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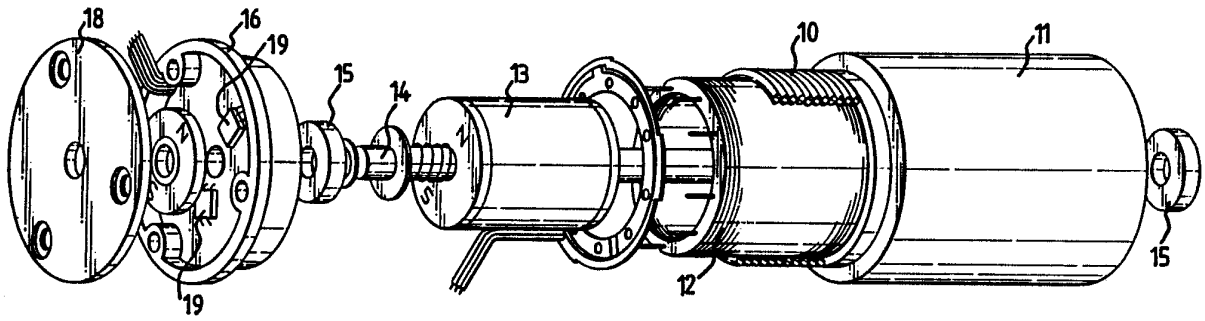
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(54) Title: ELECTRIC MOTOR



(57) Abstract

An electric motor includes a stator core formed by a closely wound helical coil (10) of ferromagnetic wire.

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Electric Motor

The invention relates to electric motors.

The invention relates more particular to a brush-less direct current electric motor. Such motors comprise a stator core formed of a stack of laminations held in a housing, having a stator winding positioned inside the stack and a magnetic rotor rotatably mounted inside the winding. The manufacture of the laminations and their formation and accurate positioning in the motor configuration requires accurate stamping to produce the laminations and often post-stamping machining to remove edge burrs, is wasteful of material, and generally leads to relatively slow production methods.

According to the one aspect of the invention there is provided a permanent magnet direct current electric motor including a stator core, a stator winding for the stator core, and a magnetic rotor rotatably mounted inside the stator core, in which the stator core comprises a closely wound helical coil of ferromagnetic wire, and in which the stator winding is positioned between the stator core and the rotor.

An embodiment of the invention may comprise a permanent magnet direct current electric motor including a stator core, a preformed cylindrical stator winding for the stator core, and a magnetic rotor rotatably mounted inside the

stator winding, in which the stator core comprises a closely-wound helical coil of ferromagnetic wire which fits snugly over the winding having a mean inside diameter substantially equal to the outside diameter of the winding, the coil being arranged to be fitted to the winding by rotating one of its ends relative to the other to increase its inside diameter and sliding the coil over the winding.

The coil of ferromagnetic wire may be formed by at least two separate wires and formed as a multi-start coil.

The ferromagnetic wire may have a rectangular cross-section and for example be square in cross-section.

The ferromagnetic windings of the coil may be held together by one or more joining seams extending axially along the outside of the coil. The seams may be formed by welding.

The electric motor may include a magnetic material housing surrounding and in close proximity to the stator core.

The ferromagnetic wire may be coated with an electrically insulating material. The wire may be aluminium and the coating comprise alumina.

According to another aspect of the invention there is provided a method of assembling a permanent magnet direct current electric motor having a stator core, a preformed

stator winding and a magnetic rotor rotatably mounted inside the stator winding, in which the stator core comprises a closely-wound helical coil of resilient ferromagnetic wire, the method comprising gripping the ends of the coil and relatively rotating the ends to increase the mean inside diameter of the coil, sliding the coil relative to the winding to fit the coil to the winding, and releasing the ends of the coil to allow the coil to relax and bear against the winding.

The method may include gripping the ends of the coil and relatively rotating the ends of the coil to decrease the mean diameter of the coil together with the winding inside the coil, sliding the coil and winding inside a casing which fits over the coil, and releasing the ends of the coil to allow the coil to relax and bear against the inside of the casing.

The method may include gripping the ends of the coil and relatively rotating the ends of the coil to decrease the mean diameter of the coil together with the winding inside the coil, and sliding the coil and winding inside a mould.

A brushless fractional horsepower direct current motor according to the invention will now be described by way of example with reference to the accompanying diagramatic drawings in which:-

Figure 1 is an exploded view of the motor;

Figure 2 is a cross-sectional view of motor; and

Figure 3 is an isometric view of another stator core for the motor.

Referring to the drawings, in Figures 1 and 2 the motor includes a stator core formed of a tightly would helical coil 10 of ferromagnetic wire which fits inside a deep drawn ferromagnetic steel can 11. A preformed basket stator winding 12 is positioned inside and against the coil 10 which in use is energised to produce a magnetic flux inside the motor. A permanent magnet rotor 13 which is polarised as indicated is mounted on a shaft 14 supported in bearings 15 by respective end plates 16 and 17. A cover plate 18 fits over the end plate 16.

The winding 12 is connected to an external supply and supplied through Hall effect integrated circuits 19 supported by the end plate 16. The circuits respond to changes in magnet field as the rotor rotates to switch and control the direction of current in the winding 12 so that the rotor is driven in one rotational direction as it rotates. Such driving and current direction control arrangements are well-known in brushless motors.

The stator core formed by the coil 10 is in contrast unique

and is provided to replace laminations formerly used to form a stator core. Laminations are normally stamped out from solid plates of magnetic material which requires accurate stamping and/or post-stamping machining especially to remove burrs. The laminations must be accurately stacked and held together and fitted inside a casing. The basket winding must then be fitted closely inside the laminations and may and can often be damaged during insertion.

In the described arrangement the coil 10 is formed by closely coiling a continuous wire of ferromagnetic wire into a cylindrical form. The coil is inherently flexible to some extent and is preferably formed with an inner diameter slightly less than the outer diameter of the basket winding 12. The diameter of the coil 10 can decreased or increased by relatively rotating its opposite ends appropriately. Thus, to fit the coil 10 onto the basket winding 12, the diameter of the coil 10 is increased and once the basket is positioned within the coil 10, the diameter of the coil 10 is decreased so that the coil 10 fits snugly against the outside surface of the winding 12. This means that any air gaps between the coils 10 and outside of the winding 12 are reduced to a minimum. This is especially the case as the springyness or flexibility of the coil 10 allows it to fit snugly along the whole length of the winding 12 even though the outside diameter of the winding 12 may vary somewhat along its length.

Normally in the described arrangement and preferably, the coil 12 is formed initially with an internal diameter which is an interference fit on the outside surface of the winding 12. The diameter of the coil 10 is increased as mentioned, by relatively rotating its ends, and the winding 12 is then slid inside the coil. The ends of the coil 10 are then released so that the coil 10 "relaxes" and snugly surrounds and embraces the winding 12.

The coil 10 can be fixed into a secure configuration by forming an axial seam to join adjacent strands of the coil. For example, a laser welding machine can be tranversed along the length of the coil 10 to form a seam of tack welds to hold the strands together. Two or more seams can be formed in this way spaced from one another around the periphery of the coil as desired.

Once the coil 10 has been fixed in this way, the assembly (of the stator core and winding 12) is rigid and if desired end caps can be fitted directly to the ends of the coil 10 to provide support for the end bearings. In other words, the motor may be made without the casing 11 shown in the drawings.

This assembly may also be first placed in an injection moulding tool in which the coil has not been fixed (e.g. welded). The coil 10 even with the winding 12 already fitted can be reduced in overall diameter at least to some

extent, as explained above. Thus, the coil 10 may be reduced in outside diameter advantageously while being fitted into the mould tool. This facilitates the fitting of the assembly into the mould tool and reduces the possibility of the tool being damaged during fitting of the assembly.

In the described arrangement, the assembly, that is the coil 10 and winding 12 must be fitted into the case 11. The case is made of steel and so additionally increases the flux return path of the motor. As the assembly is somewhat flexible as described, the fitting is preferably carried out by temporarily and slightly reducing the outside diameter of the coil 10, as described. Once the coil has been slid inside the case 11 the ends of the coil 10 are released to allow the coil to expand and fit snugly against the inside of the case 11 as desired. As such in the final assembly, the three components (the case 11, the coil 12 and the winding 12) become a tight snug fit with one another. The end caps and the rotor are then fitted to this final assembly to form the complete motor.

The wire used to form the stator core in Figure 1 is round wire and formed by a single start winding. If desired the coil may be formed with a multistart winding for example using two or three strands of wire wound together side by side along the length of the finished coil. Also, the wire may be rectangular in cross-section, as shown in Figure 3.

The wire of the coil 10 may be pre-coated with electrical insulating material before being wound into its cylindrical form. The coil may be formed of aluminium or an aluminium coating may be applied to the outer surface of wire of other materials. In such a case the outside of the wire can be oxidised in a continuous process to form alumina which provides an outer insulating coating, and then the wire is wound into a coil. Such a coil is also generally chemically inert and therefore suitable for use in motors used as fuel pumps or in chemical process plants where the motor may be submerged.

Claims:

1. A permanent magnet direct current electric motor including a stator core, a stator winding for the stator core, and a magnetic rotor rotatably mounted inside the stator core, in which the stator core comprises a closely wound helical coil of ferromagnetic wire, and in which the stator winding is positioned between the stator core and the rotor.

2. A permanent magnet direct current electric motor including a stator core, a preformed cylindrical stator winding for the stator core, and a magnetic rotor rotatably mounted inside the stator winding, in which the stator core comprises a closely-wound helical coil of ferromagnetic wire which fits snugly over the winding having a mean inside diameter substantially equal to the outside diameter of the winding, the coil being arranged to be fitted to the winding by rotating one of its ends relative to the other to increase its inside diameter and sliding the coil over the winding.

3. An electric motor according to claim 1 or 2, in which the coil of ferromagneic wire comprises at least two separate wires and formed as a multi-start coil

4. An electric motor according to any one of claims 1 to 3, in which the ferromagnetic wire has a rectangular cross-section.

5. An electric motor according to any one of claims 1 to 4, in which the ferromagnetic windings of the coil are held together by one or more joining seams extending axially along outside of the coil.

6. An electric motor according to claim 5, in which the seams are formed by welding.

7. An electric motor according to any one of claims 1 to 6, in which the coil and winding are surrounded by a rigid protective coating formed in a mould.

8. An electric motor according to any one of claims 5 to 7, in which end plates are fitted to the coil and arranged to rotatably support the magnetic rotor.

9. An electric motor according to any one of claims 1 to 8, including a magnetic material housing surrounding and in close proximity to the stator core.

10. An electric motor according to any one of claims 1 to 9, in which the ferromagnetic wire is coated with an electrically insulating material.

11. An electric motor according to claim 10, in which the ferromagnetic wire is aluminium and the coating comprises alumina.

12. A method of assembling a permanent magnet direct current electric motor having a stator core, a preformed stator winding and a magnetic rotor rotatably mounted inside the stator winding, in which the stator core comprises a closely-wound helical coil of resilient ferromagnetic wire, the method comprising gripping the ends of the coil and relatively rotating the ends to increase the mean inside diameter of the coil, sliding the coil relative to the winding to fit the coil to the winding, and releasing the ends of the coil to allow the coil to relax and bear against the winding.

13. A method according to claim 12, including gripping the ends of the coil and relatively rotating the ends of the coil to decrease the mean diameter of the coil together with the winding inside the coil, sliding the coil and winding inside a casing which fits over the coil, and releasing the ends of the coil to allow the coil to relax and bear against the inside of the casing.

14. A method according to claim 12, including gripping the ends of the coil and relatively rotating the ends of the coil to decrease the mean diameter of the coil together with the winding inside the coil, and placing the coil and winding into a mould.

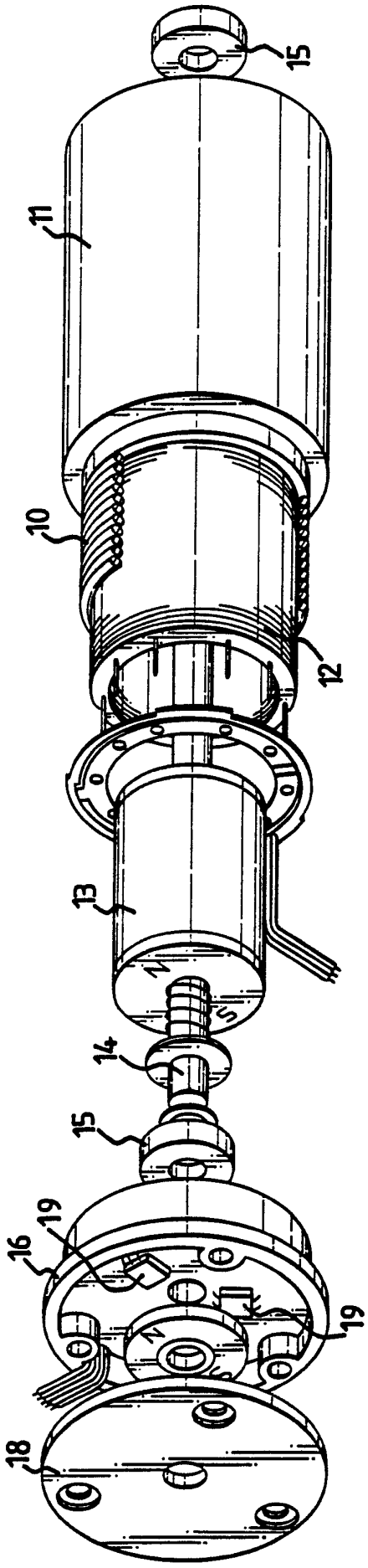


FIG.1

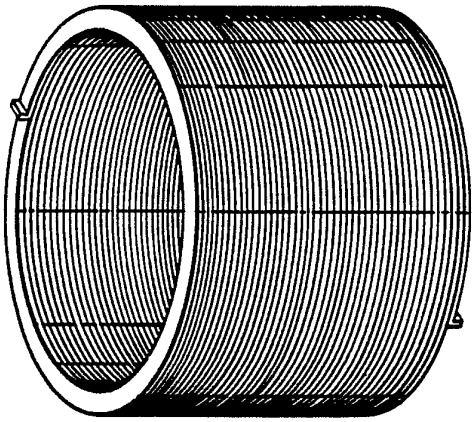


FIG.3

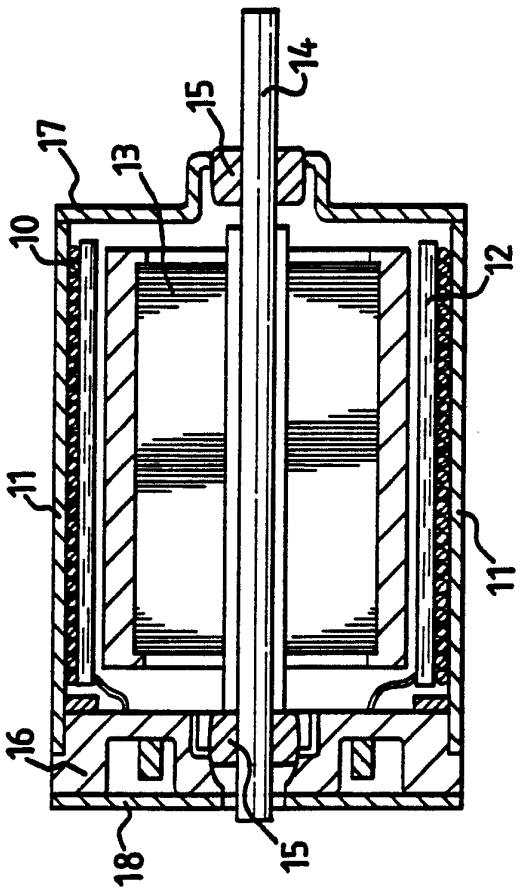


FIG.2

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/01173

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 H02K1/12 ; H02K3/47

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	H02K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	EP,A,0 313 514 (MAVILOR SYSTEMES) 26 April 1989 see column 3, line 40 - column 4, line 40; figures 1-3,7	1,7,10
Y		4,5,6,8, 11
A		2,12

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
17 OCTOBER 1991	19. 11. 91
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9101173 SA 49645

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 17/10/91
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