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Other: **ONLINE: WPI, EPODOC**

(54) Title of the Invention: **An electrical machine**
Abstract Title: **A stator assembly incorporating permanent magnets and wound field poles for an inductor machine.**

(57) The stator 102 comprises a plurality of circumferentially spaced-apart stator poles 114. comprising armature poles 116 and at least one field pole 118, each armature pole 116 having an armature winding 122 arranged thereabout and comprising a slot 128 having a radially-extending circumferentially-polarised permanent magnet 130 located therein. The or each field pole 118 comprises a field winding 132 which is arranged, in use, to carry a direct current. Various numbers of passive rotor poles are disclosed.

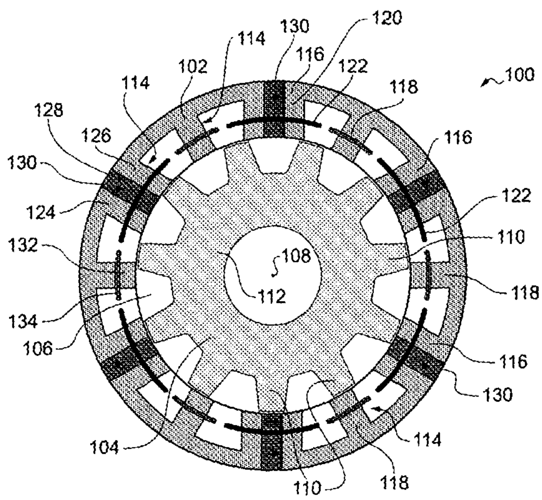

FIG. 2

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

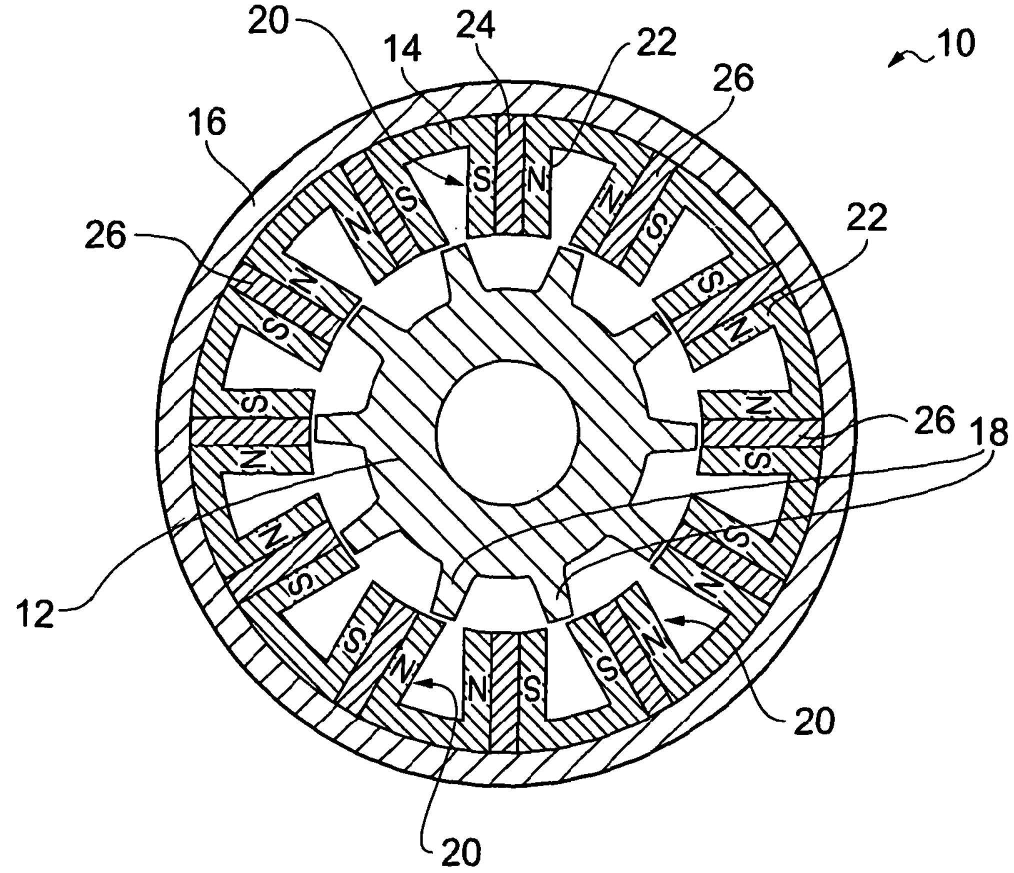
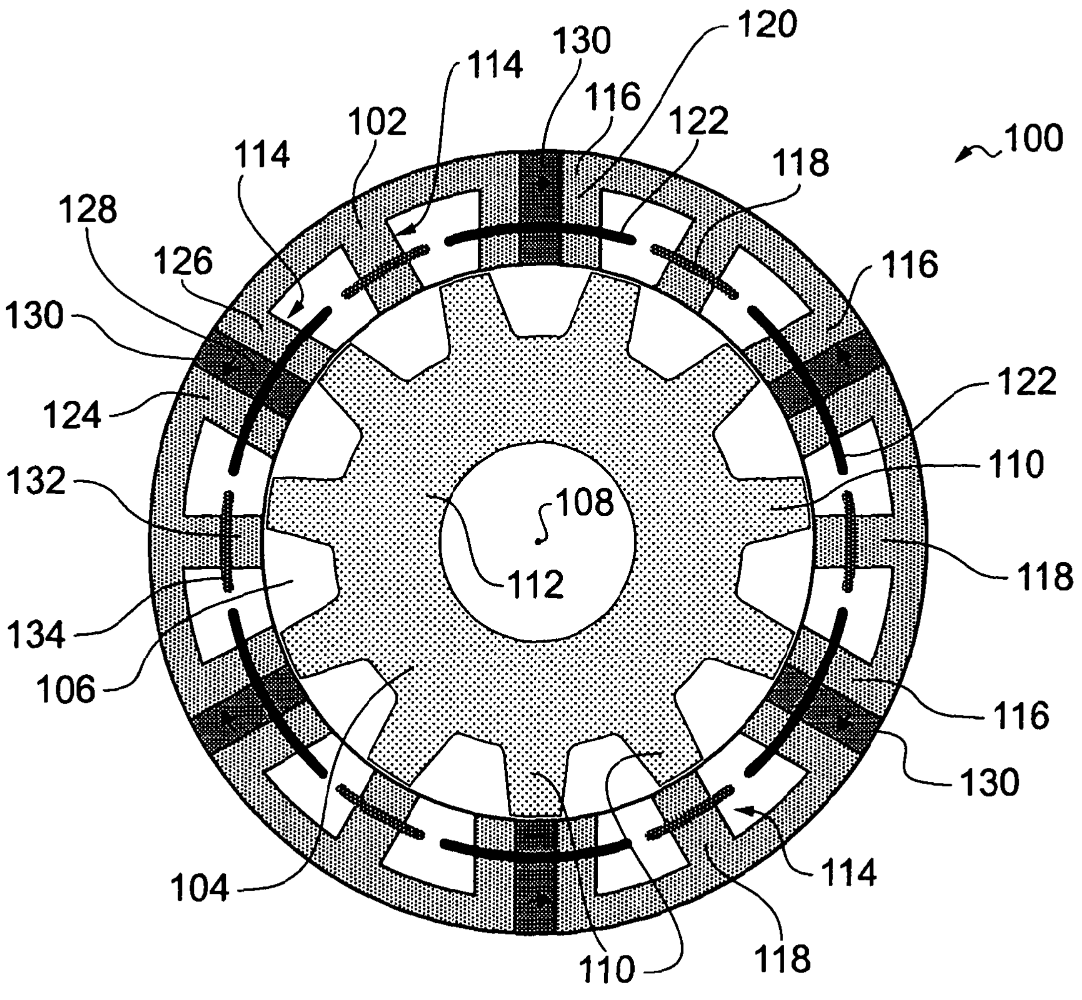


FIG. 1


100
102
104
106
108
110
110
112
114
114
114
116
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118
118
118
120
122
122
124
126
128
130
130
130
132
134

FIG. 2

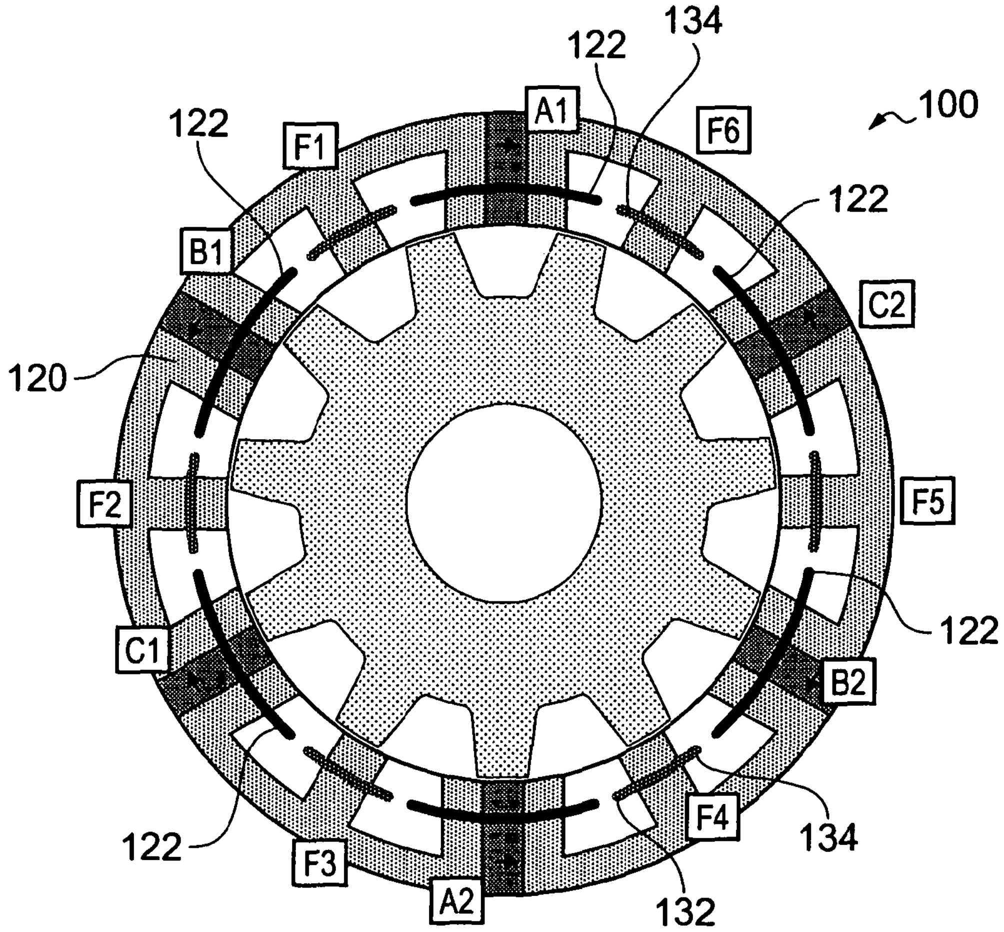
134
122
100
A1
F6
F1
122
122
B1
C2
120
F2
F5
122
C1
B2
F4
134
122
F3
A2
132

FIG. 3

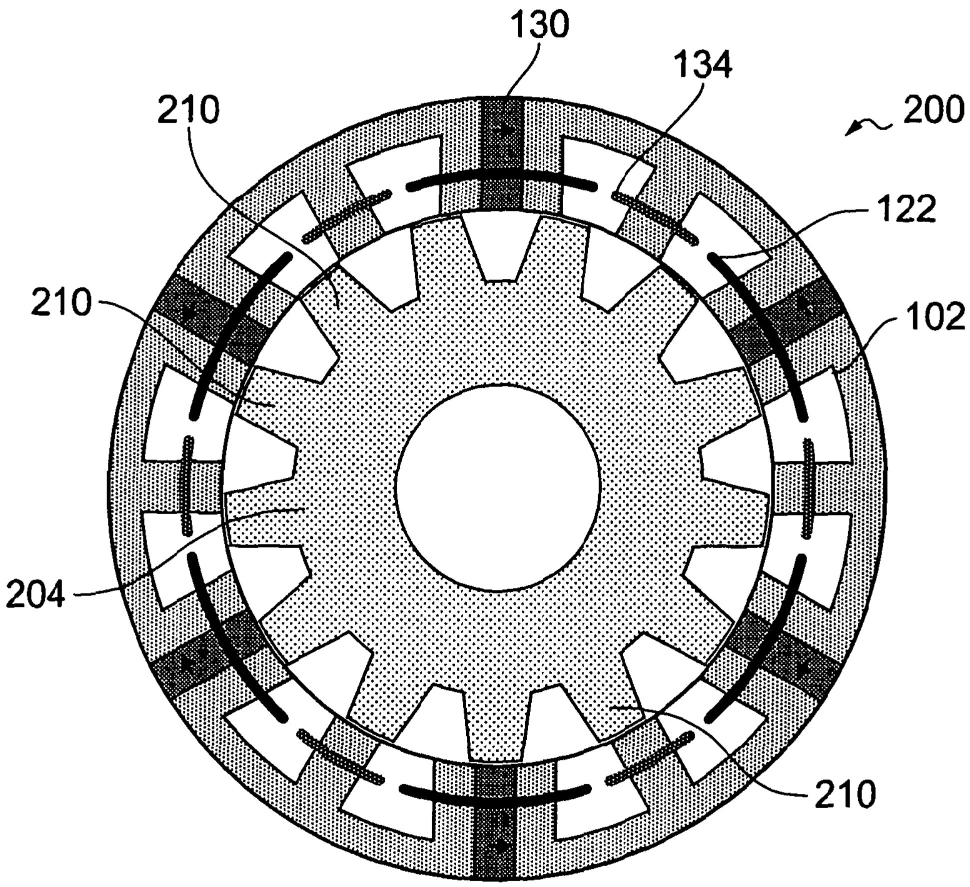

FIG. 4

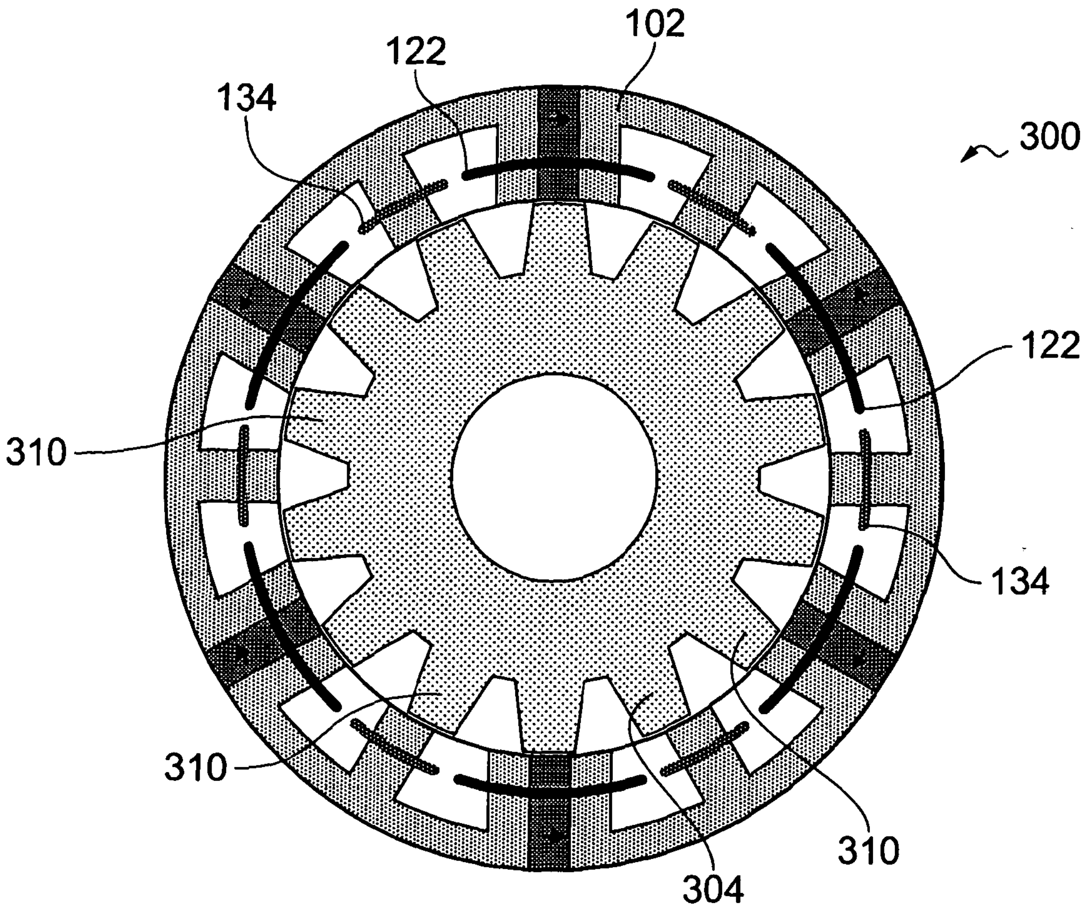

FIG. 5

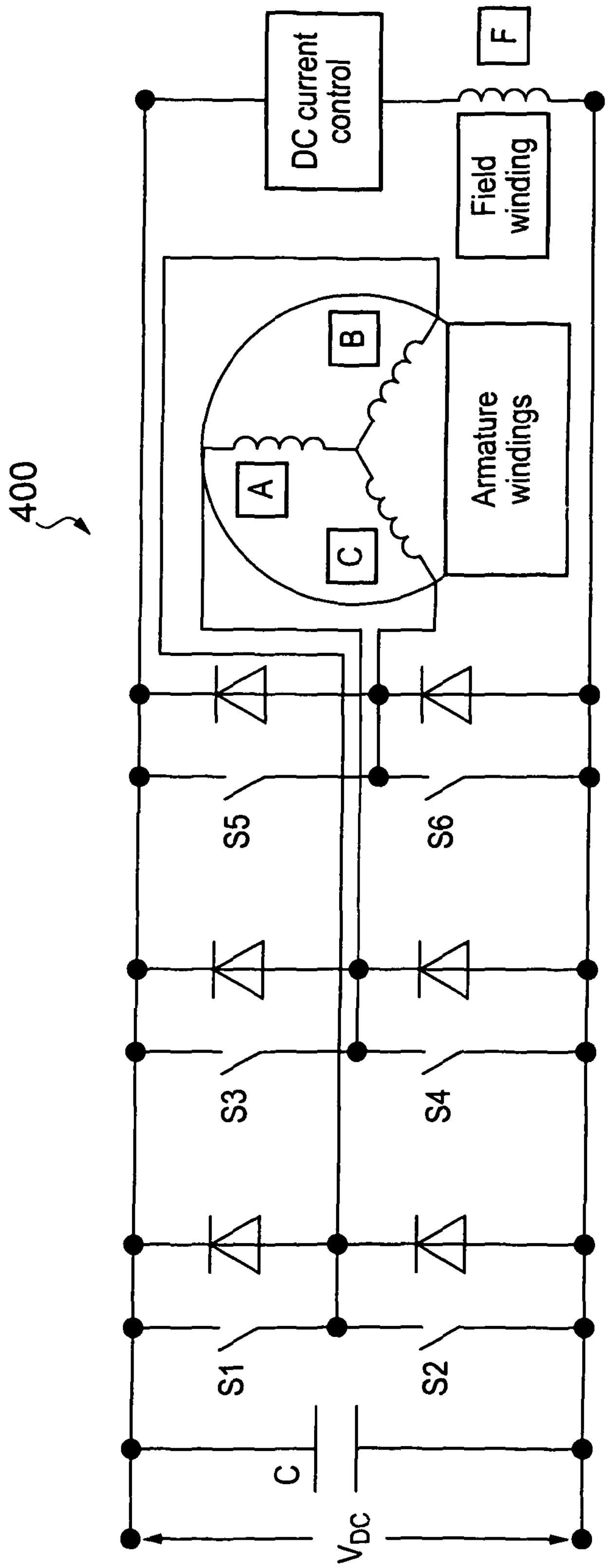
DC current control
F
Field winding
B
A
C
Armature windings
400
S5
S6
S3
S4
S1
S2
C
V_{DC}

FIG. 6

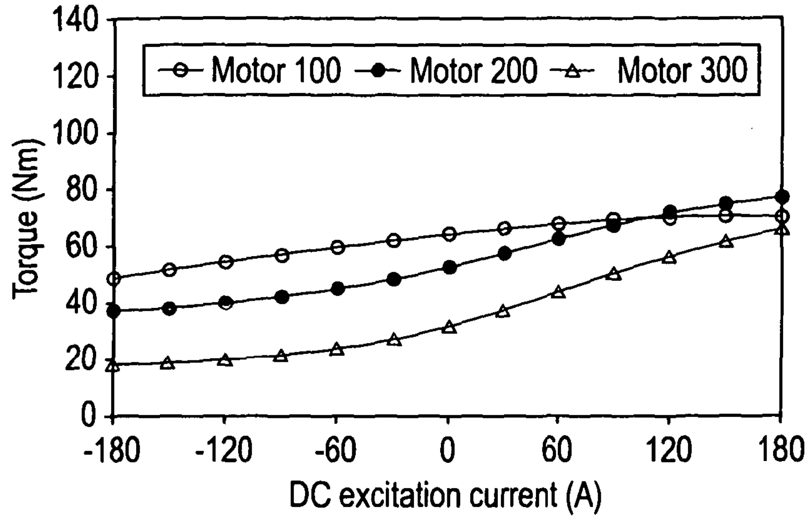

FIG. 7

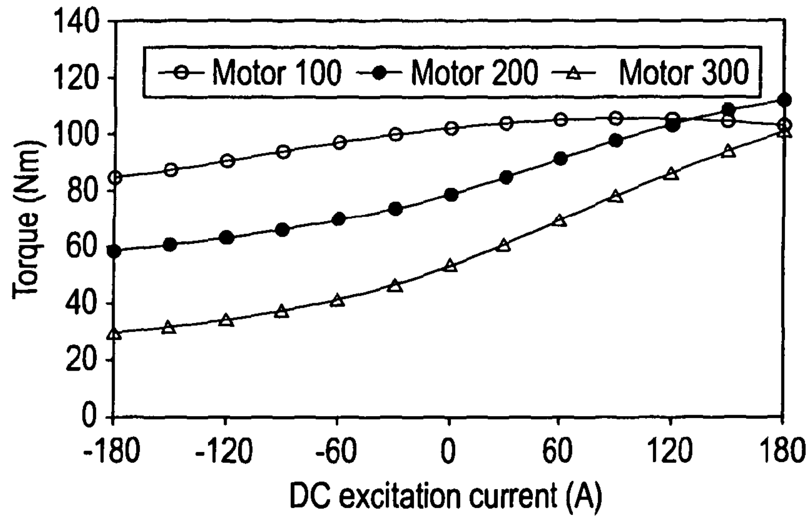

FIG. 8

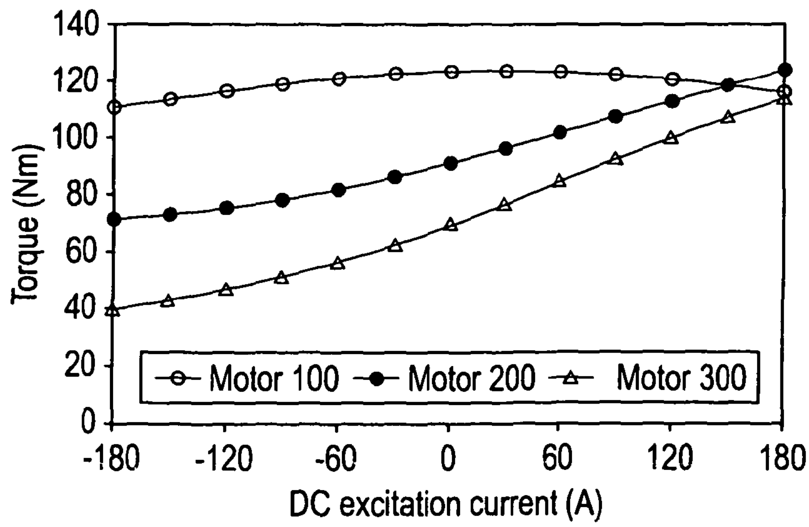

FIG. 9

24 6 09

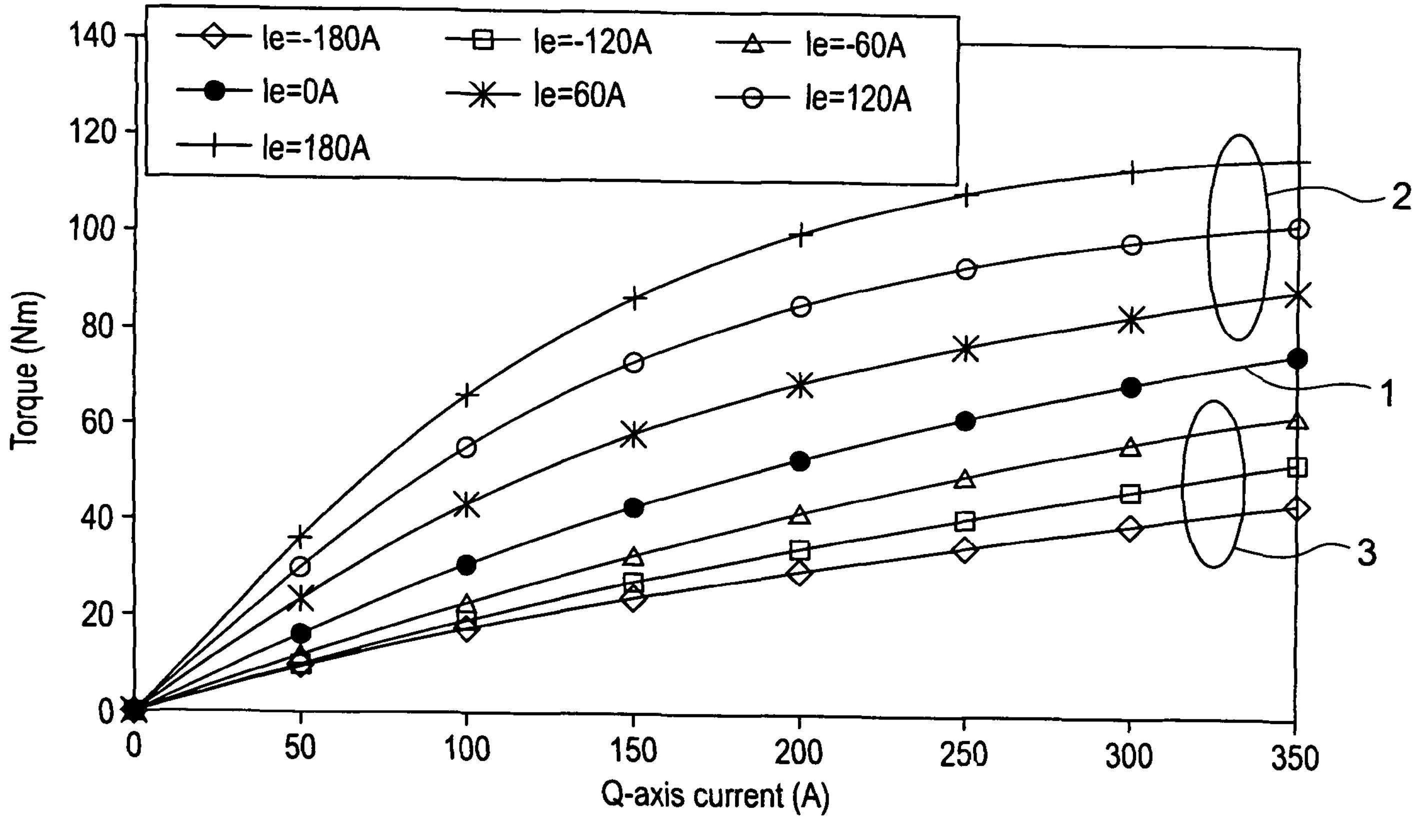
Ie=-180A
Ie=-120A
Ie=-60A
Ie=0A
Ie=60A
Ie=120A
Ie=180A
Torque (Nm)
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
Q-axis current (A)
1
2
3

FIG. 10

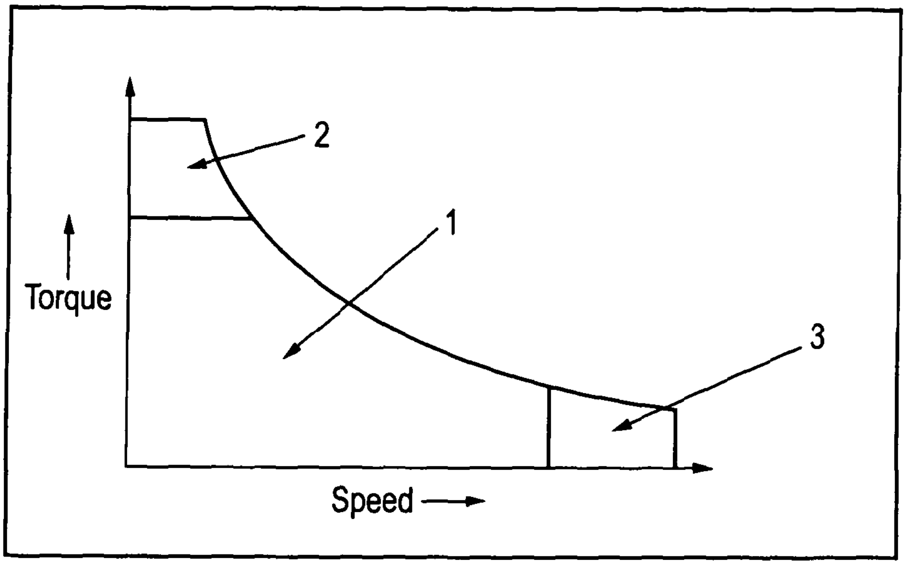

FIG. 11

An Electrical Machine

The present invention relates to an electrical machine. Particularly, but not exclusively, the present invention relates to an electrical machine having enhanced performance. The present invention may be applied to motors and to generators.

A known electrical machine is described and illustrated in the paper "Switching flux permanent magnet polyphased synchronous machines" by Emmanuel HOANG, Abdel Hamid BEN AHMED and Jean LUCIDARME, published in the EPE'97 conference proceedings, pages 3.903 to 3.908, 1997. Such machines comprise a passive salient pole rotor and a number of stator poles.

Figure 1 shows an example of a known three phase salient pole motor. The motor 10 comprises a salient pole rotor 12 and a stator 14. The stator 14 is enclosed within an outer housing 16. The rotor has ten salient rotor poles 18 and the stator has twelve stator poles 20. Each stator pole 20 comprises a tooth 22 having a slot 24 formed therein. A radially-extending permanent magnet 26 is located in each slot 24. The permanent magnets 26 are polarised circumferentially as indicated by the arrows. As indicated in Figure 1, adjacent magnets 26 are oppositely polarised. Armature windings (not shown) extend around the teeth 22 of the stator poles 20. The armature windings are connected in three phases and can be energised by known machines.

A motor is generally optimised for a specific operating range. For example, in the case of a motor such as that shown in Figure 1, incorporating magnets with a higher field strength will increase the available torque at low speeds but will reduce the maximum speed at which the motor can efficiently operate because the electromotive force (emf) generated in the motor becomes correspondingly higher as the speed of the motor increases. A motor cannot operate when the generated emf exceeds the supply voltage to the motor.

Concomitantly, incorporating magnets having a lower field strength will reduce the available torque at low speeds but will increase the maximum speed at which the motor can efficiently operate because the electromotive force (emf) generated in the motor will be not exceed the fixed supply voltage of the motor until a greater motor speed is reached.

It is also known to provide a motor arrangement in which the field strength experienced by the rotor can be controlled. In the paper "A New Structure of a Switching Flux Synchronous Polyphased Machine with Hybrid Excitation" by Emmanuel HOANG, Michel LECRIVAIN and Mohamed GABSI, EPE 2007, a flux switching electrical machine is disclosed. The electrical machine has a plurality of stator poles comprising permanent magnets, and a number of field coils located radially outwardly of the magnets and electromagnetically coupled thereto. The current through the field coils can be varied to boost or to weaken the field generated by the permanent magnets.

It is an object of the present invention to provide an improved electrical machine. It is a further object of the present invention to provide an electrical machine with which is able to provide good torque delivery at low speeds and which is also efficient in high speed operation.

According to the present invention there is provided an electrical machine comprising a passive rotor and a stator, the stator comprising a plurality of circumferentially spaced-apart stator poles, the stator poles comprising armature poles and at least one field pole, each armature pole having an armature winding arranged thereabout and comprising a slot having a radially-extending circumferentially-polarised permanent magnet located therein, and the or each field pole comprising a field winding which is arranged, in use, to carry a direct current.

By providing such an arrangement, the field winding can be energised in a first current direction such that the field winding boosts the torque of the motor. However, for high speed operation, the field winding can be energised in a second current direction opposite to the first current direction such that the field winding weakens the torque generated by the motor. This regime is beneficial in enabling the motor to operate at higher speeds. Consequently, by providing a motor which is able to operate in different torque/speed regimes, the versatility of the motor is increased.

In one variation, a plurality of field poles are provided, consecutive stator poles alternately comprising armature poles and field poles. This arrangement provides even distribution of torque and maximises the performance of the motor. Further, the magnet volume in the stator is reduced when compared to a conventional arrangement comprising only armature poles. This reduces magnet losses in the electrical machine and reduces the cost of manufacture thereof.

In a further variation, an equal number of armature poles and field poles are provided. In the present embodiments, six armature poles and six stator poles are provided. This arrangement has been found to deliver good performance.

It is useful for each field pole to be located between adjacent armature poles in the circumferential direction. This arrangement results in a compact stator arrangement because the armature poles and field poles are distributed at essentially similar radial distances from the stator bore.

It is desirable that the or each field pole comprises a unitary stator tooth. Preferably, the field poles are permanent magnet-free. This reduces the magnet volume in the electrical machine, making the manufacture more straightforward when compared to conventional arrangements.

Preferably, the armature windings of the armature poles are connected to a source of AC power. In order to rotate the rotor, the current through the armature windings must be alternating. A variety of AC sources may be used as appropriate.

In one arrangement, the armature windings of the armature poles are connected in three phases. A three phase system is cost-effective to implement and has performance benefits.

Preferably, the field windings of the field poles are connected to a source of DC power, more preferably in series. The field poles are required to generate, in use, a substantially constant field and so require a DC power source. An advantage of a DC power source is that it does not require complex control mechanisms. Therefore, it is cost-effective to implement.

It is useful that the or each field winding is arranged such that when a DC current is applied in a first direction, the magnetic field generated by the at least one field pole is arranged to increase the torque experienced by the rotor, and when a DC current is applied in a second direction the magnetic field generated by the at least one field pole is arranged to reduce the torque experienced by the rotor.

In one arrangement, the electrical machine may take the form of a motor, preferably a flux switching permanent magnet motor.

In an alternative arrangement, the electrical machine may take the form of a generator.

An embodiment of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a front cross-section of a known three phase salient pole motor;

Figure 2 is a front cross-section of a three phase salient pole motor in accordance with a first embodiment of the present invention;

Figure 3 is a front cross-section of the motor of Figure 2 showing the three phase configuration as a function of stator poles;

Figure 4 is a front cross-section of a three phase salient pole motor in accordance with a second embodiment of the present invention;

Figure 5 is a front cross-section of a three phase salient pole motor in accordance with a third embodiment of the present invention;

Figure 6 is a schematic of a suitable drive circuit for the motors of Figures 2 to 5;

Figure 7 is a graph showing electromagnetic torque (on the Y-axis) as a function of DC excitation current passing through field windings (on the X-axis) for the first, second and third embodiments under a Q-axis armature current of 100 A;

Figure 8 is a graph showing electromagnetic torque (on the Y-axis) as a function of DC excitation current passing through field windings (on the X-axis) for the first, second and third embodiments under a Q-axis armature current of 200 A;

Figure 9 is a graph showing electromagnetic torque (on the Y-axis) as a function of DC excitation current passing through field windings (on the X-axis) for the first, second and third embodiments under a Q-axis armature current of 300 A;

Figure 10 is a graph showing torque (on the Y-axis) as a function of Q-axis current through the armature coils (on the X-axis) for the motor of the third embodiment; and

Figure 11 is a graph showing torque (on the Y-axis) against speed (on the X-axis) for the motor of the first, second and third embodiments when operating under different field pole energisation states.

Figure 2 shows a three-phase motor 100 according to the present invention. The motor 100 comprises a stator 102 and a rotor 104 rotatable with respect thereto. The stator 102 is formed from a laminated ferromagnetic material (such as, for example, iron) and has a stator bore 106 formed therein.

The rotor 104 is rotatably located in the stator bore 106 about an axis 108 relative to the stator 102. The rotor 104 is a passive rotor. By this is meant that the rotor does not comprise any windings (for example, armature windings) or permanent magnets which may generate a magnetic field. The rotor 104 has a plurality of salient rotor poles 110 (in this case, eleven) which are arranged about a rotor hub 112. The rotor hub 112 and rotor poles 110 are formed from a laminated ferromagnetic material (such as, for example, iron).

The stator 102 comprises a plurality of stator poles 114 (in this case, twelve) facing radially inwardly towards the stator bore 106. The stator poles 114 are all magnetically coupled to one another through the stator 102.

Consecutive stator poles 114 alternately comprise armature poles 116 and field poles 118. By this is meant that, moving consecutively around the inner circumference of the stator 102, the stator poles 114 comprise an armature pole 116, a field pole 118, an armature pole 116 and so on. Consequently, a field pole 118 is located on either side of an armature pole 116.

Each armature pole 116 comprises an armature stator tooth 120 and an armature winding 122 extending thereabout. Six armature poles 116 are provided in this embodiment. The stator teeth 120 of each armature pole 116 have a first tooth portion 124 and a second tooth portion 126. The first and second tooth portions 124, 126 are spaced by a radially-extending slot 128. A radially-extending permanent magnet 130 is located in each slot 128. The permanent magnets 130 are polarised circumferentially. Alternate permanent magnets 130 are polarised in opposite directions as indicated by the arrows in Figure 2.

Each armature winding 122 is wrapped around a stator tooth 120 in a racetrack shape when viewed in a radial direction. The armature windings 122 of the armature poles 116 are connected to a source of AC power and are connected in three phases A, B and C. Each phase group A, B, C comprises two armature windings 122 connected in series. Consequently, as shown in Figure 2, phase A has armature windings A1 and A2, phase B has armature windings B1 and B2 and phase C has armature windings C1 and C2.

As shown in Figure 3, the two armature poles 116 in each phase group A, B or C are diametrically opposed to one another. The armature windings 122 are connected to a three phase AC source and can be energised by a circuit such as that shown in Figure 6 and which will be described later.

Each field pole 118 comprises a field stator tooth 132 and a field winding 134 extending thereabout. Six field poles 118 are provided in this embodiment. These are labelled F1 to F6 in Figure 3. Each stator tooth 132 is unitary and comprises neither a slot nor a permanent magnet. Each field winding 134 is coiled (or wrapped) around a stator tooth 132 in a racetrack shape when viewed in a radial direction. The field windings 134 of the field poles 118 are connected in series (i.e. F1 to F6 are connected in series). The field windings F1 to F6 are connected to a source of DC power such as that shown in Figure 6 and which will be described later. The polarity of the current flowing through the field windings 134 determines whether the field generated by the field windings 134 either increases (i.e. boosts) or diminishes (i.e. weakens) the torque of the motor 100. In other words, the polarity of the current through the field windings 134 determines whether the field generated by the field windings 134 either assists or counteracts the field generated by the permanent magnets 130.

Since each of the armature windings 122 and field windings 134 only extend around a single stator tooth 120, 132, the windings 122, 134 are circumferentially spaced from one another. Consequently, there is no overlap between adjacent windings 122, 134. In other words, each stator tooth 120, 132 only carries (or is located adjacent) a single type of winding (i.e. armature winding or field winding).

Six armature poles 116 are provided in this embodiment. This is half the number of armature poles 116 provided in the conventional arrangement shown in Figure 1. This reduces the magnet volume in the stator 102, reducing magnet losses and enabling manufacture to be more cost effective.

Figure 4 illustrates a second embodiment of the present invention. The motor 200 of the second embodiment has a stator which is substantially similar to the stator 102 of the first embodiment. Consequently, identical reference numerals to the first embodiment have been used to denote the stator 102 and parts thereof. The difference between the first and second embodiments lies in that the rotor 204 of the second embodiment comprises thirteen salient poles 210, in contrast to the first embodiment which has eleven poles. The ratio of thirteen rotor poles 210 to six armature poles 116 has also been found to be particularly effective. Multiples thereof (e.g. twelve armature poles 116 to twenty six rotor poles 210) has also been found to be effective.

Figure 5 illustrates a third embodiment of the present invention. The motor 300 of the third embodiment has a stator 102 which is substantially similar to the stator 102 of the first embodiment. Consequently, identical reference numerals to the first embodiment have been used to denote the stator 102 and parts thereof. The difference between the third and the first or second embodiments lies in that the rotor 304 of the third embodiment comprises fourteen salient poles 310, in contrast to the first embodiment which has eleven poles. The ratio of fourteen rotor poles 310 to six armature poles 116 has also been found to be particularly effective and to give good control of torque with current through the field windings 134. Multiples thereof (e.g. twelve armature poles 116 to twenty eight rotor poles 310) has also been found to be effective.

Figure 6 shows a drive circuit 400 suitable for driving the motors 100, 200, 300 of the first to third embodiments shown in Figures 2 to 5. A DC supply voltage V_{DC} is applied between a positive rail and a ground rail. A capacitor C is connected between the positive and ground rails.

A switch arrangement including switches S1 to S6 and an array of diodes are provided in order to control the current and voltage delivered to each of the three phases A, B, C. The switches S1 to S6 can comprise any suitable switching devices; for example, power MOSFETs or Insulated Gate Bipolar Transistors (IGBTs) could be used. As shown in Figure 6, each of the armature windings 122 corresponding to phase A are connected in series. Each of the armature windings 122 corresponding to phase B and each of the armature windings 122 corresponding to phase C are connected in series respectively.

A DC current control is located between the positive and ground rails and is arranged in series with the field winding F (which is connected to the field windings F1 to F6, each connected in series). The DC current control can take any suitable form which enables a) current magnitude variation and b) current direction variation.

In use, the armature windings 132 are supplied with an alternating current in three phase which reverses in polarity with the passing of each rotor pole 110, 210, 310. This process continues for each of the three phases A, B, C. The phases A, B, C are arranged in order to energise the relevant poles at the correct time. As shown in Figure 3, each armature pole 116 is offset from an adjacent armature pole 116 by an angle of 60 °.

The field windings 134 of the field poles 118 are energised by the DC current control shown in Figure 6. The field windings 134 are supplied with a DC current which is bidirectional and can be varied substantially continuously depending upon the operational requirements of the motors 100, 200, 300. A particular current value generates a particular torque output from the motor 100, 200, 300. Consequently, the torque output of the motor 100 can be varied by increasing the direct current supplied to the field windings 134 in either a positive (or first) direction or a negative (or second) direction respectively.

Figures 7 to 9 show a graph of torque (on the Y-axis) against DC excitation current (on the X-axis) for the first (open circles), second (closed circles) and third (open triangles) embodiments (i.e. for motors 100, 200 and 300 respectively). Torque is measured in Newton-metres (Nm) and current in Amps (A). The winding packing factor Kp is equal to 0.6. Figure 7 shows the results for the first, second and third embodiments with a Q-axis current through the armature coils 122 of 100 A. Figure 8 shows the results for the first, second and third embodiments with a Q-axis current through the armature coils 122 of 200 A. Figure 9 shows the results for the first, second and third embodiments with a Q-axis current through the armature coils 122 of 300 A.

As shown in Figures 7 to 9, the motor 100 of the first embodiment has the largest torque value of the three embodiments when zero current is applied to the field windings 134. However, the torque of the motor 100 (which is proportional to the flux through the rotor 110) can only be varied by a relatively small amount through energisation of the field windings 134 in either a positive (or first) direction or a negative (or second) direction respectively.

In contrast, the motor 300 of the third embodiment having fourteen rotor poles 310 shows the greatest variation in torque per unit DC excitation current through the field windings 134. Consequently, the torque of the motor 300 (which is proportional to the flux through the rotor 310) can be boosted or weakened significantly by energisation of the field windings 134 in either a positive (or first) direction or a negative (or second) direction respectively. However, the motor 300 of the third embodiment also shows the poorest torque performance of the three embodiments when zero current is applied to the field windings 134.

Figure 10 shows a graph of Torque (on the Y-axis) against Q-axis current through the armature windings 122 (on the X-axis) for the motor 300 of the third embodiment.

Line 1 shows the characteristics of the motor 300 when no current is applied to the field windings 134. The lines marked 2 illustrate three different excitation currents (Ie) when applied to the field windings 134. In this case, the currents are applied in a first, positive direction. As clearly shown, as the current increases in 60 A steps, the torque output of the motor 300 improves as a function of armature current. This provides more torque across a broader speed range than a conventional motor arrangement such as that shown in Figure 1.

The line marked 3 shows three different excitation currents (Ie) when applied to the field windings 134 in a second, negative, direction. As clearly shown, when the current is increased in the negative direction in 60 A steps, the torque output of the motor 300 decreases as a function of armature current. This reduces the torque output for a given armature current. This arrangement can be beneficial when it is desired to operate a motor at high speed, because although the torque output is lower, the generated emf in the motor 300 is correspondingly lower, enabling the motor 300 to reach higher speeds before the generated emf equals or exceeds the supply voltage V_{DC}. This gives the motor 300 the ability to operate in a wider torque-speed regime than the arrangement shown in Figure 1.

Figure 11 shows a graph of torque (on the Y-axis) as a function of motor speed (on the X-axis). As described previously, in region 1 where no excitation current is applied to the field windings 134 (i.e. the motors 100, 200, 300 are operating in the manner of a conventional motor such as that shown in Figure 1), the motors 100, 200, 300 have a maximum torque at low speed and a maximum operating speed dictated by generated emf at high speed. However, the present invention provides the embodiments of the present invention to operate more effectively in these regimes.

By providing a positive current excitation to the field windings 134 in order to boost the flux through the rotor, the torque output of the motor can be usefully boosted at low speeds when compared to a known motor arrangement such as that shown in Figure 1. This is shown in region 2 of Figure 6.

However, for high speed operation, a negative current excitation can be applied to the field windings 134 in order to weaken the flux through the rotor. Whilst this reduces the available torque per unit armature current, the emf generated by the motor is correspondingly reduced such that the motor is able to operate at higher speeds without the generated emf exceeding the supply voltage V_{DC}.

Known motors are designed to have specific operating characteristics, e.g. low speed and high torque, or low torque and high speed. However, a motor 100, 200, 300 according to the present invention and as described in the above embodiment enables a single motor design to operate efficiently under both regimes, i.e. high torque/low speed and high speed/low torque.

The benefits of the present invention are also applicable to electrical machines such as generators. Generators incorporating the present invention are able to operate efficiently over much greater speed ranges.

Additionally, the present invention has the added advantage that, under no coil excitation, the torque output as a function of current is lower than that for a known motor arrangement. This means that the apparatus is fail-safe because a loss of power to the field windings will reduce will prevent the motor 100, 200, 300 from running out of control.

Although the invention has been described with reference to the above specific examples, the invention is not limited to the detailed description given above. Variations will be apparent to the person skilled in the art.

Whilst the invention has been described by way of example to three phase machines, it may be applied to machines of other numbers of phases. Whilst the invention has been described by way of example to a motor, the invention is also applicable to corresponding generators.

Additionally, the location and/or configuration of the field poles and field windings may take any suitable form. Only one field winding need be provided, although a plurality of field windings is beneficial to the invention.

The motor need not have the exact number of stator poles, rotor poles and field poles as set out in the present invention. Motors having any suitable number of stator poles, rotor poles or field poles may be used.

While the invention is susceptible to various modifications and alternative forms, specific embodiments are shown by way of example in the drawings and are herein described in detail. It should be understood, however, that drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the invention is to cover all modifications, equivalents and alternatives falling within the scope of the appended claims.

CLAIMS

1. An electrical machine comprising a passive rotor and a stator, the stator comprising a plurality of circumferentially spaced-apart stator poles, the stator poles comprising armature poles and at least one field pole, each armature pole having an armature winding arranged thereabout and comprising a slot having a radially-extending circumferentially-polarised permanent magnet located therein, and the or each field pole comprising a field winding which is arranged, in use, to carry a direct current.

2. An electrical machine as claimed in claim 1, wherein a plurality of field poles are provided, consecutive stator poles alternately comprising armature poles and field poles.

3. An electrical machine as claimed in claim 2, wherein an equal number of armature poles and field poles are provided.

4. An electrical machine as claimed in claim 2 or 3, wherein each field pole is located between adjacent armature poles in the circumferential direction.

5. An electrical machine as claimed in any one of claims 1 to 4, wherein the or each field pole comprises a unitary stator tooth.

6. An electrical machine as claimed in any one of the preceding claims, wherein the field poles are permanent magnet-free.

7. An electrical machine as claimed in any one of the preceding claims, wherein the or each field winding is connected to a source of DC power.

8. An electrical machine as claimed in claims 2 and 7, wherein the field windings of the field poles are connected in series to the source of DC power.

9. An electrical machine as claimed in claim 7 or 8, wherein the or each field winding is arranged such that when a DC current is applied in a first direction, the magnetic field generated by the at least one field pole is arranged to increase the torque experienced by the rotor, and when a DC current is applied in a second direction the magnetic field generated by the at least one field pole is arranged to reduce the torque experienced by the rotor.

10. An electrical machine as claimed in any one of the preceding claims, wherein each armature winding is connected to a source of AC power.

11. An electrical machine as claimed in claim 10, wherein the armature windings of the armature poles are connected in three phases.

12. An electrical machine as claimed in any one of the preceding claims in the form of a motor.

13. An electrical machine as claimed in claim 12, wherein the motor is a flux switching permanent magnet motor.

14. An electrical machine as claimed in any one of claims 1 to 11 in the form of a generator.

15. An electrical machine as claimed in any one of claims 12 to 14 further comprising means for energising the stator.

16. A salient pole electrical machine substantially as hereinbefore described with reference to Figures 2 to 11 of the accompanying drawings.

Amendments to the claims have been filed as follows:

CLAIMS

1. An electrical machine comprising a passive rotor and a stator, the stator comprising:

a plurality of circumferentially spaced-apart stator poles, the stator poles comprising armature poles and at least one field pole, each armature pole having an armature winding arranged thereabout and comprising a slot having a radially-extending circumferentially-polarised permanent magnet located therein, and the or each field pole comprising a field winding which is arranged, in use, to carry a direct current;

wherein a plurality of field poles are provided, consecutive stator poles alternately comprising armature poles and field poles.

2. An electrical machine as claimed in claim 1, wherein an equal number of armature poles and field poles are provided.

3. An electrical machine as claimed in claim 1 or 2, wherein each field pole is located between adjacent armature poles in the circumferential direction.

4. An electrical machine as claimed in any one of claims 1 to 3, wherein the or each field pole comprises a unitary stator tooth.

5. An electrical machine as claimed in any one of the preceding claims, wherein the field poles are permanent magnet-free.

6. An electrical machine as claimed in any one of the preceding claims, wherein the or each field winding is connected to a source of DC power.

7. An electrical machine as claimed in claims 1 and 6, wherein the field windings of the field poles are connected in series to the source of DC power.

8. An electrical machine as claimed in claim 6 or 7, wherein the or each field winding is arranged such that when a DC current is applied in a first direction, the

magnetic field generated by the at least one field pole is arranged to increase the torque experienced by the rotor, and when a DC current is applied in a second direction the magnetic field generated by the at least one field pole is arranged to reduce the torque experienced by the rotor.

9. An electrical machine as claimed in any one of the preceding claims, wherein each armature winding is connected to a source of AC power.

10. An electrical machine as claimed in claim 9, wherein the armature windings of the armature poles are connected in three phases.

11. An electrical machine as claimed in any one of the preceding claims in the form of a motor.

12. An electrical machine as claimed in claim 11, wherein the motor is a flux switching permanent magnet motor.

13. An electrical machine as claimed in any one of claims 1 to 10 in the form of a generator.

14. An electrical machine as claimed in any one of claims 11 to 13 further comprising means for energising the stator.

15. A salient pole electrical machine substantially as hereinbefore described with reference to Figures 2 to 11 of the accompanying drawings.

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PROPERTY OFFICE

Application No: GB0904691.3 **Examiner:** Mr John Cockitt
Claims searched: 1-16 **Date of search:** 17 July 2009

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 at least	WO2007/101876 A1 CENTRE NAT - see figs 8,9 for
A		GB2428903 A IMRA
A		US6495941 B1 MITSUBISHI

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

H2A

Worldwide search of patent documents classified in the following areas of the IPC

H02K

The following online and other databases have been used in the preparation of this search report

ONLINE: WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
H02K	0021/44	01/01/2006
H02K	0001/14	01/01/2006
H02K	0001/17	01/01/2006