

Brush for a sonic toothbrush with longitudinal axis vibration

Technical field

The invention relates to a brush for a sonic toothbrush with longitudinal axis vibration. The brush
 5 has an elongate base body which forms an adapter on a base portion for rotationally fixed
 coupling to a sonic toothbrush drive in order to oscillate the brush about a longitudinal axis of
 the base portion. A bristle support is formed on a head portion of the brush, in which a plurality
 of bristles are anchored. A neck portion is formed between the base portion and the head
 portion. The base body forms a kink angle in such a way that the base portion longitudinal axis
 10 and a head portion alignment axis include an angle γ in the range of 7° to 17° . The bristle support
 has a deflection A in the range of 5% to 20% in relation to the length of the base body. The
 bristles are substantially perpendicular to the head portion alignment axis.

The invention further relates to a set comprising a brush according to any one of the preceding
 claims and a hand apparatus with sonic brush drive.

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State of the art

There are different types of electrically powered toothbrushes.

From the publications DE 10 2016 011477 (Schiffer), EP 2'454'967 A1 (Braun), WO 2005 046508
 A1 (Trisa) and others, the principle of the round brush head is known, which can rotate around
 20 an axis parallel to the bristle direction and is moved back and forth around this axis. The
 advantage of this arrangement is that the moving part (namely the round brush head) is very
 small. It does not require much drive energy and the forces (torques) that occur tend to be small.
 The disadvantage of this principle is that the bristle movement depends on the distance to the
 axis of rotation. The closer the bristles are to the axis of the brush head, the smaller the back

and forth movement. The movement pattern is therefore very inhomogeneously distributed across the bristle field.

The principle of the pendulum motion is known from the publications JP H04-43127 (Kao), US 2006 168744 A1 (Butler), US 2012/0291212 (Montagnino) and others. Here, the brush oscillates
 5 about a pendulum axis which is perpendicular to the hand apparatus (drive) and to the attached brush and which intersects the longitudinal axis of extension of the hand apparatus and brush at the point where the brush is coupled to the hand apparatus. The advantage is that the intensity of movement is homogeneously distributed over the entire bristle field. This is because all the bristles have more or less the same distance from the pendulum axis. The disadvantage,
 10 however, is that relatively large forces (torques) occur because the brush head with its mass is relatively far away from the pendulum axis.

The principle of housing vibration is known from the publications JP 2012-161368 (Sanion), DE 299 13 406 U1 (Rowenta), US 6,766,548 B1 (Rowenta), WO 2005 046508 A1 (Trisa), WO 2013/104020 A1 (Erskine) and others. A drive in the hand apparatus or in the brush neck
 15 generates an undefined vibration that is transmitted to the bristles. The advantage of this design is that you do not have to concern yourself with the technical details of motion transmission. The one-piece disadvantage, however, is that the entire housing has to be vibrated and more drive energy is required than if only a small part has to be vibrated. In addition, the vibration must not be too strong, as this impairs comfort when holding the hand apparatus. Finally, the
 20 effective movements of the bristles are not known and the cleaning effect of this type of undefined and uncontrolled vibration is anything but optimal.

Another principle is known from publications WO 2012-151259 A1 (Water Pik), EP 2'548'531 B1 (Trisa) and others. Here, the hand apparatus has a coupling pin that rotates back and forth around the longitudinal axis. The brush mounted on the coupling pin has a straight neck and a
 25 bristle plate at the end, from which the bristles are transverse to the longitudinal axis of the hand apparatus or the brush neck. The advantage of this geometry is that relatively low forces (torques) occur because the mass (neck, bristle plate) of the brush attachment is relatively close to the longitudinal axis (center of movement). The intensity of movement is also distributed relatively evenly across the bristle field.

30 However, the disadvantage of this principle is that the bristles only perform a one-dimensional movement (back and forth).

It is known that the cleaning effect of manual toothbrushes depends on the hardness of the bristles. Depending on the intended use, bristles of different hardness have different cleaning effects and different damage potential. These effects are known in specialist circles and are regularly included in the advice given to patients.

5 WO 2016/178142 A1 (Braun GmbH), for example, discloses a manual toothbrush with spring-mounted bristles. These protrude from the carrier plate at an oblique angle and are therefore particularly resilient. This allows them to change their length under load, which increases comfort for the gums. The range for the buckling force of a bristle is specified as 0.01 N to 2 N, for example 0.4 N.

10 The importance of the softness or flexibility of the filaments has also been discussed for electrically powered toothbrushes.

EP 1 713 413 B1 (Church & Dwight), for example, describes a modular electric toothbrush in which the user can replace certain parts of the brush head. The brush head consists of a stationary bristle support and a bristle support that can be moved linearly in the longitudinal
15 direction of the brush. The bristle stiffness is mentioned as a factor in the cleaning efficiency of this design. This is represented as a function of four parameters: Bristle diameter, bristle length, Young's modulus, number of bristles of the brush. This should be in the range of 0.2 to 0.8.

Sonic toothbrushes are very comfortable for the user and are also considered efficient because the electrically driven brush makes the movements much faster than can be done by hand.

20 In the case of sonic toothbrushes, it has previously been assumed that the higher the frequency of the motor and the greater the cleaning movement of the bristles, the better the cleaning results.

A sonic toothbrush with an angled brush head is known from WO 2017/050612 A1 (Curaden). Because the sonic toothbrush is angled forwards, the various areas of the dentition are more
25 easily accessible. In addition, the bend ensures that the filaments of the brushes vibrate with greater amplitude transverse to the longitudinal axis of the brush. The preferred operating frequency is 2000 to 8000 Hertz. However, the frequencies can also be higher, for example at 10 kHz, 50 kHz or even lower, for example at 200 Hz or 500 Hz.

An ultrasonic toothbrush is known from US 2012/0291212 A1, which has two parallel channels running transverse to the longitudinal axis of the brush to increase the resonant frequency. The frequency is increased in the forward-backward direction if the two channels are positioned at the front. If the channels are provided on the left and right of the brush neck, the frequency is increased in the lateral direction.

Disadvantages:

There is still a lack of sufficient understanding of the cleaning behavior of sonic toothbrushes. The knowledge we have today about the cleaning effect of manual toothbrushes cannot be transferred to the highly dynamic situation of a sonic toothbrush. In EP 1,713,413 (Church & Dwight) it is pointed out that a bristle stiffness of 0.2 - 0.8 is advantageous for the effectiveness of cleaning. EP 3'291'700 (Braun) describes a buckling force in the range of 0.01 N to 2 N as advantageous.

Disclosure of the invention

The object of the invention is to create a toothbrush for sonic toothbrushes which belongs to the technical field mentioned at the beginning and which has a better cleaning effect, in particular one which is gentle on the gums. In particular, a defined and controlled two-dimensional movement of the bristles is to be generated.

The solution to the object is defined by the features of claim 1. According to the invention, the essential part of the bristles has a buckling stress σ_k in a range from 0.1 MPa to 10 MPa, wherein

$$\sigma_k = \frac{\pi^3}{L^2} \cdot E \cdot r^2$$

π = number Pi (= 3.14)

E = Young's modulus of the bristles,

r = half the diameter of the bristle

L = length of the bristle

It was found that the desired two-dimensional movement of the bristle tips is a combination effect of the geometry of the brush according to the invention and the specified buckling tension of the bristles. In particular, the two-dimensional movement can be described as a kind of "8"

movement, because the bristle tips draw a kind of "8". The "8" is considerably larger in a y-direction than in the perpendicular x-direction. The exact geometry of the "8" movement can be controlled by various factors.

The invention is based on the following basic features:

- 5 a) The brush has a base portion on which an adapter to the hand apparatus, a so-called drive adapter, is formed. The adapter is geometrically designed to be connected to a coupling part (e.g. pin) of the sonic toothbrush drive in a rotationally fixed (but replaceable) manner. The sonic tooth brush drive generates a longitudinal axis vibration that is to be transmitted to the brush. The drive adapter defines a geometric base portion longitudinal axis (x) of the
10 brush. This longitudinal axis is normally the direction in which the brush can be attached to the hand apparatus. The brush is rotated back and forth around this longitudinal axis.
- b) Furthermore, the brush has a head portion with a bristle support in which a large number of bristles are anchored (bristle field). The head portion is in principle the upper end of the brush (whereas the base portion forms the lower end). The head portion defines a head
15 portion alignment axis. The bristles anchored in the head portion, for example, protrude at right angles to the head portion alignment axis. Typically, but not necessarily, the bristles are perpendicular to the head portion alignment axis.
- c) The base body has a neck portion between the base portion and the head portion. The neck portion therefore connects the base portion and head portion. The design of the neck
20 portion can be different.

In a particular embodiment, the neck portion is tapered in cross-section compared to the base portion. This means that if the base portion is viewed in cross-section (in relation to the longitudinal axis of the base portion), the dimensions in the x or y direction are smaller than the cross-section of the neck portion (i.e. transverse to the longitudinal axis of the neck portion).
25 The tapered cross-section refers to the cross-sectional area. It is therefore not mandatory that the dimensions in the x-direction and y-direction are smaller.

In order for the bristle tips to make the "8" movement according to the invention, the base body of the brush must be designed according to the invention. The kink angle γ and the deflection play a role here. The kink angle ensures that when the bristles are perpendicular to the head
30 portion alignment axis, they are not perpendicular to the longitudinal axis of the base portion

and therefore not perpendicular to the axis of longitudinal axis vibration. Instead, they form an angle in the range of 83° to 73° ($= 90^\circ - 7^\circ$ or $= 90^\circ - 17^\circ$). The kink angle must be of a certain size so that the "8" movement according to the invention can occur to a sufficient extent. If the kink angle is too large, the "8" movement collapses again or is degenerated by unwanted dynamic influences.

The deflection of the brush head also plays a role in the formation of the "8" movement. In the context of the invention, the deflection is in the range of 5% to 20%. If the deflection is below the range according to the invention, the movement of the head portion is not able to give sufficient excitation to the anchored part of the bristles. If the deflection is too great, vibration can occur in the base body in combination with the kink angle, which runs counter to the excitation of the "8" movement according to the invention.

According to a particular embodiment, the buckling stress is at most 4 MPa, in particular at most 1 MPa. This is because the buckling stress is one of the parameters that has a particular influence on the shape of the "8" movement. If the buckling stress is significantly below the upper limit according to the invention (i.e. in the sense of the present embodiment), the x-component of the "8" movement can become significantly larger. At a buckling stress of 1 MPa or less, the bristles are relatively flexible and can still perform the "8" movement according to the invention well even for brushes with a small kink angle and/or a small deflection.

According to another particular embodiment of the invention, the buckling stress is at least 1 MPa. This makes it possible to achieve a smaller "8" movement in the x-direction. Another effect that can be achieved with this lower limit is that the deflection can be increased without the "8" movement becoming unstable. If the deflection is relatively large, this can lead to the bristle tips no longer performing a controlled "8" movement, but only "whipping chaotically".

In one particular embodiment, the buckling stress is in the range from 1 MPa to 4 MPa. This has the advantage that the brush is suitable for higher operating frequencies of 250 Hz and more in particular. Different operating frequencies can usually be set for sonic toothbrushes. The operating frequency is one of the parameters that has an influence on the movement of the bristle tips and therefore on the "8" movement. It is therefore important to ensure that the brush performs the optimized "8" movement when the operating frequency recommended or preferred in the individual case matches the brush and the buckling stress of the bristles.

According to another particular embodiment, the Young's modulus of the material of the bristles is in the range of 1000 MPa to 3500 MPa. This makes it possible to work with materials such as polybutylene terephthalate (PBT) with 10% glass fibers. For materials with a Young's modulus in this range, the bristle length can be shorter without significantly reducing the buckling stress.

- 5 In particular, it can be advantageous for the Young's modulus not to exceed 2000 MPa. Such materials are also found in PBTs with a low glass fiber content.

However, it can also be advantageous to use materials with a Young's modulus in the range of 2500 MPa to 3500 MPa. This allows the bristle diameter to be reduced, which makes finer bristle tips possible.

- 10 The invention also extends to particular embodiments which have a Young's modulus of 4000 MPa or more. This range may have advantages if the bristles are not in tightly packed tufts or if the mutual friction between the bristles is rather low. Another advantage can be that the bristles can be longer without losing the "8" movement. Such bristles can be produced using polybutylene terephthalate (PBT) with carbon black content, for example."

- 15 According to a particular embodiment, the average length of the bristles is in the range of no more than 10 mm. If the bristles are too long, the brush can become unwieldy.

According to another particular embodiment, the average length of the bristles is at least 5 mm. This ensures that the cross-section of the bristles is too fine, which is advantageous when producing the brush.

- 20 Typically, the bristles of the brush are grouped together in tufts. If the bristles in the tuft have different lengths (e.g. if the tuft is rounded or pointed at the end, then the average value of the bristle length in the tuft is used as the relevant bristle length in the context of the invention. If a brush has tufts of different lengths, then the different tufts generally also have a different function. The buckling stress according to the invention is particularly relevant for bristles or
25 tufts that clean the edge area of the tooth or that are effective at the transition to the gum.

According to a particular embodiment, the deflection is in the range from 5% to 15%, in particular in the range from 7% to 13*. The deflection is one of the factors influencing the geometric shape of the "8" movement. A large deflection tends to increase the "8" movement and a small deflection reduces it. However, the kink angle must also be taken into account.

Because the "8" movement is based on a dynamic effect resulting from the combination of the various parameters (geometry of the brush, dimensioning and Young's modulus of the bristles, etc.) during operation, it also depends on the vibration frequency at which the brush is operated. The particular embodiments of the invention are designed so that brushes exhibit the "8
 5 movement" when they are operated at a frequency in the range from 100 Hz to 400 Hz, i.e. when they are combined with a drive in this range.

Preferably, the deflection is in the range of 5 to 10 mm.

A further special embodiment is that the bristles have a diameter of no more than 0.12 mm, in particular no more than 0.1 mm. If a certain desired number of bristles per tuft is assumed in
 10 individual cases, a thinner tuft can be created with thinner bristles. The area of thinner bristles can be combined with an area of shorter bristle length.

Normally, the bristles are round in cross-section. If they comprise a non-circular cross-section, an average value between the maximum and minimum transverse dimension is considered to be the diameter within the meaning of the invention.

15 According to a particular embodiment of the invention, the angle γ is in the upper range, i.e. in the range from 12° to 17° . This is advantageous for brushes in which the distance of the geometric kink position from the adapter plane is at least 50% of the length of the brush. (The geometric kink position results from the intersection of the base portion longitudinal axis and the head portion alignment axis). The angle range can also be advantageous for brushes with
 20 only a single tuft of bristles.

Large kink angles seem to amplify the "8" movement of the bristle tips in the x-direction. This means that the eyes of the "8" movement become larger, so to speak.

Another special embodiment of the invention is that the kink angle γ is in the range of 7° to 12° . This is advantageous for brushes in which the brush head is plate-shaped and has a large number
 25 of bristle tufts. In addition, in these embodiments, the neck part can be tapered in cross-section relative to the head part.

According to a preferred embodiment, the bristles of the brush are arranged in the form of a plurality of tufts which are spaced apart from each other. The tufts can, for example, be arranged in such a way that an inner bristle field and an outer bristle field are defined. The inner bristle

field is surrounded by the outer bristle field. The bristles in the inner bristle field may have a different length than the bristles in the outer bristle field. Within the scope of the invention, it is possible that only the bristles in the outer bristle field have the defined kink tension.

5 However, it also generally corresponds to a particular embodiment that at least two different bristle lengths are provided on the brush head. However, it is advantageous if bristles of different lengths belong to different bristle tufts. In other words, the bristle lengths within a bristle tuft are preferably essentially the same size.

10 According to a preferred embodiment of the invention, the adapter for rotationally fixed coupling to the sonic toothbrush drive has a channel running parallel to the longitudinal axis of the base portion for positively engaging a pin of the sonic toothbrush drive. The brush can therefore be plugged onto a pin of a sonic toothbrush drive using the adapter. Preferably, a latching element is provided so that the brush engages on the sonic toothbrush drive. The pin is pivoted back and forth around its longitudinal axis and the brush as a whole performs this longitudinal axis oscillating movement.

15 In a preferred embodiment of the invention, the base body comprises a load-bearing material with a Young's modulus of not more than 6000 MPa and not less than 2000 MPa. The bristle support is formed integrally with the base portion, in particular the adapter. Within the scope of the invention, the one-piece base body can also be formed from several elements bonded by a material bond (base portion, neck portion, head portion). The main part of the brush can, for example, be a synthetic material injection-molded part. The bristle support, brush neck and base portion are then formed on this injection-molded part. If required, a local or total coating with a soft plastic sheath can be provided.

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The invention also relates to a set comprising a brush of the type according to the invention and a sonic brush drive. The sonic brush drive has the form of a hand apparatus onto which the brush can be attached. The sonic brush drive is designed to oscillate the brush back and forth about the longitudinal axis of the base portion. The operating frequency should be in the range of 150 - 400 Hz, in particular in the range of 150 Hz to 300 Hz.

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In this range, the bristles according to the invention are best able to perform the desired two-dimensional "8" movement.

A special embodiment of the brush and sonic brush drive set is characterized by the fact that the sonic brush drive generates an vibration with an angular amplitude of max. 3° (relative to a central position). It has been shown that only very small angular amplitudes are required. The amplitude in the "8" movement of the bristles will be larger, not least because the design of the brush and the buckling stress of the bristles according to the invention combine to achieve this.

The adapter of the base portion, for example, has a channel and the sonic brush drive has a pin which can be positively inserted into the channel in order to create a non-rotating connection with respect to the longitudinal axis of the base portion, so that the brush as a whole can be driven to oscillate about the longitudinal axis of the base portion (longitudinal axis of the pin).

Further advantageous embodiments and combinations of features of the invention result from the following detailed description and the entirety of the patent claims.

Brief description of the drawings

The drawings used to illustrate the embodiment example show:

- Fig. 1 a schematic representation of a top view of a brush;
- 15 Fig. 2 a schematic representation of a side view of the brush;
- Fig. 3 a schematic representation of a rear view of the brush;
- Fig. 4 a schematic representation of a top view of a sonic toothbrush comprising the brush;
- Fig. 5a, b a schematic side view and a top view of a sonic toothbrush;
- 20 Fig. 6 a schematic representation of a side view of a sonic toothbrush with exactly one tuft;
- Fig. 7 a schematic representation of the "8" movement according to the invention;
- Fig. 8 a schematic representation of the angular amplitude of the longitudinal axis vibration;
- 25 Fig. 9 an embodiment with an oval brush head;

Fig. 10 an embodiment of a single-tufted brush with a bristle field on the back;

Fig. 11 an embodiment of a single-tufted brush with a bristle field on the front side.

In principle, identical parts are marked with the same reference symbols in the figures.

Ways to carry out the invention

5 Figure 1 shows a schematic representation of a top view of a brush 10. The brush 10 comprises a frustoconical base portion 11, a rod-shaped neck portion 12 which adjoins the frustoconical base portion 11, and finally a plate-shaped head portion 13 which adjoins the neck portion 12. The three parts form the supporting base body of the brush.

10 The frustoconical base portion 11 comprises a drive adapter. In the present case, this is essentially formed by a channel-shaped receptacle 14, into which a pin of the hand apparatus of the sonic toothbrush can be inserted and latched (see Figure 4 below). The brush 10 comprises a base portion longitudinal axis 20, which is aligned coaxially to the holder 14 or coaxially to the pin when the sonic toothbrush is in operation. This longitudinal axis defines the x-axis of the x-y-z coordinate system used here. In other words, the drive adapter defines the
15 geometric base portion longitudinal axis (x) of the brush.

Figure 1 also shows the bristle field 17 of the head portion 13, which in the present case comprises several (e.g. 20 - 40) tufts, each with a plurality (e.g. 100 - 200) of bristles.

According to a preferred embodiment, the head portion 13 is teardrop-shaped in the front view. In other words, its shape widens successively - starting at the transition to the neck portion -
20 almost to the upper end of the head portion, where it ends in a rounded end contour. With this shape (for a given length of the bristle field in the x-direction), the center of gravity of the head portion 13 is closer to the end of the brush. This can increase the eccentric effect at the specified operating frequency and thus also the "8" movement.

The main surface of the plate-shaped head portion 13 extends essentially transversely along the
25 x-axis in the y-direction.

Furthermore, an "8" lying in the y-direction is shown on the bristle field 17 with the reference sign 23. The "8" illustrates the movement which is executed due to the selected material property (Young's modulus), the angle between the geometric base portion longitudinal axis 20

and the geometric head portion alignment axis (see further below) and the kink position in the plane during operation.

In addition to the "8", the brush also performs a small nodding movement with the head portion 13 - this movement is directed essentially at right angles to the "8", i.e. essentially in the z direction. In a preferred embodiment, the bristles are thus moved in three dimensions (x, y, z).

Figure 2 shows a schematic representation of a side view of the brush 10. In addition to the geometric base portion longitudinal axis 20, the geometric head portion alignment axis 21 can also be seen in this figure. In the illustration according to Figure 1, the base portion longitudinal axis 20 and the head portion alignment axis 21 are one behind the other. The head portion alignment axis 21 is essentially the longitudinal axis of the head portion. The two axes intersect in the geometric kink position 22. In the present embodiment, the geometric base portion longitudinal axis 20 and the geometric head portion alignment axis 21 include an angle γ (gamma) of 10° . The geometric kink position 22 comprises a distance K from the end surface of the base portion 11 of 50% of the total length L of the brush 10. In this combination of the angle to the kink position 22, a brush 10 is created with which a particularly effective and gum-friendly cleaning of the teeth is possible.

As can be seen from the combination of Figures 1 and 2, in the present embodiment the head portion 13 is plate-shaped and the neck portion 12 is rod-shaped. In the projection of the base body onto the x-z plane, the head portion 13 and the neck portion 12 have the same transverse dimension (i.e. the same thickness). In the projection onto the x-y plane (front view according to Figure 1), the head portion 13 is about three times as wide (y-direction) as the neck portion 12. The length (x-direction) of the head portion is about one third greater than the width (y-direction). For example, the neck portion 11 is one third as wide and 1.5 times as long as the head portion 13.

The neck portion 12 is tapered in relation to the head portion 13 and the base portion 11. In the present example, the neck portion 12 is less wide than the head portion 13 in at least one of the side views (viewed here in the z-direction according to Figure 1).

In the present example, the base body of the brush 10 has a glass fiber-reinforced polypropylene Borealis GB311U with a Young's modulus of approximately 3500 MPA (Tensile Strength at yield

= 97 MPa; Elongation at Yield = 2.8%; Young's modulus = Tensile Strength at Yield / Elongation at Yield) as the load-bearing material.

The deflection is determined by the ratio of distance A to length L of the brush. The distance A corresponds to the distance from the front center of the head portion (which in this case corresponds to the center of the bristle field 17) to the longitudinal axis 20 of the base portion (see Figure 2). In this example, the deflection is 14%.

The bristles are arranged here in several tufts and project vertically away from the main surface of the plate-shaped head portion. In the present case, they are perpendicular to the y-direction and run in the x-z plane. In the present embodiment, the bristles are attached to the front side of the head portion (or the front side 27 of the brush), that is, they point slightly downwards towards the adapter surface (y-z plane) of the base portion. The longitudinal axis of the bristles forms an angle with the longitudinal axis of the base portion that is less than 90°: namely 90° minus the kink angle γ .

Figure 3 shows a schematic representation of a back view of the brush 10 according to Figures 1 and 2. As can be seen from the figures, the base body has a different material on the back 26, which is soft and provides protection (protective coating, protective sheath) when the back of the brush comes into contact with the teeth. This material is non-load-bearing and can therefore have a Young's modulus outside the Young's modulus range of 2000 - 6000 MPa according to the invention. The load-bearing material can be seen on the front side 27 and it makes up a significant part of the cross-section of the base body.

Figure 4 shows a schematic representation of a top view (z-direction) of a sonic toothbrush comprising the brush 10 and a hand apparatus 16 with a pin 15. The brush 10 is attached to the pin 15 so that the brush is detachable, rotationally fixed and axially fixed. The hand apparatus 16 rotates the pin 15 back and forth at a frequency of, for example, 180 - 270Hz with an amplitude of, for example, 2° (relative to a rest position) about the longitudinal axis of the pin 15 (which corresponds to the longitudinal axis of the hand apparatus 16). The brush thus rotates back and forth about the base portion longitudinal axis 20 (x-axis).

Figure 5a shows a schematic representation of a side view of a sonic toothbrush 10. The sonic toothbrush 10 comprises a hand apparatus 16 and a brush 10. The drive of the hand apparatus 16 is designed as a piezoelectric drive (not shown), which generates a vibration of the brush 10

about the x-axis 20 (longitudinal axis of the hand apparatus). The brush 10 thus performs a rotational oscillation about the x-axis 20 relative to the handle during operation. Due to the deflection of the head portion 13 according to the invention, an unbalance is created which supports a movement component in the Y-direction 24 and/or in the Z-direction 25 (see below, Figure 5b). This effect is controlled by the suitably angled bend in the brush neck, the suitably selected Young's modulus and can be adjusted by further geometric design features of the brush (such as bend angle position, deflection, mass distribution and other features according to the particular embodiments of the invention).

Figure 5b shows a schematic top view of a personal care appliance as shown in Figure 5a. The Z-direction 25 can be seen in this illustration. It essentially runs in the direction of the bristles. As can be seen from the figure, the hand apparatus is significantly larger than the brush. Only in this way can it generate longitudinal axis vibration (instead of an undefined or undirected vibration movement, as is the case with known sonic toothbrushes).

Figure 6 shows an embodiment of the sonic toothbrush which comprises exactly one tuft 18. The tuft 18 is arranged at the rear with respect to the head portion 13. The head portion is inclined backwards, so to speak.

Figure 7 shows a schematic representation of the "8" movement according to the invention. In the present case, the "8" movement comprises the shape of an "8" flattened on one side, with an axis of symmetry (X axis) running through the center 27 of the "8". The two loops 28a, 28b of the "8" extend in the y-direction. However, the invention is not limited to exactly this form of "8" movement; the exact form of the movement ultimately depends on the parameters of the brush head and the vibration generated by the motor of the hand apparatus.

Figure 8 illustrates the amplitude of the longitudinal axis oscillation movement. The x-axis is perpendicular to the plane of the drawing. The plate-shaped head portion 13 (shown without bristles) swivels around the x-axis by the angle α (alpha). (The bristles extend upwards in the z-direction in Figure 8). The main component of the swivel movement (and thus the bristle wiping movement) is in the y-direction. The angle α (alpha) between the rest position (drive switched off) and the maximum deflection from the rest position is preferably a maximum of 3° , preferably 2° . The deflection from "maximum left" to "maximum right" is therefore 6° or 4° .

Figure 9 shows a brush 10 with a plate-shaped oval head portion 13. The longitudinal axis of the oval shape runs essentially in the x-direction and the transverse axis in the y-direction. The center of the head portion 13 is further away from the upper end of the brush 10 than in the drop-shaped head portion shown in Figure 1.

- 5 Figure 10 shows a brush with a kink angle γ (gamma) of 14° and a distance K from the geometric kink position 22 to the end surface 29 of the base portion 11 of 75% relative to the length L of the brush.

The base portion 11 tapers from the end surface 29 to the transition into the neck portion 12. The base portion 11 can be, for example, frustoconical or truncated pyramid-shaped, whereby
10 it has, for example, a concave profile in longitudinal section. Thus, the center of gravity of the base portion 11 is closer to the end surface 29 than in a comparable base portion with straight profile lines.

In the embodiment shown, the neck portion 12 occupies approximately half the length (L) of the brush. As Figure 10 illustrates, the neck portion 12 does not necessarily have to have a constant
15 cross-section over its entire length. It can certainly have a changing contour.

The head portion 13 is formed by the extension of the neck portion 12. In the present example, the head portion 13 has essentially the same transverse dimensions (viewed in a section perpendicular to the head portion alignment axis 21) as the neck portion 12. The bristle field 17 is positioned at the side of the head portion 13. The bristles therefore protrude perpendicular
20 to the head portion alignment axis 21.

Figure 11 shows an embodiment in which the base portion 11 is essentially formed by a pin 30 as a drive adapter. The neck portion 12 is rod-shaped and occupies, for example, 90% of the length of the brush. The head portion 13 is the part in which the bristle field 17, here in the form of a single tuft, is anchored. The pin 30 is inserted into the hand apparatus in the x-direction for
25 rotation-fixed coupling to a sonic tooth brush drive with longitudinal axis vibration, whereby the drive adapter defines the geometric base portion longitudinal axis (x) of the brush.

A brush according to Fig. 11, for example, is made of a material with a Young's modulus of approx. 4600 MPa. An example of such a material is LNP ULTEM® EXCP0096 Polyetherimide, 30% Carbon Fiber Reinforcement, 10% PTFE Lubricant (Tensile Strength at Yield = 163 MPa, Elongation at Yield = 3.5%, Tensile Strength / Elongation = 4650 MPa).
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In further embodiments not shown, the brush 10 comprises an interdental brush for cleaning the interdental spaces instead of the bristle field 17.

The invention will now be explained with reference to specific examples of suitable parameters. Here, the length LB of the bristles is measured from their exit from the front of the head portion to their tip as shown in Fig. 2. In examples 1 to 6, the bristles are arranged in a plurality of slightly spaced-apart tufts.

Example 1: The brush has a kink angle $\gamma = 14^\circ$ and a deflection A in relation to the length L of the brush of 10%. The buckling stress of the bristles is around 9.7 MPa. All bristles are made of the same material and have the same geometric dimensions. The Young's modulus of the bristles is 2000 MPa. The length LB of the bristles is 6 mm. The bristles are circular in cross-section and have a diameter of 0.15 mm. This brush is particularly suitable for longitudinal axis vibration with a frequency of no more than 200 Hz. The brush can be designed, for example, as shown in Figure 10 or 11.

Example 2: The brush has a kink angle $\gamma = 12^\circ$ and a deflection A in relation to the length L of the brush of 11%. The buckling stress of the bristles is around 4.5 MPa. All bristles are made of the same material and have the same geometric dimensions. The Young's modulus of the bristles is 4000 MPa. The length LB of the bristles is 10 mm. The bristles are circular in cross-section and have a diameter of 0.12 mm. This brush is particularly suitable for longitudinal axis vibration with a frequency of 150 - 300 Hz.

Example 3: The brush has a kink angle $\gamma = 10^\circ$ and a deflection A in relation to the length L of the brush of 7%. The buckling stress of the bristles is around 2.4 MPa. All bristles are made of the same material and have the same geometric dimensions. The Young's modulus of the bristles is 4500 MPa. The length LB of the bristles is 12 mm. The bristles are circular in cross-section and have a diameter of 0.10 mm. This brush is particularly suitable for longitudinal axis vibration with a frequency of 150 - 300 Hz.

Example 4: The brush has a kink angle $\gamma = 8^\circ$ and a deflection A in relation to the length LB of the brush of 70%. The buckling stress of the bristles is around 1.5 MPa. All bristles are made of the same material and have the same geometric dimensions. The Young's modulus of the bristles is 3500 MPa. The length LB of the bristles is 12 mm. The bristles are circular in cross-section and

have a diameter of 0.09 mm. This brush is particularly suitable for longitudinal axis vibration with a frequency of up to 400 Hz.

Examples 2 to 4 can be designed, for example, like the brush shown in Figures 1 to 3.

5 Example 5: The brush has a kink angle $\gamma = 10^\circ$ and a deflection A in relation to the length L of the brush of 10%. The buckling stress of the bristles is around 0.52 MPa. All bristles are made of the same material and have the same geometric dimensions. The Young's modulus of the bristles is 1500 MPa. The length LB of the bristles is 12 mm. The bristles are circular in cross-section and have a diameter of 0.08 mm. This brush is particularly suitable for longitudinal axis vibration with a frequency of 150 - 300 Hz.

10 Example 6: The brush has a kink angle $\gamma = 11^\circ$ and a deflection A in relation to the length L of the brush of 8%. The buckling stress of the bristles is around 2.3 MPa. All bristles are made of the same material and have the same geometric dimensions. The Young's modulus of the bristles is 3000 MPa. The length LB of the bristles is 10 mm. The bristles are circular in cross-section and have a diameter of 0.10 mm. This brush is particularly suitable for longitudinal axis vibration
15 with a frequency of 150 - 300 Hz.

Example 7: The brush has a kink angle $\gamma = 9^\circ$ and a deflection A in relation to the length L of the brush of 7%. The brush has two different types of bristles. In an edge area, which is essential for cleaning at the transition between tooth and gum, the bristles have a buckling stress according to Example 2. In an inner area enclosed by the edge area, the Young's modulus is 4000 MPa and
20 the length of the bristles is 9 mm. The bristles are circular in cross-section and have a diameter of 0.12 mm in the entire area. The buckling stress in the inner area is 5.5 MPa. This brush is particularly suitable for longitudinal axis vibration with a frequency of 150 - 300 Hz.

Example 8: The brush has a kink angle $\gamma = 16^\circ$ and a deflection A in relation to the length L of the brush of 17%. The brush has two different types of bristles. The majority of the bristles, which
25 are essential for cleaning at the transition between the tooth and gum, have a buckling stress of 2.6 MPa. The Young's modulus of the bristles mentioned is 4500 MPa, the length LB of the bristles is 7 mm. The bristles are circular in cross-section and have a diameter of 0.06 mm throughout. This brush is particularly suitable for longitudinal axis vibration with a frequency of 150 - 300 Hz.

Examples 5 to 8 can be designed, for example, as shown in each of the brushes in Figures 1 to 3 and 9 to 11.

The bristles need not be circular in cross-section. They can also be slightly oval or non-circular, for example in that the transverse dimension in one direction is 20% larger than the transverse
5 dimension in the direction perpendicular thereto.

In summary, according to the invention, a brush for a sonic toothbrush drive is provided which leads to a particularly advantageous movement of the head portion for effective and efficient cleaning of the teeth.

Claims

1. Brush for a sonic toothbrush with longitudinal axis vibration, having an elongate base body which forms an adapter on a base portion for rotationally fixed coupling to a sonic toothbrush drive in order to vibrate the brush about a base portion longitudinal axis, and
 5 which forms a bristle support on a head portion, in which a plurality of bristles are anchored, a neck portion being formed between the base portion and the head portion, and wherein.
 - a) the base body forms a kink angle in such a way that the base portion longitudinal axis and a head portion alignment axis include an angle γ in the range from 7° to 17° ,
 - 10 b) the bristle support has a deflection in the range of 5% - 20% in relation to a length (L) of the base body,
 - c) the plurality of bristles are substantially perpendicular to the head portion alignment axis,
 - d) characterized in that the essential part of the bristles have a buckling stress σ_k in the
 15 range from 0.1 to 10 MPa, wherein

$$\sigma_k = \frac{\pi^3}{L^2} \cdot E \cdot r^2$$

π = number Pi (= 3.14)

E = Young's modulus of the bristles,

r = half the diameter of the bristle

20 L = length of the bristle

2. Brush according to claim 1, characterized in that the buckling stress is at most 4 MPa, in particular at most 1 MPa.
3. Brush according to claim 1 or 2, characterized in that the buckling stress is at least 1 MPa, in particular at least 4 MPa.

4. Brush according to one of the preceding claims, characterized in that the buckling stress is in the range from 1 MPa to 4 MPa.
5. Brush according to one of the preceding claims, characterized in that the Young's modulus of the bristles is in the range from 1000 MPa to 3500 MPa.
- 5 6. Brush according to one of the preceding claims, characterized in that the Young's modulus of the bristles is not more than 2000 MPa.
7. Brush according to one of claims 1 to 5, characterized in that the Young's modulus of the bristles is in the range from 2500 MPa to 3500 MPa.
8. Brush according to one of the preceding claims, characterized in that the average length of
10 the bristles is in the range up to a maximum of 10 mm.
9. Brush according to one of the preceding claims, characterized in that the deflection is in the range from 5% to 15%, in particular in the range from 7% to 13%.
10. Brush according to one of the preceding claims, characterized in that the bristles have a diameter of not more than 0.12 mm, in particular of not more than 0.1 mm, and particularly
15 preferably of 0.08 to 0.12.
11. Brush according to one of the preceding claims, characterized in that the angle γ is in the range from 12° to 17°.
12. Brush according to one of claims 1 to 10, characterized in that the angle γ is in the range from 7° to 12°.
- 20 13. Brush according to one of the preceding claims, characterized in that the bristles are arranged in the form of tufts which are preferably spaced apart from one another.
14. Brush according to one of the preceding claims, characterized in that at least two different bristle lengths are provided.
- 25 15. Brush according to one of the preceding claims, characterized in that the adapter for rotationally fixed coupling to the sonic toothbrush drive has a channel extending parallel to the longitudinal axis of the base portion for positively receiving a pin of the sonic toothbrush drive.

16. Brush according to one of the preceding claims, characterized in that the base body comprises a load-bearing material having a Young's modulus of not more than 6000 MPa and not less than 2000 MPa.
- 5 17. Set containing a brush according to one of the preceding claims and a hand apparatus with a sonic brush drive, characterized in that the brush can be plugged onto the sonic brush drive and in that the hand apparatus drives the brush to oscillate about the base portion longitudinal axis and the sonic brush drive has an operating frequency in the range from 150 to 400 Hz, in particular in the range from 150 Hz to 300 Hz.
- 10 18. Set according to claim 17, characterized in that the motor excites a vibration with an angular amplitude of max. 3°.
- 15 19. Set according to claim 18, characterized in that the adapter of the base portion has a channel and the sonic brush drive has a pin which can be positively inserted into the channel in order to create a non-rotating connection with respect to the longitudinal axis of the base portion, so that the brush as a whole can be driven to oscillate about the longitudinal axis of the base portion.