

Electric Toothbrush with Rotary Bristle Carrier

This invention relates to an electric toothbrush with a handle section comprising an electric motor drive. A brush section is adapted to be connected to the handle section, with the brush section including a shaft having means for delivering a torque to a bristle carrier, with a bristle carrier being rotatably carried at an end of the brush section remote from the handle section. The bristle carrier comprises means for receiving a torque and means for mounting bristles, with an axis of rotation of the bristle carrier being disposed at an angle, particularly at approximately right angles, to a longitudinal center line of the brush section.

A toothbrush incorporating the features identified is already known from international patent application publication number WO 84/02453 or from U.S. Pat. No. 4,619,009 having issued from this application. The bristle carrier of this toothbrush has a bearing section carried in a bearing bore at the head end of the brush section. The bristle carrier is located by means of a slide lock engaging in an annular groove of the bearing section. The bristle carrier is driven by means of a drive shaft extending through a mounting tube and having bevel gear teeth at its head end. These bevel gear teeth mesh with gear teeth on the bristle carrier, with these gear teeth being arranged on the bristle carrier directly underneath a mounting plate of the bristle carrier. The axis of rotation of the bristle carrier being disposed at right angles to the longitudinal axis of the mounting tube, the mounting plate and the means for receiving the torque of the bristle carrier are both arranged on one

side of the longitudinal center line of the mounting tube or brush section.

This known arrangement has the following disadvantages: Not only the rotary parts including, for example, the drive shaft and the bristle carrier, but also the locking device and the bearing mount of the bristle carrier as well as in particular the means for delivering and receiving a torque, are subject to major wear. In this connection, it is to be considered in particular that toothbrushes are conventionally used in combination with tooth cleaning agents containing abrasives to a greater or lesser degree. For these reasons, it is advisable to provide means prolonging the life of the electric toothbrush also in cases where this toothbrush is used in combination with tooth-cleaning agents.

It is an object of the present invention to avoid the disadvantages of the prior art known and to provide an electrically powered toothbrush having a long service life also when used with tooth-cleaning agents and affording economy of manufacture.

This object is accomplished by an electric toothbrush incorporating the features initially referred to, in which all the means for transmitting a torque are configured as separate parts, are made of sintered metal and are connected to the shaft and, respectively, to the means for mounting the bristles by means of interengaging splines, in particular dovetails.

The use of sintered metal for the torque-transmitting means has the advantage of reducing the wear of these severely loaded components significantly also in

cases where the toothbrush is used in combination with tooth cleaning agents.

For cost reasons, only the torque-transmitting means are made of sintered metal, excluding the shaft and the means for mounting the bristles. A reliable and durable location of the torque-transmitting means in their respective positions on the shaft and on the means for mounting the bristles is ensured by providing splines, in particular dovetails, in order to connect the torque-transmitting means to the shaft and, respectively, the means for mounting the bristles. In contrast to conventional connections, the splined connections of these sintered metal parts with the shaft and, respectively, with the means for mounting the bristles which, as a rule, are both made of industrial plastics, ensure an areal impact, and thus a durable transmission of the necessary torques.

Because the means for receiving the torque and the means for mounting the bristles are in relative opposite arrangement on the bristle carrier, in particular below and, respectively, above the longitudinal center line of the brush section, and because the means for delivering the torque of the shaft engage in an overlapping fashion in the bristle carrier in the area intermediate the torque-receiving means and the means for mounting the bristles, the following advantage is achieved. The shaft with the torque-delivering means serves at the same time an interlocking function for the bristle carrier, because the shaft engages in an overlapping fashion in the bristle carrier between the torque-receiving means and the means for mounting the bristles on the bristle carrier. This completely eliminates the need to provide an additional interlocking arrangement for the bristle

carrier with the attendant increased wear of the bearing parts.

Because the bristle carrier is mounted on a shaft of the brush section and the torque-receiving means are arranged on the bristle carrier in the area of a low end of the shaft, the radial forces acting on the shaft of the bristle carrier as a result of the torque transmission in the gear train are introduced in the shaft at a location where the tilting or bending moments which they produce are minimal. By these means, friction of the bearing parts as well as wear are reduced.

Moreover, this arrangement contributes to ensuring a safe function of the toothbrush while allowing a certain amount of wear of the movable parts. This will be explained in more detail in the following with reference to the prior art identified. After prolonged use, the bearing section or the bearing bore will experience a certain amount of attrition so that the bristle carrier, as a result of the special arrangement of the gears of the gear drive and the resultant radial force components acting on the bristle carrier, will be tilted out of the ideal axis of rotation in the direction of the side wall. With progressive wear of the bearing parts, the engagement of the gears will become less and less until, from a certain moment, they are completely out of mesh. The known toothbrush is then no longer usable and has to be replaced.

A particularly advantageous configuration is obtained by arranging the torque-transmitting means in such a manner that the transmission of torques to the bristle carrier occurs above a low end of a shaft for mounting the bristle carrier and below the longitudinal center

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line of the brush section. Although the radial forces occurring during torque transmission act on the bristle carrier axially as a tilting moment, causing actual tilting of the bristle carrier after corresponding wear of the bearing parts, this tilting movement of the rotary shaft of the bristle carrier does not result in disengagement of the torque-delivering and torque-receiving means. On the contrary, the torque-transmitting means have shown to mesh even closer when tilting of the rotary shaft occurs. In contrast to the embodiment of the prior art, this special arrangement for introducing the torque has the effect that attrition of the movable parts tends to cause the torque-transmitting means to move in the direction of a closer mesh.

Configuring the torque-transmitting means as bevel gear teeth has the advantage of affording controllability of manufacture and relative ease of computation of the geometry. The arrangement of a mounting plate opposite the bevel gear teeth of the bristle carrier for the mounting of bristles or tufts of bristles ensures a free structure and optimization of the bristle pattern with respect to the cleaning effect of the toothbrush of the invention. Configuring the bevel gear teeth of the shaft as a bevel gear segment makes it possible to reduce the overall length of the brush section while maintaining the above-mentioned advantages. The bristle carrier which is driven to rotate in an angular range of about $\pm 35^\circ$, reversing direction in alternating sequence, ensures an intensive cleaning effect by the toothbrush. The provision of apertures in a mounting tube of the brush section ensures that cleaning and drying of the toothbrush after brushing pose no problems, and that also during brushing no or only a minor pumping action occurs

within the brush section as a result of the direction-reversing rotary motion of the bevel gear segment of the shaft. By this means, the entry of tooth cleaning agents in the bearings can be largely avoided or, if tooth cleaning agents have already entered the bearings, they can be removed from the bearings after brushing is completed. Wedge-shaped beadings provided on the shaft in the area of the apertures of the mounting tube of the brush section cause water that has entered the shaft area to be centrifuged to the outside away from the wedge-shaped beadings. By this means, liquid which has entered the mounting tube is largely prevented from travelling through the entire mounting tube to the handle section, the major part thereof being previously removed from the mounting tube by the centrifugal rings. This, too, contributes substantially to a reduced wear of the brush section caused the entry of tooth cleaning agents in the body.

Further advantages of the invention will become apparent from the subsequent description of an embodiment in conjunction with the accompanying drawings.

In the drawings,

FIG. 1 is a schematic view of a toothbrush of the invention illustrating an embodiment thereof;

FIG. 2 is a longitudinal sectional view of the forward end of the brush section of the toothbrush of FIG. 1, with the shaft being shown not sectioned; and

FIG. 3 is a top plan view of the sleeve section, the pin, the bevel gear teeth and the shaft, sectioned along the line A-A of FIG. 2.

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In the Figures, reference numeral 20 identifies an electric toothbrush. The toothbrush 20 comprises a handle section 22 and a brush section 24 which is adapted to be coupled together with the handle section 22. The handle section 22 houses an accumulator 26 or, alternatively, a battery, an electric motor 28 and a translating device 30 for converting the continuous rotary motion of the electric motor 28 into a rotary motion reversing direction in alternating sequence. On the outside of the handle section is a switch 32 for activating the toothbrush 20. The brush section 24 comprises a hollow mounting tube 36 receiving a shaft 34. The mounting tube 36 and the shaft 34 are adapted to be connected to the handle section 22 by a coupling means 40 not shown in greater detail. Arranged at the end of the brush section 24 remote from the handle section 22 is a bristle carrier 38 with a mounting plate 44 for receiving bristles 45 or tufts of bristles. At its end opposite the mounting plate 44, the bristle carrier 38 includes bevel gear teeth 46 meshing with a bevel gear segment 48 arranged at the head end of the shaft 34. The axis of rotation of the bristle carrier 38 defines an angle with respect to the axis of rotation of the shaft 34 of approximately 90°. It will be understood that this angle may also assume values of between 30° and 120° without limiting the scope of the invention. The bevel gear train 42 comprised of the bevel gear teeth 46 and 48 transmits the torque of the direction-reversing rotary shaft 34 to the bristle carrier 38 which is arranged preferably at right angles to the shaft 34. The range of the angle of rotation covered by the bristle carrier 38 may assume values on the order of between +/-20° and +/-100°, the preferred angle being, however, +/-35°, approximately.

As becomes more clearly apparent from the representation of FIG. 2, the hollow conical mounting tube 36 tapers in the direction towards the head end remote from the handle section 22. The head end of the mounting tube 36 is configured as an upwardly open cup-shaped socket 50. In a transition area 51, the inside diameter of the mounting tube 36 diminishes abruptly to about three fourths of its original diameter. This bearing surface serves, in connection with the ring 60 and the circlip 62, for axially securing a shaft member 75 which is arranged in the transition area 51 of the mounting tube 36. At its end close to the cup-shaped socket 50, the shaft member 75 includes a bevel gear segment 48. The bevel gear segment 48 is arranged at the end of the shaft member 75 close to the bottom area of the cup-shaped socket 50 below a longitudinal center line 52 of the brush section 24. The cross section of the shaft member 75 in the abruptly diminished area is identified by reference numeral 74. The diameter of the shaft member 75 increases from a small diameter in its upper area abruptly to a larger diameter in its lower area, with the small diameter being maintained over an angular range of approximately 250° , while the large diameter is maintained over an angular range of 110° . This construction enables the shaft member to perform rotations of about $\pm 35^\circ$, reversing direction in alternating sequence. At its end remote from the bevel gear segment 48, the shaft member 75 has cylindrical peripheral dimensions adapted to the inside diameter of the mounting tube 36. The shaft member terminates in a hub 49 having splines 80 on its inner circumference. The inner circumferential line of the splines extends in an approximately sinusoidal or rosette pattern, thereby ensuring an optimum areal torque transmission from the shaft 34 whose head end has an

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outer splined section adapted to fit into the inner splined section 80 of the shaft member 75. The shaft member 75 is preferably made of sintered metal, while the shaft 34 is an injection-molded part made of industrial plastics. Arranged in the center of the bottom of the cup-shaped socket 50 is a frusto-conical elevation 63 having a centrally arranged blind-end bore 57 serving to clampingly receive a shaft 56 which is preferably made of a non-abrasive material as, for example, steel. The shaft 56 defines a right angle with respect to the shaft 34 and serves to carry the rotary bristle carrier 38. In the present embodiment, the bristle carrier 38 is a two-piece structure, comprising a pin 59 having an annular shoulder 61 integrally formed therewith, and a sleeve section 58 fitting over the pin 59 and having a mounting plate 44 integrally formed therewith which extends above the cup-shaped socket 50, covering it. In the transition area intermediate the annular shoulder 61 and the pin 59, bevel gear teeth 46 meshing with the bevel gear segment 48 are provided. The bevel gear teeth 46 are arranged in the area of the low end 53 of the shaft 56. Preferably, the accurate axial positioning of the bevel gear teeth 46 is in such an area that the transmission of torques to the bevel gear teeth 46 occurs a small distance above the low end 53. The pin 59 has its bottom end recessed in the manner of a central frustum of a cone, enabling part of the elevation 63 to engage in this recess, with a narrow gap being maintained between the elevation 63 and the pin 59. The pin 59, the annular shoulder 61 and the bevel gear teeth 46 are preferably an integral sintered metal part, while the sleeve section 58 and the mounting plate 44 are an injection-molded part made of industrial plastics.

For the transmission of the necessary torques from the pin 59 to the sleeve section 58, these are provided with splines 81 as shown in FIG. 3. The bevel gear teeth 46 and the splines 81 which are arranged on the center part of the pin 59 as a one-sided eccentric dovetail are clearly recognizable. The sleeve 58 fitting over the pin has a corresponding one-sided, eccentric dovetailed structure, thereby providing a sufficient surface for transmission of the torques to the mounting plate 44. Axial securing of the mounting plate 44 or the sleeve section 58 relative to the pin 59 is accomplished by injection-molding around it, adhesive bonding or ultrasonic welding. Extending through the center of the pin 59 is a blind-end bore 55 serving to receive the free end of the shaft 56. Bores for accommodating individual bristles 45 or tufts of bristles are provided in the mounting plate 44.

In the off-center bottom area of the cup-shaped socket 50, the housing is provided with apertures 64, 65. Like apertures are in the housing wall area of the mounting tube 36. Apertures in the area of the shaft 34 are identified by reference numerals 66 and 67. The housing of the mounting tube 36 includes further apertures not shown in the drawings, these being disposed in the upper housing section 68 in the side wall area above the shaft member 75.

The brush section 24 is assembled as described in the following. The bristle carrier 38 is inserted into the cup-shaped socket 50 of the mounting tube 36 from above and placed down upon the free end of the shaft 56. The eccentrically arranged dovetailed splined section is aligned in the direction of the front end of the brush

section 24 adjacent to the side wall 47. Through the opening of the mounting tube 36 at the handle end, the shaft member 75 is inserted in the mounting tube 36 by means of a tool, such that the shaft member 75 abuts the bearing surface in the transition area 51. By virtue of the fact that the shaft member 75 is only provided with a bevel gear segment 48, its teeth not extending over the entire circumference, the bevel gear segment 48 is required to be oriented in a predetermined angular position relative to the longitudinal center line 52. The shaft member 75 is subsequently secured axially by means of the ring 60 and the circlip 62, for example, a notched ring. By reason of the bevel gear segment 48 fitting over the bevel gear teeth 46 of the bristle carrier, the bristle carrier 38 is also secured against axial displacements relative to the shaft 56. Finally, the shaft 34 is inserted in its mount in the area of the hub 49 of the shaft member 75. The transmission of torques from the shaft 34 to the shaft member 75 is ensured by the splines 80 in the area of engagement of the shaft 34 in the shaft member 75. By means not shown in greater detail in the drawings, also the shaft 34 is secured against an axial displacement relative to the longitudinal center line 52. The shaft 34 is adapted to be coupled together with a drive shaft of the handle section 22, and the mounting tube 36 is adapted to be coupled to the housing of the handle section.

Owing to the advantageous arrangement of the shaft 34 or the shaft member 75 with respect to the bevel gear teeth 46 of the bristle carrier 38, the shaft 34 or the shaft member 75 not only fulfil an axial securing function for the bristle carrier, but rather, further advantages result as will be described in the following. As

becomes readily apparent from general reference manuals on kinematics or bevel gear designs, the force acting on a driven gear, which force essentially acts normal to the tooth surfaces, can be broken down into its components including circumferential force, axial force and radial force. It is the circumferential force which is the force component by which the torque received by the driven gear is determined. Axial force and radial force are lost forces which, while contributing nothing to the magnitude of the torque transmitted, place a load on particularly the bearings of the driven gear. In the present embodiment, the axial force acts along the axis of rotation 54 of the bristle carrier in the direction of the bottom section of the cup-shaped socket 50. This axial force is taken up by the abutment means between the head end of the shaft 56 and the head area of the blind-end bore 55. In this area, barely visible wear of the bearing occurs, because tooth cleaning agents can hardly penetrate in this area because of the precise fit between shaft 56 and blind-end bore 55. By contrast, the radial forces exert a bending moment on the shaft 56 which naturally increases with the distance between the point of force application to the shaft and the fastening point of the shaft. Thus, it will be advantageous to introduce the force or torque into the bristle carrier 38 in such an axial area which is as close as possible to the fastening point of the shaft 56. This provision minimizes the bending moments acting on the shaft 56 as a result of the radial force components occurring in the transmission of torques. It is particularly advantageous to introduce the force into the bevel gear teeth 46 in an axial area of the rotary shaft 56 lying a small distance above the fastening point of the shaft 56. The tilting moment on the shaft 56 resulting from the radial force

components causes the shaft 56 to tilt in the direction of the side wall 47 of the cup-shaped socket 50. In consequence, also the annular shoulder 61 with the superposed bevel gear teeth 46 tilts about this angle, leaving its ideal position. However, this brings the teeth of the bevel gear segment 48 and the bevel gear teeth 46 into even closer mesh. Assuming that over time the teeth of the bevel gear train 42 are abraded or worn down by the action of tooth cleaning agents and that the clearance between the shaft 56 and the blind-end bore 55 increases also, a transmission of torque is possible over a prolonged period of time, because the tilting moments acting on the shaft 56 as a result of the radial forces act in the direction of a closer mesh of the gears of the gear train 42. With this advantageous arrangement of the gears of the gear train 42 relative to each other and relative to the fastening point of the shaft 56, it is possible to prolong the life of the brush section 24 even in the presence of a certain degree of wear.

The apertures 66 and 67 in the mounting tube 36 and the apertures 64 and 65 in the bottom of the cup-shaped socket 50 serve to facilitate cleaning of the brush section, which involves the removal of tooth cleaning agents and other extraneous material. The apertures at 68 above the shaft member 75 in the upper side wall area of the mounting tube 36 beneath the mounting plate 44 are only secondary to the cleaning of the brush section 24. The shaft member 75 being configured as indicated by the cross section 74, it acts like a pump while oscillating, forcing liquid matter contained in this area not only into the cup-shaped socket 50 but also in the direction of the shaft 34 through the gap maintained between the shaft member 75 and the inner wall of the mounting tube

36. To relieve this pressure, apertures are provided in the housing section 68 of the mounting tube 36 above the shaft member 75. Since, in spite of such means, the possibility of liquid mixed with extraneous material entering the interior of the mounting tube 36 past the shaft member 75 and penetrating along the shaft 34 in the coupling area 40 between the handle section 22 and the brush section 24 cannot be eliminated entirely, wedge-shaped beadings 70, 71, 72 are provided on the shaft 34 in the area of the apertures 66 and 67 of the mounting tube 36. If liquid mixed with extraneous material passes over these beadings 70, 71, 72, the increased centrifugal force acting at these beadings will cause the major part of the liquid and extraneous material to be centrifuged away from the shaft 34 and through the apertures 66, 67 out of the mounting tube 36. The beadings 70, 71, 72 thus have the effect of centrifugal rings for the removal of foreign particles and liquid from the interior of the mounting tube 36. This provision, too, adds to ensure an increased functional reliability and wear resistance of the brush section 24.

The embodiment of the invention was described with reference to a toothbrush in which the bristle carrier 38 rotates perpendicularly to the longitudinal center line 52 of the brush section 24 at an angle of approximately $\pm 35^\circ$, reversing direction in alternating sequence. It will be appreciated, however, that the invention is not limited to this particular embodiment and that it is with equal advantage suitable for use with continuously rotating toothbrushes arranged at angles other than right angles with respect to the longitudinal center line of the brush section.

**Patent Claims**

1. An electric toothbrush (20) incorporating the following features:

(a) a handle section (22) comprising an electric motor drive (28);

(b) a brush section (24) adapted to be connected to the handle section (22);

(c) the brush section (24) comprising a shaft (34) and means (75) for delivering a torque to a bristle carrier (38), and a bristle carrier (38) rotatably carried at the end remote from the handle section (22);

(d) the bristle carrier (38) comprising means (59, 61) for receiving the torque and means (44) for mounting bristles (45);

(e) an axis of rotation (54) of the bristle carrier (38) being arranged at an angle, particularly at approximately right angles, to a longitudinal center line (52) of the brush section (24);

characterized in that all the means (59, 61, 75) for transmitting a torque are configured as separate parts, are made of sintered metal and are connected to the shaft (34) and, respectively, to the means (44) for mounting the bristles (45) by means of interengaging splines (80, 81), in particular dovetails.



2. The electric toothbrush as claimed in claim 1, characterized in that the means for receiving the torque and the means for mounting the bristles (45) are in relative opposite arrangement on the bristle carrier (38), in particular below and, respectively, above the longitudinal center line (52) of the brush section (24), and the means for delivering the torque of the shaft (34) engage in an overlapping fashion in the bristle carrier (38) in the area intermediate the torque-receiving means and the means for mounting the bristles.

3. The electric toothbrush as claimed in claim 1 or claim 2, characterized in that the bristle carrier (38) is mounted on a shaft (56) of the brush section (24), and the torque-receiving means are arranged on the bristle carrier (38) in the area of a low end (53) of the shaft (56).

4. The electric toothbrush as claimed in any one of the claims 1 to 3, characterized in that the torque-transmitting means are arranged in such a manner that the transmission of torques to the bristle carrier (38) occurs above a low end (53) of a shaft (56) for mounting the bristle carrier (38) and below the longitudinal center line (52) of the brush section (24).

5. The electric toothbrush as claimed in any one of the claims 1 to 4, characterized in that the shaft (34) includes bevel gear teeth at its end close to the bristle carrier (38), which teeth are in engagement with bevel gear teeth (46) provided in the bottom area of the bristle carrier (38).



6. The electric toothbrush as claimed in claim 5, characterized in that the bristle carrier (38) includes a mounting plate (44) opposite the bevel gear teeth (46) for the mounting of bristles (45) or tufts (45) of bristles.

7. The electric toothbrush as claimed in claim 5 or claim 6, characterized in that the bevel gear teeth of the shaft (34) are configured as a bevel gear segment (48), and that the bristle carrier (38) is driven to rotate in an angular range of about plus/minus 35°, reversing direction in alternating sequence.

8. The electric toothbrush as claimed in any one of the claims 1 to 7, characterized in that the brush section (24) includes a mounting tube (36) for receiving the shaft (34), with the mounting tube (36) terminating in a cup-shaped socket (50) for receiving the bristle carrier (38).

9. The electric toothbrush as claimed in claim 8, characterized in that a shaft (56) has one end fastened to the bottom of the cup-shaped socket (50), its other end being adapted to be received in a blind-end bore (55) in the bristle carrier (38).

10. The electric toothbrush as claimed in claim 8 or claim 9, characterized in that the mounting tube (36) and the cup-shaped socket (50) are provided with apertures (64-68).

11. The electric toothbrush as claimed in claim 10, characterized in that the shaft (34) includes wedge-shaped beadings (70, 71, 72) extending over the shaft circumference in the area of the apertures (66, 67).