

Electric Motor

This invention relates to rotary electric motors.

5 So-called "miniature" electric motors commonly employ a rotor in the form of one or more permanent magnets mounted interiorly of a motor case. The rotor is carried by a shaft which is mounted for rotation in bearings commonly made of oil-impregnated sintered metal. 10 As the rotor rotates in use in the magnetic field of the stator, there is a tendency for the shaft to vibrate radially under the effect of the magnetic field. This shaft wobble within the bearings tends to produce a rolling noise which is considered undesirable for audio 15 equipment and the like.

In an effort to overcome or eliminate this unwanted rolling noise, work has centered on seeking to reduce the clearance between the shaft and the inside diameter of the bearing down to as little as a few 20 microns. This arrangement inevitably involves increased friction. We have found that it tends to lead to a number of problems, not the least being the likelihood of seizing of the shaft and the bearing and overloading of the motor.

25 The present invention proposes to deal with this problem in a quite different manner. As will be clear from the description which follows, we deliberately set out to unbalance the magnetic field of the stator on the rotor so as to produce a net biasing magnetic force 30 on the rotor in one radial direction. The detailed description which follows proposes a number of different ways in which this effect is achievable.

In its broadest context, the present invention provides an electric motor, comprising: a motor case 35 having an axial end face mounting a bearing; a stator comprising one or more permanent magnets; a rotor fixedly fitted to a shaft supported via said bearing for rotation within said case, and having core windings; a commutator mounted for rotation with said rotor; and brush gear 40 adapted for sliding contact with said commutator; the

rotor and stator being so constructed and/or arranged relative to each other to generate a net biasing magnetic force acting at all times on the rotor to urge the shaft
5 in a radial direction against said bearing.

The rotor shaft may be eccentrically mounted relative to the stator, whereby to physically produce a greater air gap between rotor and stator on one side of the rotor and stator than on the other side whereby the
10 intensity of the magnetic field of the stator is structurally unbalanced.

Alternatively, the stator may be formed from a first permanent magnet member generally C-shaped in axial section and a similar second permanent magnet member
15 diametrically opposed to the first. The first such member is made of greater thickness than the second whereby the intensity of the magnetic fields of the two permanent magnet members at the rotor is unbalanced. The two magnets can be arranged to create an air gap between
20 the first permanent magnet member and the rotor which is less than the corresponding air gap between the second permanent magnet member and the rotor, the air gaps otherwise being essentially identical if the two permanent magnet members were not of different thickness.

25 In another alternative arrangement, the stator may instead comprise a single generally ring-shaped permanent magnet member the thickness of which is greater at one portion than in the diametrically opposed portion. As a result the intensity of the magnetic field of the
30 stator at the rotor is greater on the side of the first portion than on the side of the diametrically opposed portion.

In the case where the stator is formed from two similar C-shaped permanent magnet members, the members
35 may be mounted within the motor case so as to define first and second circumferential gaps between the edges of the magnet members, one such gap being substantially greater than the other so as to cause an unbalanced magnetic force in the medial plane including the axis of
40 the shaft which bisects both the gaps.

Again, in the case where the stator may comprise two similar C-shaped permanent magnet members, one may have a stronger magnetic field than the other. A similar effect may be achieved by having a single generally ring-shaped permanent magnet in which diametrically opposed portions have different magnetism leading to the net biasing magnetic force on the rotor therebetween.

The invention is hereinafter more particularly described by way of example only with reference to the accompanying drawings, in which:-

Figs. 1A to 1F are generally schematic diagrammatic views illustrating the relative position of rotor and stator in a number of different embodiments of motor constructed in accordance with the present invention; and

Fig. 2 is a side elevational view, partly in section of an electric motor constructed in accordance with the present invention and including a rotor/stator arrangement according to one of Figs. 1A to 1F.

Fig. 2 illustrates, somewhat schematically, the structure of a typical miniature electric motor of a kind commonly employed, the only difference between the motor in accordance with the present invention of Fig. 2 and conventional such motors being in the arrangement of rotor and stator, as described below in more detail with reference to Figs. 1A to 1F.

As will be seen from Fig. 2, the motor comprises a stator in the form of one or more permanent magnets 1 mounted interiorly of a motor case 5 and a rotor 2 with rotor windings mounted on a rotor shaft 3 which rotates in bearings 4 respectively mounted in an axial end face of the motor case 5 and in an end closure 6 for the opposite otherwise open end of the motor case. The end closure 6 also mounts brush gear for the motor, which brush gear comprises terminals 7 which extend exteriorly of the end closure 6 for connection in an external electric circuit and brushes 8 adapted for sliding contact with a commutator 9 mounted on the rotor shaft 3.

Referring now to Fig. 1A, it will be seen that the stator 1 is here formed from two permanent magnet members 1a and 1b which are

generally C-shaped in axial section. The axis of the rotor shaft 3 is eccentrically mounted relative to the stator by a distance l_3 . As a result, the air gap l_1 between the rotor and permanent magnet member 1a is less than the corresponding air gap l_2 between the rotor and the other permanent magnet member 1b. Consequently, the intensity of the magnetic field of the stator at the rotor is structurally unbalanced giving rise to a net biasing magnetic force on the rotor. The net biasing magnetic force tends to prevent the rolling effect aforementioned as the shaft tends to be attracted to one side of the bearing in accordance with the direction of the net biasing magnetic force.

Fig. 1B illustrates another means of achieving a similar effect. Here instead of eccentrically mounting the rotor and its shaft in the casing, and thus relative to the stator, the first C-shaped permanent magnet member 1a has a thickness t_1 which is greater than the thickness t_2 of the other permanent magnet member 1b giving rise to a smaller air gap l_1 between member 1a and the rotor than the corresponding air gap l_2 between the other member 1b and the rotor. Again this results in a net biasing magnetic force tending to reduce or eliminate the rolling noise effect.

The arrangement of Fig. 1C corresponds exactly to that of Fig. 1B except that the stator is formed as a single ring-shaped member 1c with the differing thicknesses t_1 and t_2 leading to air gaps l_1 and l_2 of different size on opposite sides of the rotor and stator.

In the arrangement of Fig. 1D, the rotor is again formed of two similar C-shaped permanent magnet members 1a and 1b. In this case, however, they are not disposed diametrically opposite each other. Instead, there are two gaps a_1 and a_2 in the circumferential direction, the gap a_1 being substantially greater than the gap a_2 . This results in the magnetic fields of the two stator elements being structurally unbalanced giving rise to a net overall biasing force resulting from the unbalanced magnetic fields, the force acting in the medial plane which includes the rotor axis and bisects the two gaps a_1 and a_2 . As a result, the rotor shaft is seated in its bearing

in a manner seeking to reduce the air gap l_1 illustrated in Fig. 1D and to maximise the air gap l_2 . This tendency enhances the net biasing force by further unbalancing the magnetic fields.

As will be appreciated, the arrangements of each of Figs. 1A to 1D produce a net biasing magnetic force by arranging the rotor and stator relative to each other so that there is a physical structural unbalance. A similar unbalance in the structure can arise purely magnetically.

Thus, in the arrangement of Fig. 1E, two otherwise similar C-shaped section permanent magnet members 1a and 1b have different magnetism, the magnetism of magnet 1a being greater than that of magnet 1b. The result is that the net biasing magnetic force acting on the rotor tends to reduce the air gap l_1 and to increase the air gap l_2 , which further enhances the magnetic unbalance by a physical unbalance and thereby increases the net biasing magnetic force.

The arrangement of Fig. 1F works in a similar fashion except that in this case a single ring-shaped permanent magnet 1c is employed in place of the two separate magnet members 1a and 1b. Again, however, the magnetism in a portion on one side of the ring-shaped element is greater than that on the diametrically opposed side leading to the magnetic unbalance which in turn leads to a tendency to reduce the air gap l_1 and to increase the air gap l_2 leading to a physical unbalance and an enhanced net biasing magnetic force.

We have found that practical embodiments of motor constructed in accordance with the present invention and with the rotor/stator arrangements of any of Figs. 1A to 1F provide miniature electric motors which can run extremely quietly without causing the rolling noise and wobbling of the rotor shaft inherent in the conventional type of miniature motor in volume production. Moreover, this improvement results without increasing the number of parts or in any way adding to the number of man hours involved in production.

CLAIMS

1. An electric motor, comprising: a motor case having an axial end face mounting a bearing; a stator comprising one or more permanent magnets; a rotor fixedly
5 fitted to a shaft supported in said bearing for rotation within said case, and having core windings; a commutator mounted for rotation with said rotor; and brush gear adapted for sliding contact with said commutator; the rotor and stator being so constructed and/or arranged
10 relative to each other to generate a net biasing magnetic force acting at all times on the rotor to urge the shaft in a radial direction against said bearing.

2. A motor according to Claim 1, wherein the rotor shaft is eccentrically mounted relative to the stator,
15 whereby to physically produce a greater air gap between rotor and stator on one side of the rotor and stator than on the other side of the rotor and stator whereby the intensity of the magnetic field of the stator is structurally unbalanced and the shaft is continually
20 biased against the bearing on said other side of the rotor.

3. A motor according to Claim 1, wherein the stator comprises a first permanent magnet member which is generally C-shaped in axial section and a second
25 permanent magnet member diametrically opposed to the first and also of generally C-shaped axial section, the first said permanent magnet member being of greater thickness than the second such member whereby the intensity of the magnetic fields of the first and second
30 permanent magnet members at the rotor is unbalanced and the shaft is continuously biased against the bearing to one side of the rotor.

4. A motor according to Claim 3, wherein the first and second permanent magnet members are arranged to
35 create an air gap between the first permanent magnet member and the rotor which is less than the air gap between the second permanent magnet member and the rotor, which air gaps would otherwise be essentially identical if the two permanent magnet members were not of



different thickness, so that the intensity of the magnetic fields of the first and second permanent magnet members at the rotor differ and the shaft is continuously
5 biased against the bearing to one side of the rotor.

5. A motor according to Claim 1, wherein the stator comprises a single generally ring-shaped permanent magnet member the thickness of which is greater at one portion than in the diametrically opposed portion,
10 whereby the intensity of the magnetic field of the stator at the rotor is greater on the side of said first portion than on the side of said diametrically opposed portion and the shaft is continuously biased against the bearing to one side of the rotor.

15 6. A motor according to Claim 1, wherein the stator comprises a first permanent magnet member which is generally C-shaped in axial section and a second similarly shaped permanent magnet member, the two said permanent magnet members being mounted within the case so
20 as to define first and second circumferential gaps therebetween, one said circumferential gap being substantially greater than the other said circumferential gap whereby to cause an unbalanced magnet field in the medial plane including the axis of the shaft which
25 bisects both the said gaps, the shaft thereby being continuously biased against the bearing to one side of the rotor.

7. A motor according to Claim 1, wherein the stator comprises a first permanent magnet member which is
30 generally C-shaped in axial section and a second permanent magnet member of similar configuration, said first permanent magnet member having a stronger magnetic field than said second permanent magnet member, and the shaft thereby being continuously biased against the
35 bearing to one side of the rotor.



8. A motor according to Claim 1, wherein said stator comprises a single generally ring-shaped permanent magnet formed with diametrically opposed portions of differing magnetism whereby to provide said net biasing magnetic force on said rotor, the shaft thereby being continuously biased against the bearing to one side of the rotor.
9. A motor substantially as hereinbefore described with reference to and as shown in Fig. 2 combined with one of Figs. 1A to 1F.
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