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Electric motor

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(73) Proprietor
Mabuchi Motor Kabushiki Kaisha,
14—11 Tateishi 3-chome,
Katsushika-ku
Tokyo
Japan

(72) Inventor
Takaichi Mabuchi

(74) Agent and/or
Address for Service
Lloyd Wise Tregear & Co.,
Norman House
105—109 Strand
London WC2R 0AE

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FIG. 1

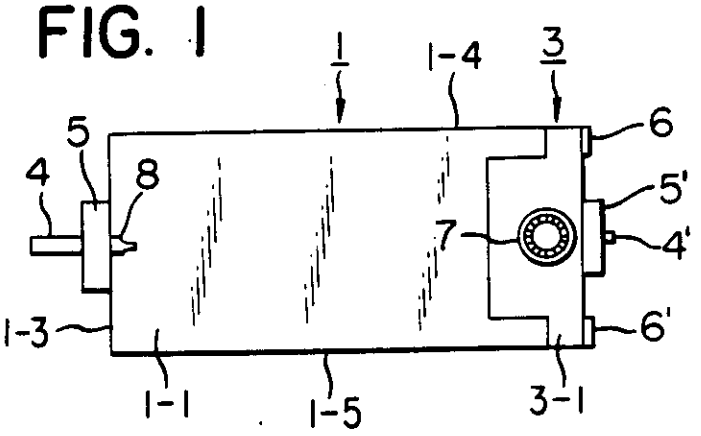


FIG. 2

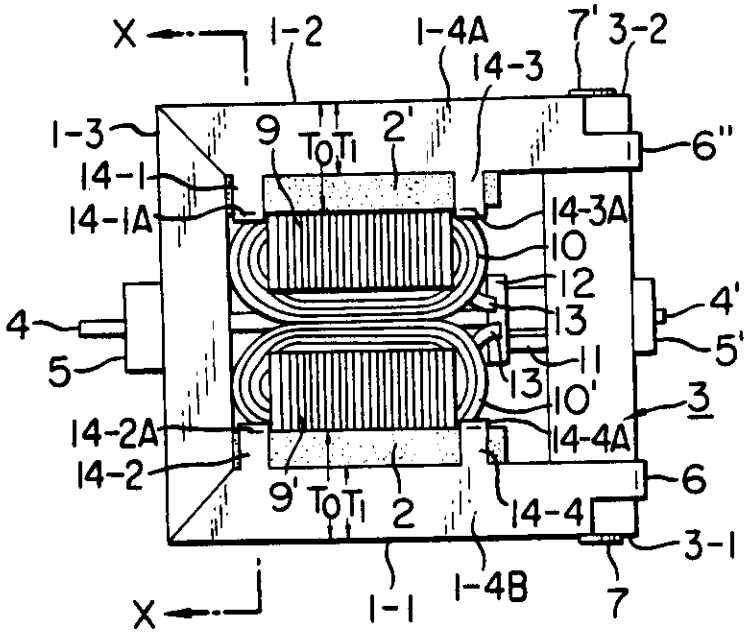


FIG. 3

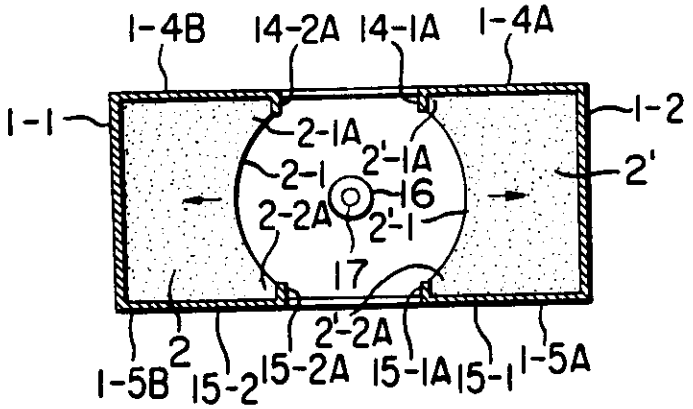


FIG. 4

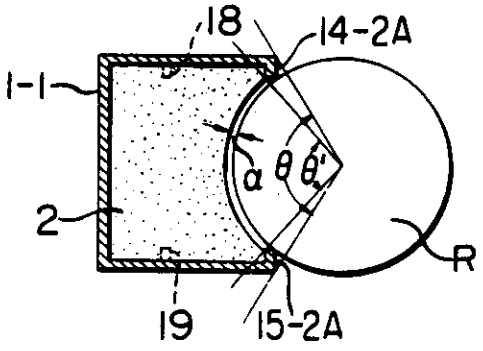

18
14-2A
1-1
α θ θ'
2
R
19
15-2A

FIG. 5

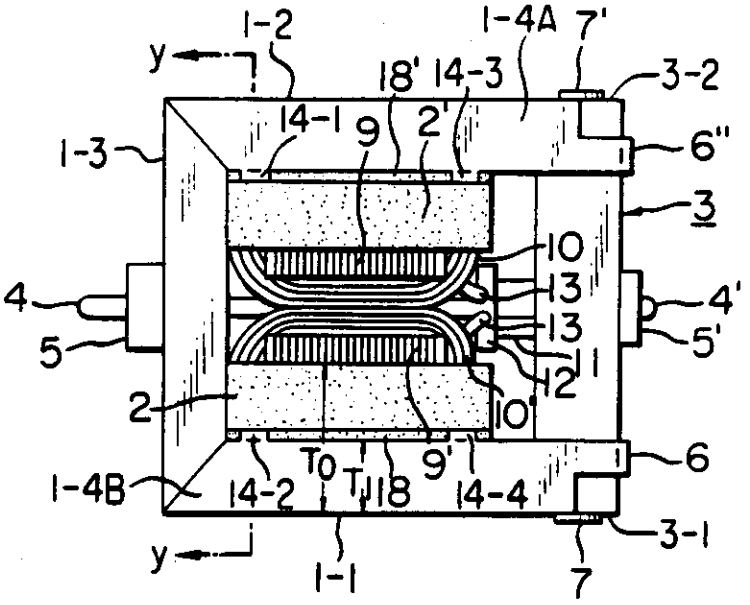

1-2
y
1-4A
7'
18'
14-3
3-2
14-1
9
2'
6"
1-3
3
10
4
13
4'
13
5
5'
11
12
2
10'
6
T0
T
9'
1-4B
14-2
18
14-4
3-1
y
1-1
7

FIG. 6

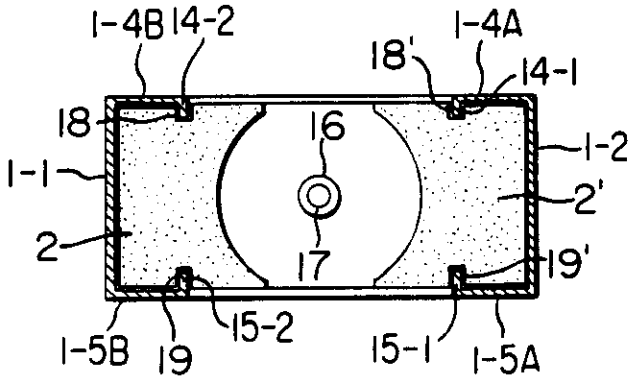


FIG. 7

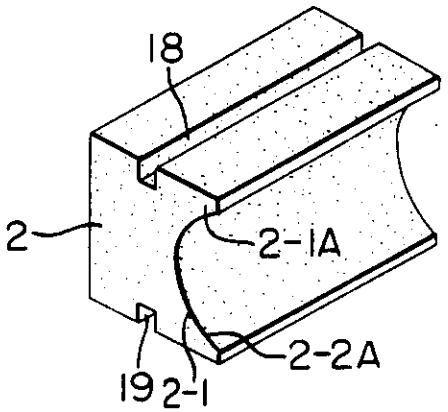
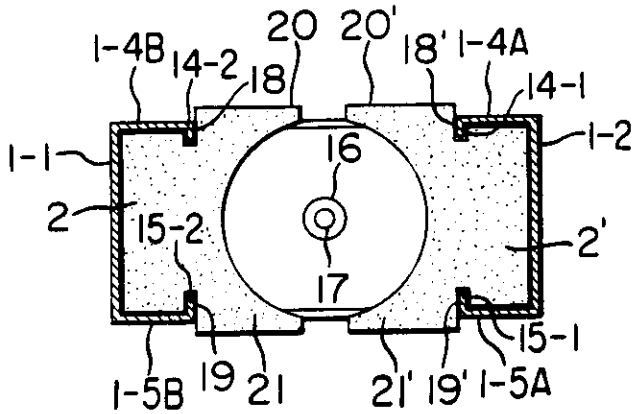


FIG. 8



SPECIFICATION

Electric motor

This invention relates to electric motors.

Small electric motors of a generally rectangular parallelepiped shape have been proposed for use in electric model toys, such as model racing cars, to improve the space factor. In general, the magnetic gap between the permanent magnet and the core of the motor rotor is minimised for small overall dimensions. The permanent magnet is suitably shaped for close fit with the inner wall of the magnet casing and bonded thereto using adhesive. For a secure bond the magnet must necessarily be in close contact with the inner wall of the casing. An arrangement is required for forcing the magnet against the inner wall of the casing and for temporarily holding it in position. We have found that in carrying out such an operation, close attention was required to prevent unwanted contact between the magnet and the motor rotor and to prevent the magnetic gap from being unbalanced. This impose a considerable degree of effort and attention due to the difficulty in visually confirming whether the magnet was in close fit with the magnet casing.

We also found that, even when the permanent magnet has been properly housed in the magnet casing during manufacture, the strength of the adhesive may decrease with time or as a result of vibrations caused by the revolution of the motor, or external impact may cause the magnet to be separated from the inner surface of the casing and to come in contact with the motor rotor. This may result in a total failure of the motor.

To overcome this problem, it was first proposed to provide lanced and formed pieces on the side face of the magnet casing to support the permanent magnet. We found that such lanced and formed pieces may form unwanted magnetic short-circuits, lowering the efficiency of the motor. The use of a material having good permeability, such as iron sheet, for the magnet casing so that it may then serve as a yoke must generally be avoided in an arrangement using lanced and raised pieces because of the increased reactive magnetic flux which may be caused by magnetic short-circuits.

To overcome the problems described above we have proposed the provision of lugs preferably formed as continuations of side walls of the magnet casing and having their distal ends bent through a right angle to engage the inner end faces of the permanent magnets in the casing. As described in our British Patent Specification 1565335, this arrangement makes it possible to securely support the permanent magnet in the magnet casing while greatly reducing the likelihood of forming an unwanted magnetic short-circuit or of the magnet coming into contact with the motor rotor, and permits a material having good permeability to be used for the casing.

Such an arrangement is described hereinbelow with reference to Figs. 1 to 4.

For reasons which we explain below, though it is an improvement, we have not found this arrangement to be entirely satisfactory. The present invention has arisen from our work seeking further to improve motors of this kind. As we shall explain in detail hereinafter, the present invention enables important advantages to be obtained.

According to the present invention, we provide an electric motor of generally rectangular parallelelpiped shape, having a magnet casing of rectangular cross-section; and a plurality of permanent magnets mounted with a close fit to the inner wall of the casing; the magnet casing having side wall portions extending inwardly thereof from said inner wall alongside the side faces of the magnets by a distance smaller than the corresponding extent of said faces, grooves being provided on the respective side faces of the permanent magnets, and the magnet casing having a plurality of lugs the distal ends of which are bent inwardly of the magnet casing and engaged in said grooves to hold the permanent magnets in the magnet casing.

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

Figure 1 is a side elevational view of a previously proposed rectangular parallelepiped-shaped electric motor;

Figure 2 is a plan view of the embodiment of Fig. 1;

Figure 3 is a cross-sectional view of the motor of Figs. 1 and 2 taken along the line X– X in Fig. 2, with the motor rotor removed;

Figure 4 is a diagram illustrating the effective surface angle of the permanent magnets and the magnetic gap between the permanent magnets and the motor rotor in the embodiment of Figs. 1 to 3;

Figure 5 is a plan view generally similar to Fig. 2 illustrating a first example of electric motor constructed in accordance with this invention;

Figure 6 is a cross-sectional view similar to that of Fig. 3 but taken along the line Y–Y in Fig. 5, with the motor rotor removed;

Figure 7 is a perspective view of a permanent magnet in the embodiment of Figs. 5 and 6; and

Figure 8 is a cross-sectional view similar to that of Fig. 6 but illustrating a second embodiment of motor constructed in accordance with this invention, with the motor rotor removed.

Figs. 1 to 4 show a magnet casing 1 which has a generally rectangular cross-section, as is evident from Fig. 3, and which is formed by bending a channel-shaped iron sheet into a generally U-shape. As is clear from Figs. 2

and 3 one side face 1–4 of the casing includes side face portions 1–4A and 1–4B of the channel in two arms of the U. The other side face 1–5 similarly includes side face portions 1–5A and 1–5B, respectively. Permanent magnets 2 and 2' are mounted as shown in the channels and have respective curved surfaces 2–1 and 2'–1 directed inwardly of the casing. A cover 3, made of synthetic resin is removably fitted to the magnet casing 1 at one end. The motor has a shaft 4, 4' mounted in motor bearings 5, 5'. Fastening means 6, 6' and 6'' fasten cover 3 to the magnet casing 1. Brush insert holes 7, 7' with brush retaining cylinders are provided on side faces 3–1 and 3–2 of the cover 3. A mark 8 is provided on the boundary between face 1–1 formed by the channel bottom on one arm of the U and the end face 1–3 of the magnet casing 1 away from cover 3, a like mark (not shown) being provided on the boundary between the opposite face 1–2 and end face 1–3. The motor has rotor cores 9 and 9' respectively wound with windings 10 and 10'. A commutator is shown at 11 and is supported at 12. Terminals 13 and 13' of the windings terminals are electrically connected to the supporting means 12. A plurality of lugs 14–1, 14–2, 14–3, 14–4, and 15–1, 15–2, 15–3, 15–4 are respectively and symmetrically formed on the side faces 1–4 and 1–5 of the magnet casing 1 and have their respective distal end portions bent into an L-shape inwardly of the casing at 14–1A, 14–2A, 14–3A, 14–4A and 15–1A, 15–2A, 15–3A and 15–4A to support and retain the magnets 2, 2' as shown. Though neither lugs 15–3 or 15–4 nor their respective distal end are actually depicted in the drawings, it will be appreciated that they occupy positions which correspond to those of lugs 14–3 and 14–4. A metal bearing 16 provided on the inner surface of the magnet casing 1 can be seen in Fig. 3 and has a hole 17 through which the motor shaft 4 passes.

As shown in Fig. 2, the width or lateral extent T1 of the side faces 1–4 and 1–5 of the magnet casing 1 is smaller than the width or lateral extent T0 of the corresponding side faces of the magnets 2 and 2'. The lugs 14 and 15 extend beyond the width T0 to be inwardly bent. Thus to firmly support and secure the permanent magnets 2 and 2' in the magnet casing 1 in this construction, the distal end portions 14–1A, 14–3A and 14–2A, 14–4A of the lugs 14–1, 14–3 and 14–2, 14–4 are hooked to edge portions, 2'–1A and 2–1A of the curved inner surfaces 2'–1 and 2–1 of the permanent magnets 2' and 2. Similarly, the distal end portions 15–1A, 15–3A and 15–4A of the lugs 15–1, 15–3 and 15–2, 15–4 are hooked to edge portions 2'–2A and 2–2A of the curved surfaces 2'–1 and 2–1 of the permanent magnets 2' and 2 on the side face 1–5. As a result, magnets 2 and 2' are securely fitted in the magnet casing 1 while maintaining an appropriate magnetic gap between the magnets and the motor rotor simply by inserting the magnets 2 and 2' in the casing 1 along the length of the respective channels (i.e. in a direction into the paper in Fig. 3) and then bringing the lugs into engagement with the edge portions of the magnets and hooking the distal ends of the lugs thereto. This arrangement can eliminate the need for adhesive to securely fit the magnets in the magnet casing. Since the arrangement described ensures that T0 is larger than T1, the possibility of an unwanted magnetic short-circuit being formed by the side faces 1–4 or 1–5 of the magnet casing 1 is practically eliminated.

Though it is certainly a great improvement, we have found this arrangement using the lugs 14 and 15 to be not entirely satisfactory since the formation of an unwanted magnetic short-circuit cannot be completely eliminated due to the presence of the lugs 14 and 15. The lugs 14 and 15 limit the angle of the effective surface of the magnets 2 and 2' to θ' instead of θ (see Fig. 4) as would otherwise be practicable. Furthermore, the magnetic gap α between the motor rotor R and the permanent magnet 2 is limited by the presence of the lugs 14 and 15 because the magnetic gap cannot be made narrower than the thickness of the lugs 14 and 15 where they engage with the edge portions 2–1A, 2–2A, 2'–1A, 2'–2A of the curved surfaces 2–1, 2'–1 of the permanent magnets 2, 2'.

For the embodiments of electric motor constructed in accordance with the present invention and illustrated in Figs. 5 to 8, like numerals refer to like parts throughout and to like parts of the embodiment of Figs. 1 to 4.

As in the prior arrangement of Figs. 1 to 3, the width or lateral extent T1 of the side faces 1–4 and 1–5 of the magnet casing 1 is made smaller than the width or lateral extent T0 of the corresponding side faces of the magnets 2 and 2'. In the present embodiment, however, the length of lugs 14 and 15 is made smaller than the width T0. The permanent magnets 2 and 2' are securely fitted in the magnet casing 1 by engaging the lugs 14–1, 14–3 and 14–2, 14–4 with grooves 18' and 18 provided on the magnetically neutral side portions of the permanent magnets 2' and 2 on side 1–4 of the casing and by similarly engaging the lugs 15–1, 15–3 and 15–2, 15–4 with grooves 19' and 19 on the opposite side of the permanent magnets 2' and 2. As a result, the permanent magnets 2 and 2' are securely fitted in the magnet casing 1 and an appropriate magnetic gap is set simply by inserting the permanent magnets 2 and 2' into the casing 1 along the length of the respective channels (i.e. in the direction in to the paper in Fig. 6 or 8) and engaging the distal ends of the lugs in the grooves on the

side faces of the magnets. This eliminates the need for adhesive to fit the magnets to the magnet casing. The possibility of an unwanted magnetic short-circuit is practically eliminated since T0>T1 and the lugs 14–1 to 14–4 and 15–1 to 15–4 are engaged with the grooves 18', 19' and 18, 19 provided on the magnetically neutral positions of the permanent magnets 2' and 2. The lugs 14 and 15 should preferably be disposed at positions where they do not face the rotor cores 9 and 9'.

In the prior arrangement of Fig. 4, the angle of the effective surface of the magnet was limited (to θ' as explained above).

In arrangements in accordance with the present invention, on the other hand, where the lugs, such as 14 and 15, are engaged with grooves, such as 18 and 19, provided at magnetically neutral positions on the magnets (as shown by dotted lines in Fig. 4), the magnet angle can be increased to θ. This results in an increase in magnetic field strength, and helps improve motor torque and reduce cogging problems.

In the arrangement of Figs. 1 to 4, as explained above, the magnetic gap between the motor rotor R and the permanent magnet 2 cannot be made smaller than the width α due to the thickness of the distal end portions, such as 14–2A and 15–2A (Fig. 4) of the lugs. However, when lugs 14 and 15 are engaged with grooves 18, 18', 19 and 19', the magnetic gap can be made as close as practicable. This will enable further miniaturization and improved performance to be obtained for small motors of this type.

The effective angle or area over which the permanent magnets 2 and 2' confront the motor rotor can be further increased by employing permanent magnets 2 and 2' shaped so that those portions 20, 20', 21 and 21' inward of the grooves 18, 18', 19 and 19' toward the rotor protrude outwardly beyond the side face portions 1–4B, 1–4A, 1–5B and 1–5A respectively of the magnet casing 1, as shown in Fig. 8.

Although the grooves 18, 18', 19 and 19' are described above as being provided at magnetically neutral positions on the permanent magnets 2 and 2', it is not essential that the grooves be positioned at magnetically neutral positions.

Thus, it will be seen that by providing lugs 14 and 15 of a simple shape on the magnet casing 1, and grooves 18, 18' 19 and 19' on the side faces of the permanent magnets 2 and 2', the magnets may be securely fitted in the magnetic casing.

Unwanted reactive magnetic fluxes between the permanent magnets 2 and 2' and the magnet casing 1 that by-pass the rotor cores 9 and 9' are substantially prevented. As compared with the arrangement of Figs. 1 to 3 the embodiments of Figs. 5 to 8 make it possible to further reduce the size of motor by reducing the magnetic gap between the permanent magnets 2 and 2' and the motor rotor R.

Again, as compared with the arrangement of Figs. 1 to 3, the described embodiments of motor in accordance with the present invention have increased effective surface angle θ of the permanent magnets 2 and 2' and thus increased magnetic field by employing lugs 14 and 15 which engage grooves 18, 18', 19 and 19' rather than edge portions of the curved surfaces of the magnets.

The effective angle over which the permanent magnets 2 and 2' confront the rotor (and thus the area over which the magnetic gap is present) may be further increased, as explained above, by employing permanent magnets 2 and 2' having protruding portions 20, 20', 21 and 21'. This will help improve motor torque and reduce cogging problems, and enables a more efficient rectangular parallelepiped-shaped small electric motor to be constructed while using a material having good permeability for the magnet casing 1.

CLAIMS

1. An electric motor of generally rectangular parallelepiped-shape, having a magnet casing of rectangular cross-section; and a plurality of permanent magnets mounted with a close fit to the inner wall of the casing; the magnet casing having side wall portions extending inwardly thereof from said inner wall alongside the side faces of the magnets by a distance smaller than the corresponding extent of the said faces, grooves being provided on the respective side faces of the permanent magnets, and the magnet casing having a plurality of lugs the distal ends of which are bent inwardly of the magnet casing and engaged in said grooves to hold the permanent magnets in the magnet casing.

2. An electric motor according to Claim 1, wherein the grooves are provided at magnetically neutral positions on the permanent magnets.

3. An electric motor according to Claim 1 or Claim 2, wherein the lugs are provided at positions where they do not confront the rotor cores.

4. An electric motor according to any of Claims 1 to 3, wherein those portions of the permanent magnets inward of the grooves towards the rotor are enlarged so that the side faces of the magnets in such portions protrude outwardly beyond the side wall portions of the magnet casing.

5. An electric motor according to any of Claims 1 to 4, wherein the magnet casing is made of a material having good permeability.

6. An electric motor of generally rectangular parallelepiped shape substantially as hereinbefore described with reference to and as shown in Figs. 5 to 7 or 8 of the accompany-

ing drawings.

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MABUCHI MOTOR KABUSHIKI KAISHA (Also known as MABUCHI MOTOR CO. LTD.), 14-11, Tateishi 3-chome, Katsushika-ku, Tokyo, Japan. Japanese Body Corporate,

TAKAICHI MABUCHI, c/o Mabuchi Motor Co. Ltd. 14-11, Tateishi 3-chome, Katsushika-ku, Tokyo, Japan,

Electric motor:

Address for Service:

Lloyd Wise, Tregear & Co., Norman House, 105-109 Strand, London WC2R 0AE.

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