-generating device a magnetizing vector describing the local flux variation moves in substantially one plane, **characterized** in that the flux from the flux elements (14) is superposed to a global, substantially travelling flux in the magnetic parts of the generator for wind power.

2. A generator for wind power as claimed in claim 1, **characterized** in that the number of poles in the wind-power generator is determined by the relative angular difference between the magnetic axes in the flux elements (14).

3. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the globally travelling flux has at least two poles.

4. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the wind-power generator comprises a second core (12).

5. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the wind-power generator comprises more than two cores.

6. A generator for wind power as claimed in any one of claims 4-5, **characterized** in that at least two of the cores are provided with windings.

7. A generator for wind power as claimed in any one of claims 4-6, **characterized** in that said magnetic flux elements (14) are arranged between two cores.

8. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that said magnetic flux elements (14) are arranged to take up forces in several directions.

9. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the magnetic flux elements (14) are arranged to rotate in a local rotary motion.

10. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the magnetic flux elements (14) are arranged to rotate with mutually different directions of rotation in said local rotary motion.

11. A generator for wind power as claimed in any one of claims 9 or 10, **characterized** in that the magnetic flux elements (14) are arranged to rotate with varying angular velocity in said local rotary motion.

12. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the means for motion is arranged so that the local rotation of said magnetic flux elements (14) is effected with varying angular velocity.

13. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the wind-power generator comprises means for movement of said magnetic flux elements (14), the axes of rotation of the magnetic flux elements following a global rotary motion about said shaft.

14. A generator for wind power 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.

15. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that said magnetic flux elements (14) comprise permanent magnets (15).

16. A generator for wind power as claimed in claim 16, **characterized** in that the permanent magnets consist of one of the following materials: Steel, AlNiCo, Ba, Sr-ferrites, Sm(Fe,Co), SmCo, SmFeN, NdFeB and nanocomposite permanent magnets.

17. A generator for wind power as claimed in any one of claims 1-15, **characterized** in that said magnetic flux elements (14) comprise a squirrel cage winding.

18. A generator for wind power as claimed in any one of claims 1-15, **characterized** in that said magnetic flux elements comprise a field winding.

19. A generator for wind power as claimed in any one of claims 1-15, **characterized** in that said magnetic flux elements (14) comprise soft magnetic material.

20. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the wind-power generator comprises means for varying the magnetic flux of the magnetic flux elements magnetically.

21. A generator for wind power as claimed in any one of claims 1-20, **characterized** in that the wind-power generator comprises means for varying the magnetic flux of the magnetic flux elements (14) electromagnetically.

22. A generator for wind power 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.

23. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the wind-power generator is multiphase.

24. A generator for wind power as claimed in any one of claims 1-23, **characterized** in that the wind-power generator is monophase.

25. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the winding of the wind-power generator comprises an insulated conductor for low voltage.

26. A generator for wind power as claimed in any one of claims 1-24, **characterized** in that the winding (11, 13) of the wind-power generator comprises

a cable for high voltage comprising one or more current-carrying conductors surrounded by at least two semiconducting layers and an intermediate insulating layer or solid insulation.

27. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that said magnetic flux elements (14) are arranged to absorb radial forces.

28. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the axis of rotation of the rotor coincides with the shaft.

29. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that said first core (10) surrounds the rotor.

30. A generator for wind power as claimed in any one of claims 1-28, **characterized** in that said first core (10) is surrounded by the rotor.

31. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that said first core (10) is arranged coaxially in relation to the rotor.

32. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that said second core (12) is arranged coaxially in relation to the rotor.

33. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that said second core (12) surrounds the first core.

34. A generator for wind power as claimed in any one of claims 1-32, **characterized** in that said second core (12) is surrounded by the first core.

35. A generator for wind power as claimed in any one of claims 4 or 5, **characterized** in that at least one core is arranged to rotate.

36. A generator for wind power as claimed in any one of the preceding claims, **characterized** in that the wind-power generator comprises a communication unit.

37. A system comprising a generator for wind power as claimed in any one of the preceding claims.

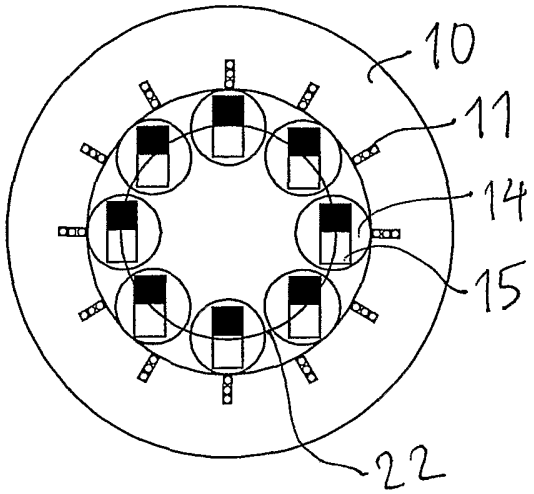


Fig 1

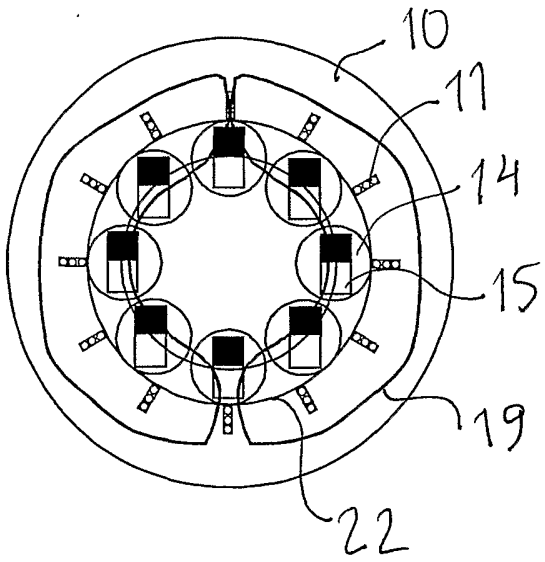


Fig. 2

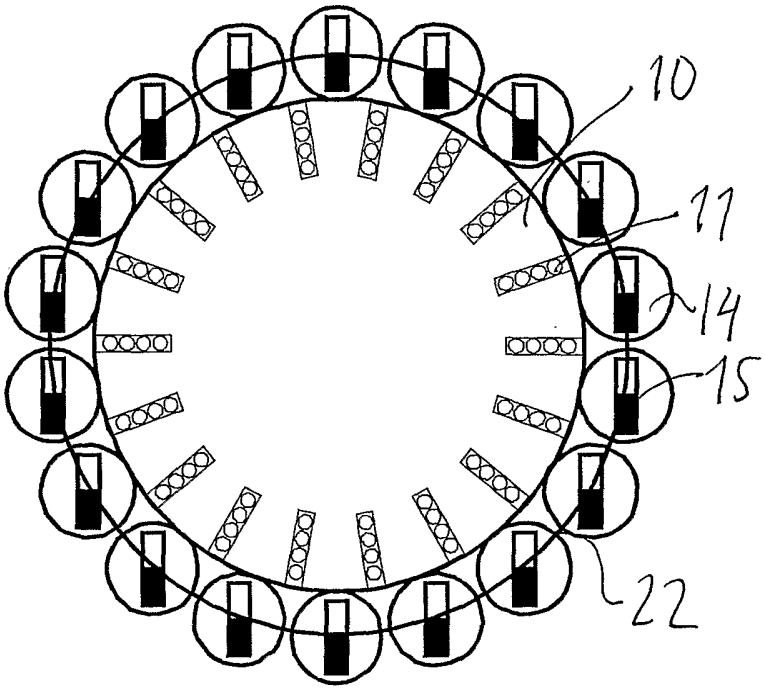


Fig. 3

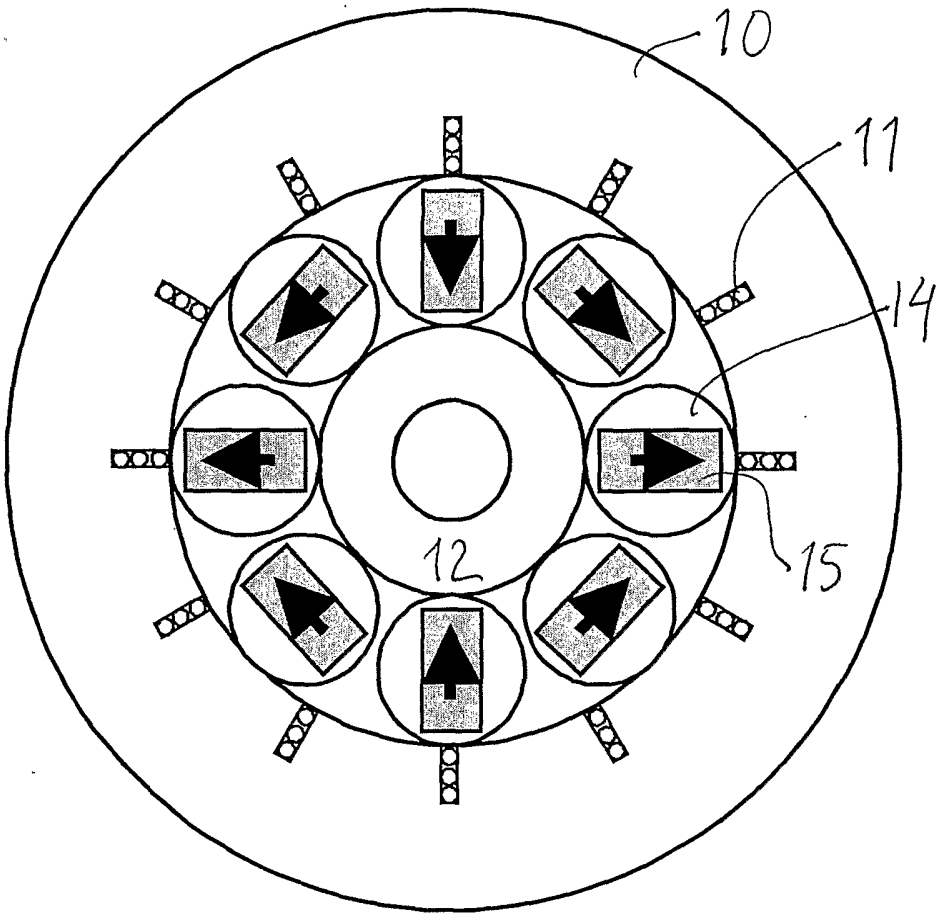


Fig. 4

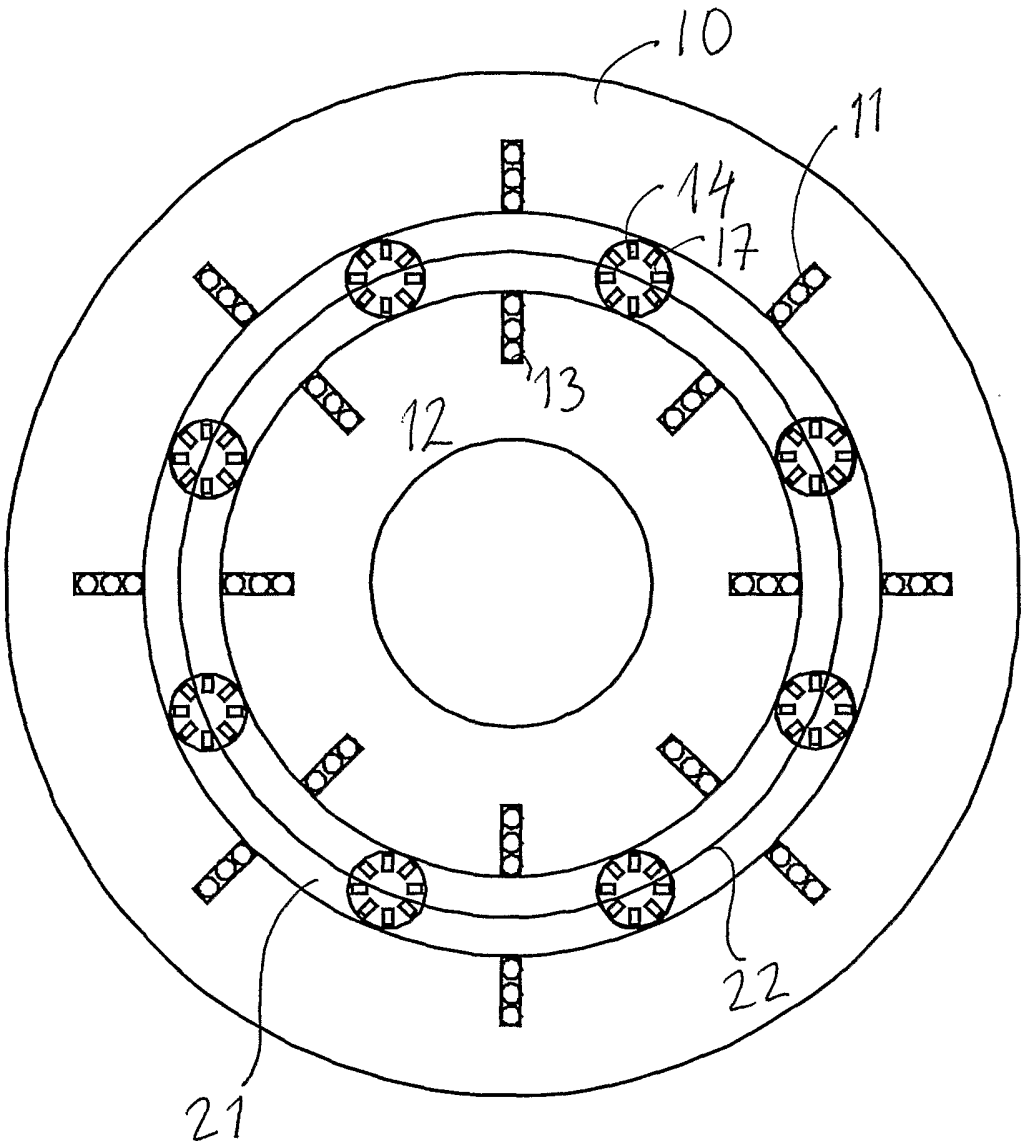


Fig. 5

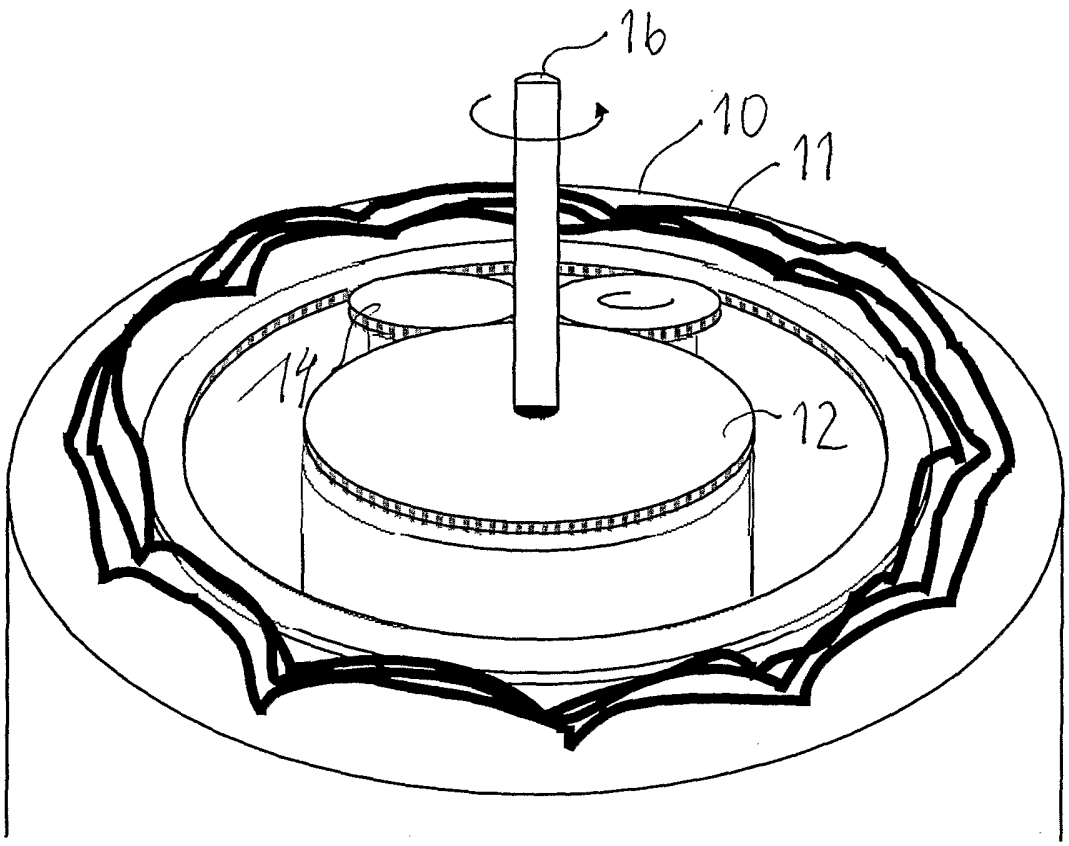


Fig. 6

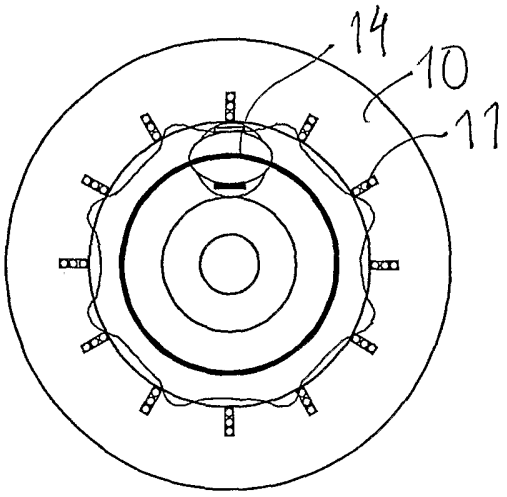


Fig. 7

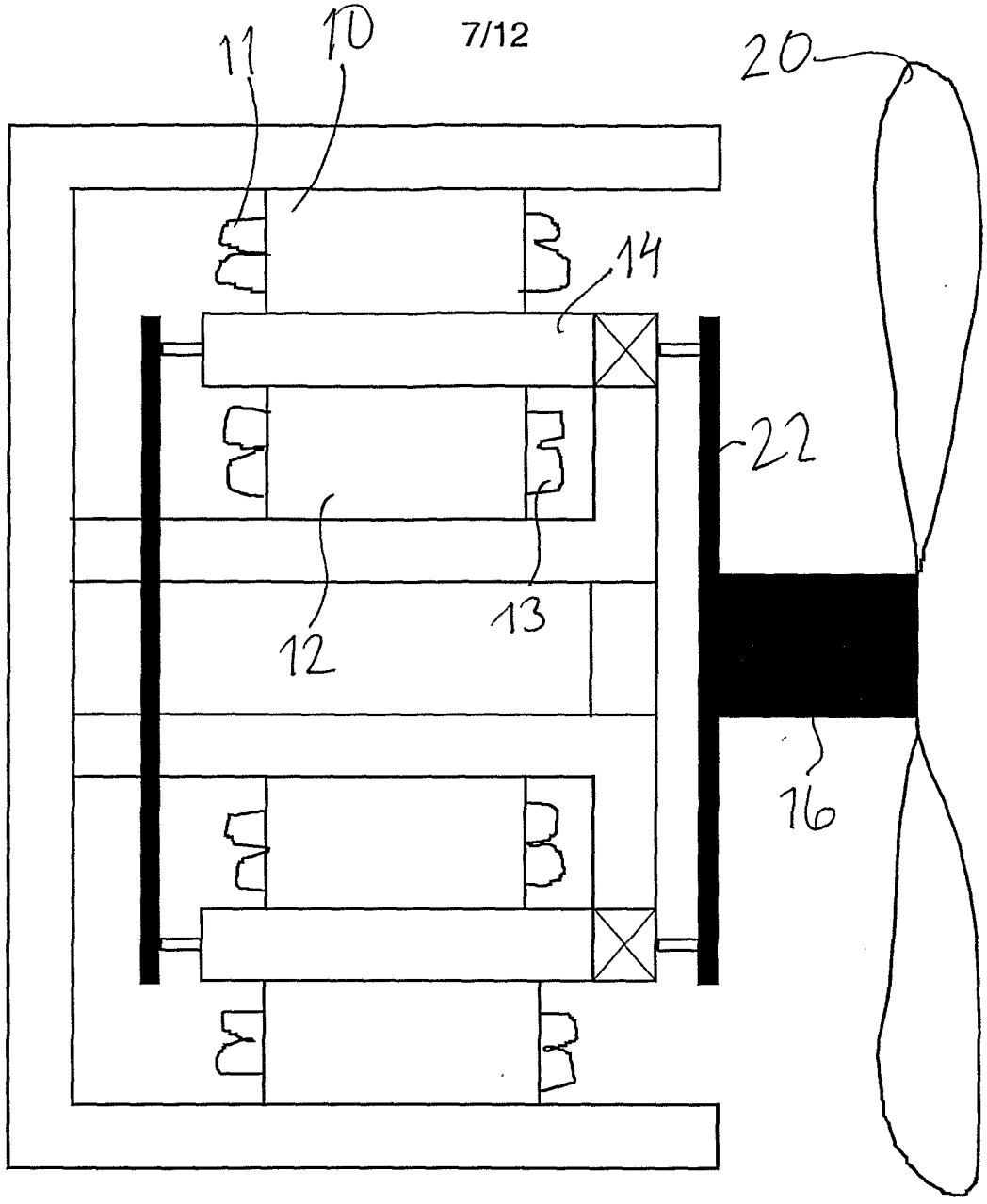


Fig. 8

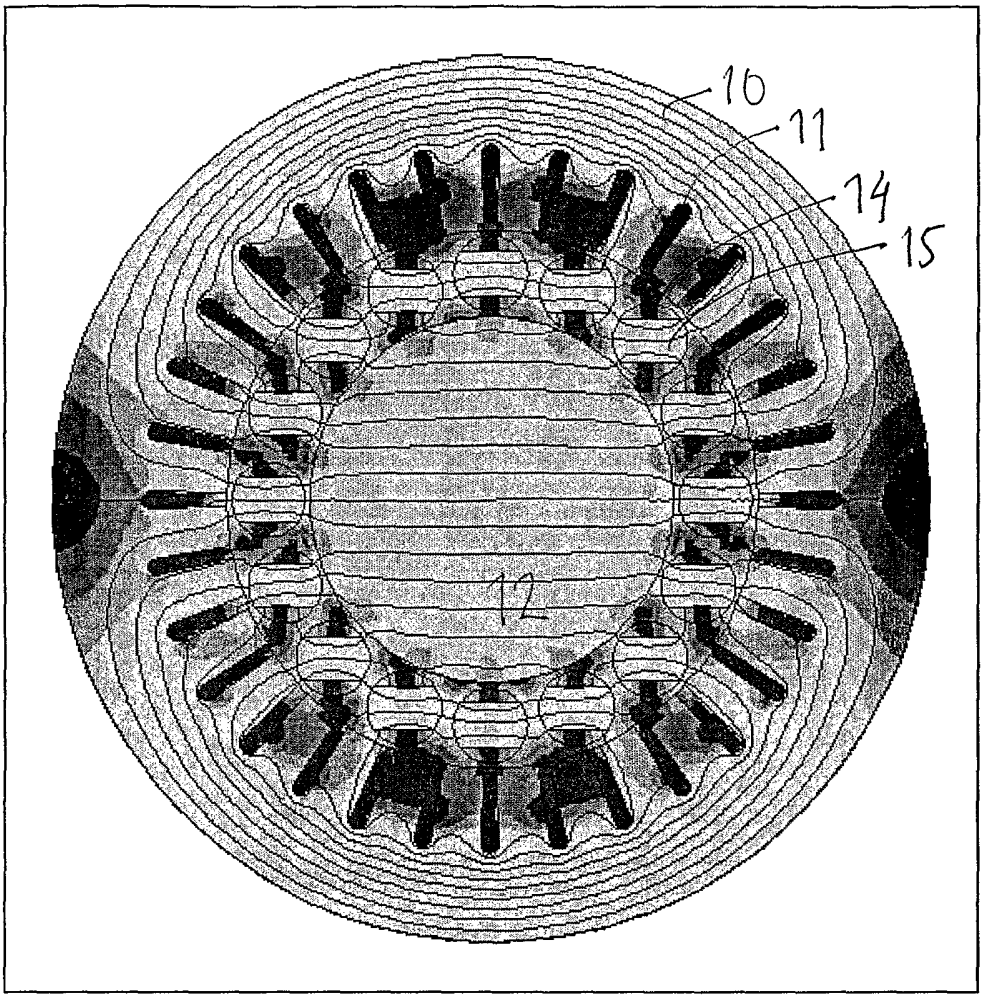


Fig. 9

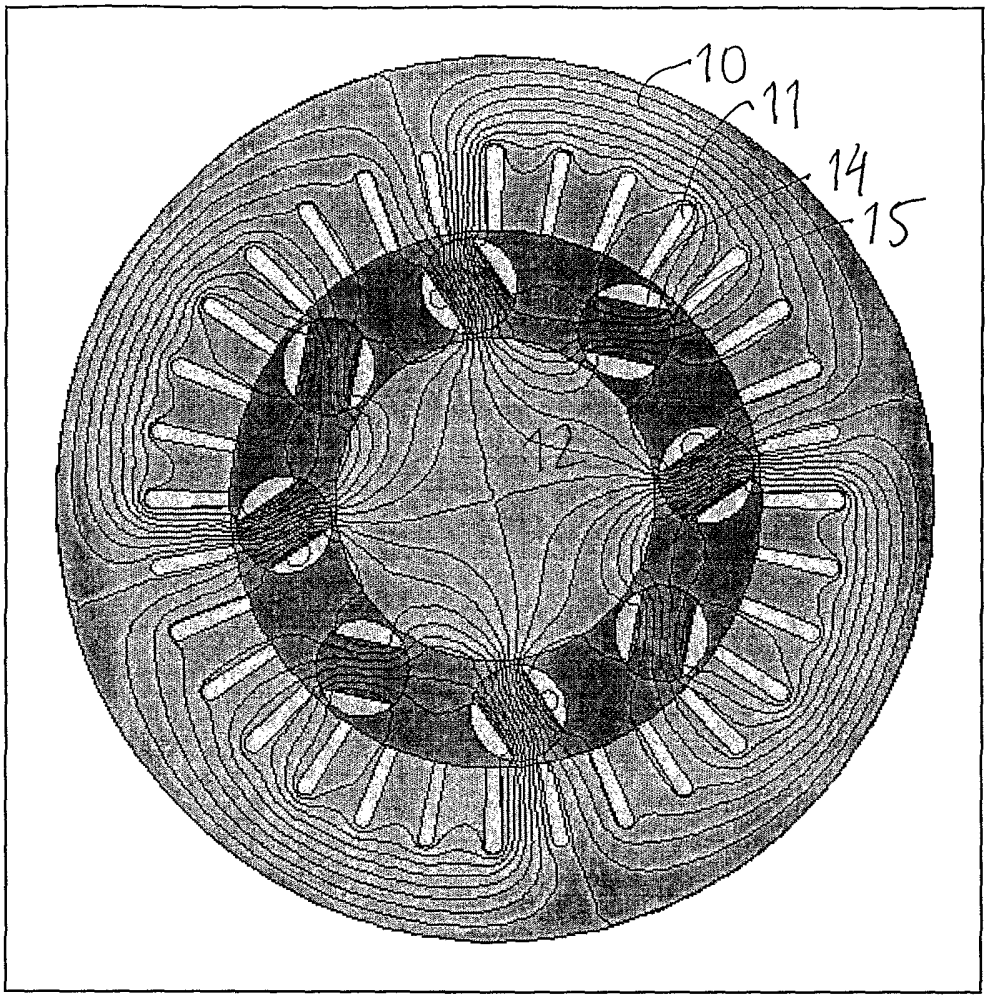


Fig. 10

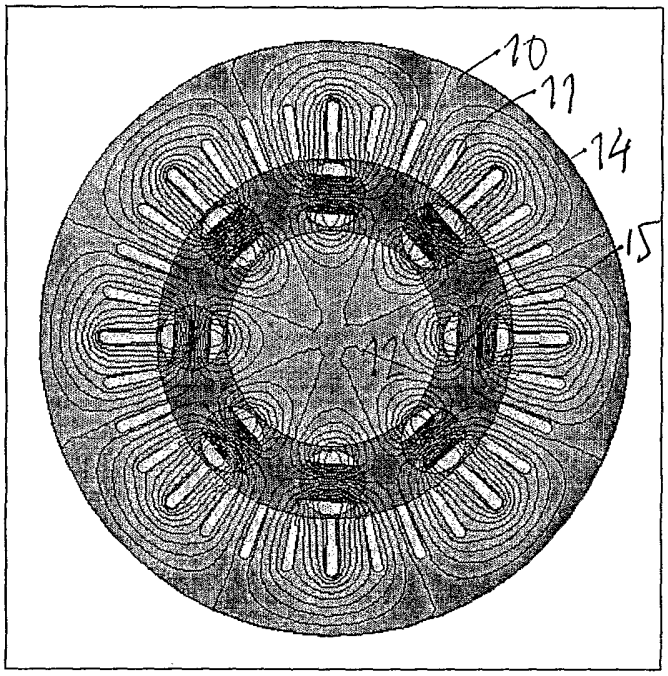


Fig. 11a

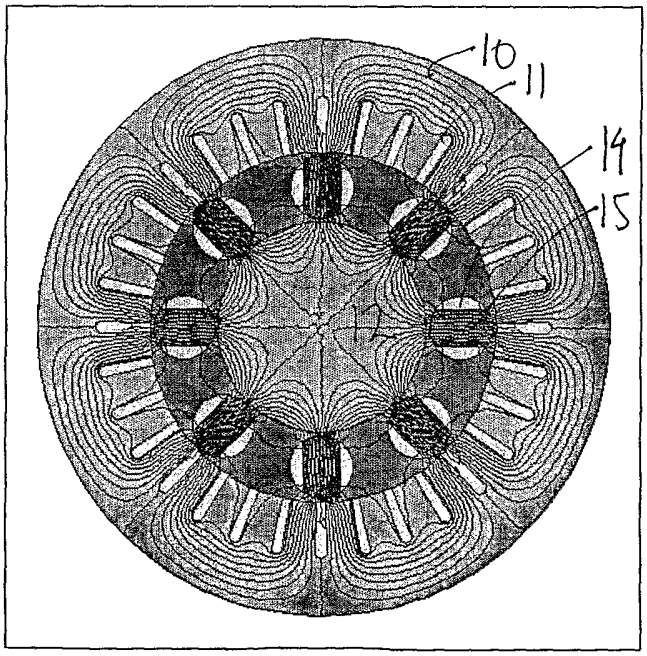


Fig. 11b

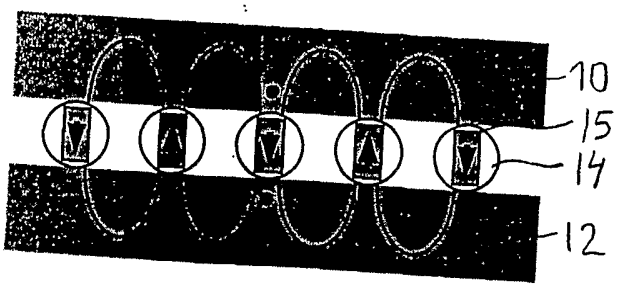


Fig. 12a

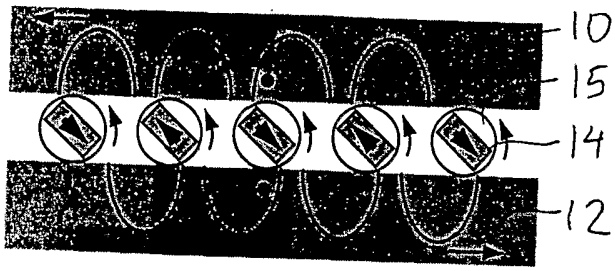


Fig. 12b

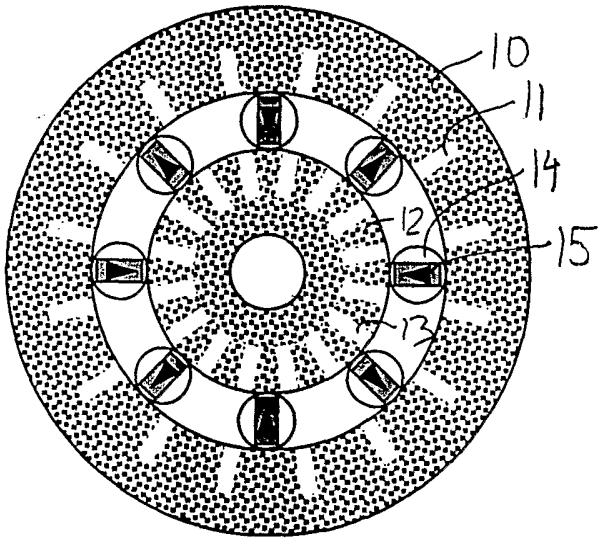


Fig. 13

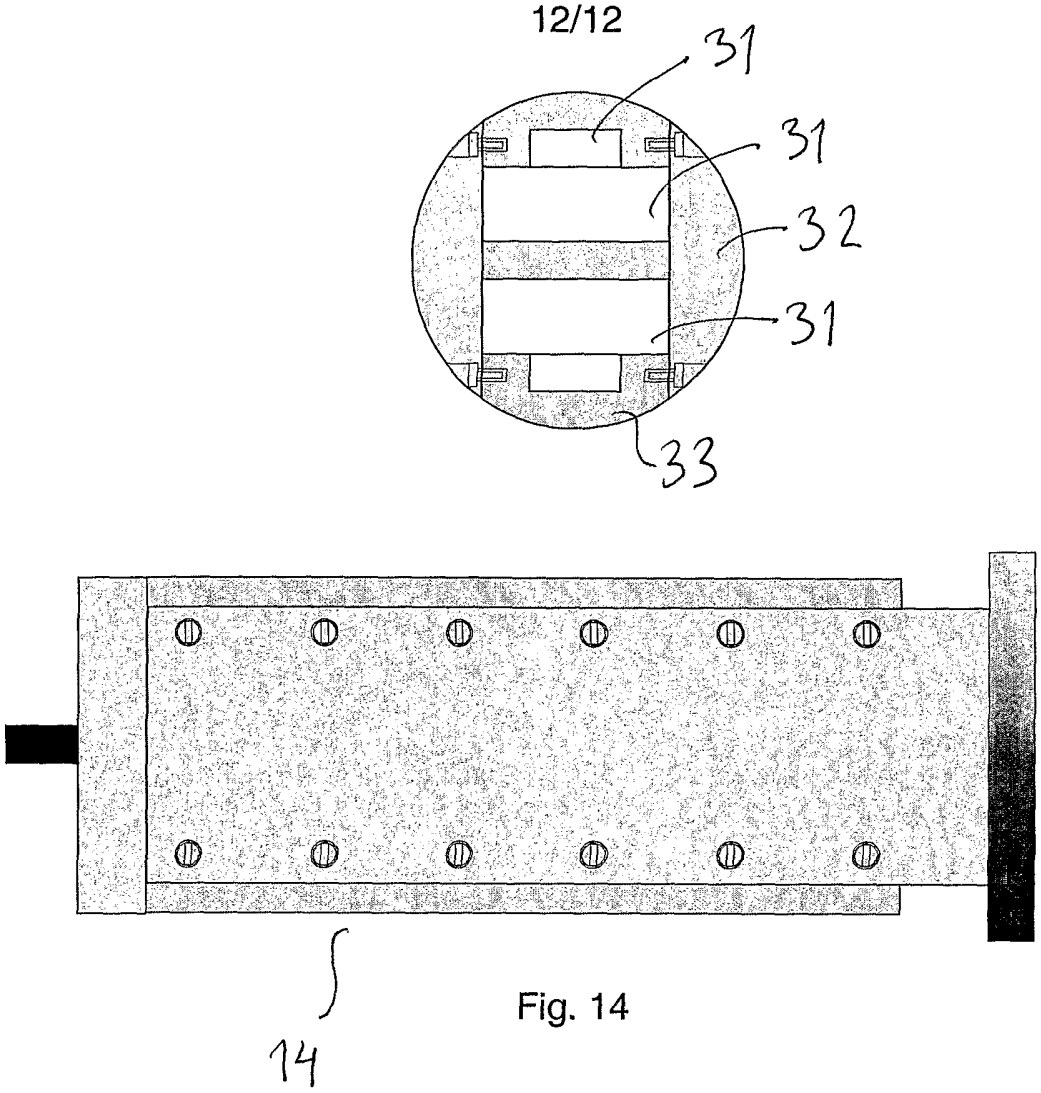


Fig. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00901

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H02K 16/00, H02K 21/12, H02K 41/06
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 BRODERICK PITT-STEELE), 30 March 1994 (30.03.94), page 2, line 7 - page 3, line 10; page 9, line 10 - page 12, line 33	1-37
A	WO 0021183 A1 (ROBERT BOSCH GMBH), 13 April 2000 (13.04.00), page 3, line 30 - page 6, line 27	1-37
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
A	US 4752706 A (MESZAROS, L.G.), 21 June 1988 (21.06.88), abstract	1

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

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 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

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

Information on patent family members

06/07/02

International application No.
PCT/SE 02/00901

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		DE 19845914 A,C	13/04/00
		EP 1119895 A	01/08/01
US 4734621 A	29/03/88	EP 0230651 A	05/08/87
		FR 2592520 A,B	03/07/87
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US 4752706 A	21/06/88	CA 1191535 A	06/08/85