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(54) BRUSH GEAR

(71) We, MABUCHI MOTOR KABUSHIKI KAISHA, also known as Mabuchi Motor Co. Ltd., of 14-11 Tateishi 3-chome, Katsushika-Ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to brush gear for an electric motor. More particularly it relates to a one-piece resilient strip brush support which provides both a terminal portion and a brush mount, and which is arranged to physically support and resiliently bias a brush towards a commutator in the assembled motor.

In general, resilient strip brush gear for a small magnetic motor is constructed in such a manner that the brush contacts the motor commutator with a relatively large pressure applied by the resiliency of the brush itself or an external resilient body such as a brush support so as to prevent unwanted movement of the brush at the position where it contacts the motor commutator. Where the pressure applied by such a brush is increased as described above, however, undesirable abrasion loss of motor commutators may occur and wear of brushes is increased. In addition, the presence of sparks in such an arrangement further accelerates the wear. In order to overcome these problems of commutator and brush wear, therefore, the so-called carbon brushes, for example, are used for the parts in contact with motor commutators to reduce contact friction resistance and to suppress spark current with their electrical resistance. On the other hand, when the thickness of the sheet material from which the brush or brush support is formed is increased to increase the pressure of the brush on the commutator, resonance may occur due to vibration caused by the rotation of the motor, resulting in undesirable oscillation of the brush at con-

tact points between the brush and the motor commutator, and shortened life of the brush. The relation between the thickness of the sheet material from which the brush or brush support is formed and the lifetime of the brush or brush support of a typical brush gear of this kind is shown in Fig. 1 of the accompanying drawings. According to Fig. 1, the lifetime of the brush or brush support depends also upon the armature current in the motor. It will be seen from the figure that for best overall results the thickness should lie in the range 0.06—0.08mm.

In general, a resilient strip brush support for transmitting an input from the exterior of a small electric motor is made of a resilient and electrically conductive flat sheet material, such as Be—Cu (beryllium-Copper) alloy, which is stamped and bent to a desired shape and size. Thin sheet material is used at a thickness of 0.06—0.08mm to extend the life of the brush as described above. An unwanted consequence of this, however, is that the terminal portion may be accidentally broken or torn off. It has been proposed that the addition of a reinforcing plate to the terminal portion be made to increase the mechanical strength of the terminal portion. Such an addition, however, is not favourable in terms of production efficiency, and particularly, in mass production, a slight increase in component costs may lead to a considerable increase in production costs. It has been an important task, therefore, to achieve excellent operating performance of the brush gear with adequate strength of the brush support while maintaining the thickness of the sheet material at an appropriate level.

According to the present invention, we therefore provide a brush for an electric motor, comprising: a brush proper; and a one-piece resilient strip brush support by which the brush proper is physically supported; the brush support comprising a base portion; a brush mount extending from the

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base portion and upon which the brush proper is mounted, and a terminal portion extending from the base portion, the side edges of the terminal portion being bent out of the plane thereof to confer increased mechanical strength on the terminal portion.

As a second, and related aspect of the invention, we also provide a brush gear for an electric motor, comprising at least one one-piece resilient strip brush support having a brush proper physically supported on said support and itself being carried by a portion of motor casing, the brush support comprising: a base portion for attaching the brush support to the motor; a brush mount extending from the base portion and upon which the brush proper is mounted; and a terminal portion extending from the base portion and through a through terminal aperture provided in said portion of motor casing, the side edges of the terminal portion being bent out of the plane thereof to confer increased mechanical strength on the terminal portion, and the strengthened part of the terminal portion being lodged in said aperture.

As a preferred feature of the invention, the side edges of the brush mount also are bent out of the plane thereof to confer increased mechanical strength on the brush mount.

In the drawings:

Fig. 1 referred to in detail above is a graphical representation showing the relation between the thickness of a sheet material from which a brush or brush support is struck and the life of the brush or brush support;

Fig. 2 is a perspective view illustrating the relation between the brush support and the motor case in an embodiment in accordance with this invention;

Fig. 3 is a perspective view illustrating the assembled state where the brush support shown in Fig. 2 is mounted on the motor case;

Fig. 4 is a view illustrating major parts to be press worked of the brush support shown in Fig. 2;

Figs. 5A and 5B are cross sections illustrating the relation between two embodiments of terminal portion and suitable terminal apertures in the motor case; and

Figs. 6A, 6B, 6C, 7A and 7B are explanatory drawings.

Fig. 2 shows a brush support and a portion of a motor case.

In Fig. 2, numerals 1 and 1' refer to brush supports, respectively, made of a resilient electrically conductive material, such as Be-Cu (beryllium-copper) alloy, and having terminal portions 2 and 2', base portions 9 and 9' and brush mounts 5 and 5', as its integral parts. Numerals 3 and 3' refer to bases of the terminal portions 2 and 2', and numerals 4 and 4' to the side edges of the terminal portions 2 and 2', the side edges

being bent out of the plane of the terminal portions to confer increased mechanical strength thereon. Numerals 6 and 6' refer to brush mounting holes on which brushes proper (not shown) are mounted, and numerals 7 and 7' to the side edges of brush mounts 5 and 5', the side edges being bent out of the plane of the brush mounts 5 and 5' to confer increased mechanical strength thereon. Numerals 8 and 8' refer to holes to be engaged, in the assembled state, with projections 13 and 13' provided on a motor case 10. Numerals 11 and 11' refer to first retaining means for retaining the brush supports 1 and 1' in the desired positions, and numerals 12 and 12' to terminal apertures provided on the motor case 10. Numerals 14 and 14' refer to second retaining means for retaining the brush supports 1 and 1', in conjunction with the first retaining means 11 and 11', and numeral 15 to a hole through which a motor shaft (not shown) is inserted.

In order to mount the brush supports 1 and 1' on the motor case 10, each of the brush supports 1 and 1', positioned in the state shown, are moved in the direction shown by arrows *a* and *a'* in the figure and inserted into the terminal apertures 12 and 12'. In the case of the brush support 1, the hole 8 on the brush support 1 engages with the projection 13 on the side of the motor case 10 as the terminal portion 2 is being inserted into the terminal aperture 12. The brush support 1' is also mounted on the motor case 10, in a similar manner to the brush support 1.

Fig. 3 shows the arrangement wherein the brush support 1 is mounted on the motor case 10. The brush support 1 is prevented from twisting about the projection 13 by the retaining means 11 and 14.

Numeral 16 refers to a brush proper mounted on the brush mount 5 so as to contact a motor commutator (not shown), and numeral 17 refers to a rivet for securing the brush support 1 to the motor case 10 where the hole 8 shown in Fig. 2 engages the projection 13. Other numerals correspond with like numerals in Fig. 2.

In the assembled state shown in Fig. 3, the right and left side edges 4 and 4' of the terminal portions 2 and 2' are disposed so that at least parts of the edges 4 and 4' are lodged in the terminal apertures 12 and 12'. The brush support 1 is folded along the fold line *c* to such a degree that, in the assembled state, where the brush 16 is in contact with the motor commutator (not shown), the brush mount tends to be forced outwards in a direction shown by an arrow *b* in the figure, while the base 9 and the terminal portion 2 of the brush spring body 1 are held rigid as shown in Fig. 3. In this assembled state, the brush proper 16 thus receives a force in a direction opposite to the direction shown by the arrow *b* in the figure due to the resiliency

of the brush support 1, causing the brush proper 16 to contact the motor commutator. The second retaining means 14 prevents the brush support 1 from being rotated around the projection 13 in the direction shown by an arrow d in the figure. Thus, the brush proper 16 and the motor commutator are in good contact without unwanted torsion of the brush support 1.

Fig. 4 is a plan view showing major parts of the brush support 1 (1') to be press worked. Numerals in the figure correspond with like numerals in Fig. 1.

In making the brush support 1 (1') shown in Fig. 1, an electrically conductive sheet material, such as Be—Cu alloy, having a uniform thickness, is punched into the shape shown by a solid line in Fig. 4, and then bent along fold lines shown by broken lines in Fig. 4.

Figs. 5A and 5B are cross sections illustrating in two embodiments of the invention the relation between the terminal portion 2 and the terminal aperture 12 of the brush gear. Numerals in the figure correspond with the like numerals in Fig. 1.

The brush support 1 shown in Fig. 5A has the terminal portion 2 formed so that each side edge 4 is disposed at an angle of 90° to the plane of the terminal portion 3, and the width t_1 of the side edges 4 in the direction shown by the arrow t_1 in the figure is almost equal to the width of the terminal aperture 12 also in the direction shown by the arrow t_1 .

The brush support 1 shown in Fig. 5B has the terminal portion 2 formed so that each side edge 4 is bent through 180° so as to form a double thickness marginal edge portion, and the thickness t_2 of each marginal edge portion in the direction shown by the arrow t_2 in the figure is almost equal to the width of the terminal aperture also in the direction shown by the arrow t_2 . The width t_2 of the terminal aperture 12 in Fig. 5B is smaller than the width t_1 in Fig. 5A.

Figs. 6A, 6B and 6C are explanatory drawings comparing the mechanical strengths of the terminal portion of a conventional brush support and the terminal portion of an embodiment of the brush support of the present invention.

Fig. 6A is a diagrammatic view illustrating a method for measuring the mechanical strength of a terminal portion. This measuring method determines to what extent the mechanical strength of the brush support of the present invention is greater than that of a conventional brush support.

As shown in Fig. 6A, in measuring the mechanical strength of a terminal portion 20 which is held in the groove 19 of a jig 18, the terminal portion 20 is first bent clockwise through an angle of 90° (Step ① in the figure), then it is bent counterclockwise through an angle of 180° (Step ③ in the

figure), and is again bent clockwise through an angle of 90° (Step ③ in the figure) to restore it to the original, vertical, position as shown in the figure. These steps ①, ② and ③ are repeated until the terminal portion 20 is broken or torn off, the number of cycles of the steps ①, ② and ③ needed to break or tear off the terminal portion being counted.

Fig. 6B shows the measurement results when a Be—Cu alloy material 0.12mm thick is used as the terminal portion 20 in Fig. 6A. In Fig. 6B, column (a) contains measurements on a conventional terminal portion having a flat cross section, column (b) contains measurements on a terminal portion having the cross section shown in Fig. 5B, and column (c) contains measurements on a terminal portion having the cross section shown in Fig. 5A.

As is evident from Fig. 6B, the average number of bending cycles needed to break or tear off the conventional terminal portion is as small as 4.0 while the average number of necessary bending cycles for the terminal portions in embodiments brush supports in accordance with the present invention, having cross sections shown in Figs. 5B and 5A, is 5.0 and 6.1, respectively, showing that the mechanical strength of the terminal portions of the present invention is greater than that of the conventional terminal portion.

Fig. 6C shows the measurement results in a test using terminal portions made of the same material and having the same thickness as the terminal portion used in the test shown in Fig. 6B but having a larger ratio of the edge width to the width of the remainder of the terminal portion. Symbols (a), (b) and (c) correspond with (a), (b) and (c) in Fig. 6B, respectively.

As is evident from Fig. 6C, the mechanical strength of the terminal portions (having measurements shown in columns (b) and (c)), particularly of the terminal portion having measurements shown in column (c) and having a cross section shown in Fig. 5A, is higher than that of the conventional terminal portion having measurements shown in column (a).

In addition to the test described in Fig. 6A, the force required to bend a terminal portion through an angle of 90° was measured, the results of which is shown in Figs. 7A and 7B.

Fig. 7A shows the measurement results in a test using terminal portions made of the same material and having the same width and thickness as those used in the test shown in Fig. 6B. Columns (a), (b) and (c) in Fig. 7A correspond with (a), (b) and (c) in Fig. 6B. Fig. 7B shows the measurement results in a test using terminal portions made of the same material and having the same width and thickness as those used in the test described in Fig. 6C. Columns (a), (b) and (c) correspond with (a), (b) and (c) in Fig. 6C.

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5 Figs. 7A and 7B indicate that the terminal portions of embodiments in accordance with the present invention require a force 1.5~2.8 times as large as that required for the conventional terminal portion for bending through an angle of 90°. This means that the mechanical strength of the terminal portions of the present invention is increased greater than that of conventional terminal portions.

10 Although the descriptions in Figs. 5 to 7 are limited to the reinforcement of terminal portions, it is needless to say that reinforcing effects can be achieved in brush mounts in a similar manner.

15 As described above, our work makes it possible to increase the mechanical strength of terminal portions merely by giving a simple shape to the terminal portions. It is possible to increase the mechanical strength of brush mounts by bending the side edges of the brush mounts. In addition to increasing the mechanical strength, this also serves to avoid unwanted resonance by shifting the characteristic frequency of the brush support by causing flexing of the brush support to concentrate at the fold line *c* in Fig. 3.

20 As described above, it is possible to provide sufficient strength of the brush support by integrally forming the brush mount and the terminal portion and bending the predetermined parts thereof. This eliminates the need to take additional mechanical reinforcing means such as a sheath for covering the terminal portion.

35 WHAT WE CLAIM IS:—

- 40 1. A brush for an electric motor, comprising: a brush proper; and a one-piece resilient strip brush support by which the brush proper is physically supported; the brush support comprising a base portion, a brush mount extending from the base portion and upon which the brush proper is mounted; and a terminal portion extending from the base portion, the side edges of the terminal portion being bent out of the plane thereof to confer increased mechanical strength on the terminal portion.
- 45 2. A brush as claimed in Claim 1, wherein the side edges of the brush mount are bent out of the plane thereof to confer increased mechanical strength on the brush mount.
- 50 3. A brush gear for an electric motor, comprising at least one one-piece resilient strip brush support having a brush proper physically supported on said support and itself being carried by a portion of motor casing, the brush support comprising: a base portion for attaching the brush support to the motor; a brush mount extending from the base portion and upon which the brush proper is mounted; and a terminal portion extending from the base portion and through a through terminal aperture provided in said
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portion of motor casing, the side edges of the terminal portion being bent out of the plane thereof to confer increased mechanical strength on the terminal portion, and the strengthened part of the terminal portion being lodged in said aperture.

70 4. A brush gear as claimed in Claim 3, wherein the side edges of the terminal portion are bent so as to form a right angle with the plane of the terminal portion, and wherein the width of the side edges is substantially equal to the width of the terminal aperture.

80 5. A brush gear as claimed in Claim 3, wherein the side edges of the terminal portion are bent through 180° so as to form a double thickness marginal edge portion, the thickness of which is substantially equal to the width of the terminal aperture.

85 6. A brush gear as claimed in any of Claims 3 to 5, wherein the side edges of the brush mount are bent out of the plane thereof to confer increased mechanical strength on the brush mount.

90 7. A brush for an electric motor, substantially as hereinbefore described with reference to and as shown in the accompanying Figures 2 to 4, and either 5A or 5B.

95 8. A brush gear for an electric motor, substantially as hereinbefore described with reference to and as shown in the accompanying Figures 2 to 4, and either 5A or 5B.

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45 2. A brush as claimed in Claim 1, wherein the side edges of the brush mount are bent out of the plane thereof to confer increased mechanical strength on the brush mount.

50 3. A brush gear for an electric motor, comprising at least one one-piece resilient strip brush support having a brush proper physically supported on said support and itself being carried by a portion of motor casing, the brush support comprising: a base portion for attaching the brush support to the motor; a brush mount extending from the base portion and upon which the brush proper is mounted; and a terminal portion extending from the base portion and through a through terminal aperture provided in said

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80 6. A brush gear as claimed in any of Claims 3 to 5, wherein the side edges of the brush mount are bent out of the plane thereof to confer increased mechanical strength on the brush mount.

85 7. A brush for an electric motor, substantially as hereinbefore described with reference to and as shown in the accompanying Figures 2 to 4, and either 5A or 5B.

90 8. A brush gear for an electric motor, substantially as hereinbefore described with reference to and as shown in the accompanying Figures 2 to 4, and either 5A or 5B.

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