SONIC ENERGY DENTAL CLEANING DEVICE
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ABSTRACT OF THE DISCLOSURE
A power-driven appliance adapted for oral use in cleaning the teeth comprises a source of vibratory energy in the sonic range disposed in vibration transmitting relation within a casing having a parabolic nose cone onto which a toothbrushing attachment is removably attached in vibration transmitting relation. A cleaning member, which preferably takes the form of a plurality of bristles, is disposed on the attachment at the end thereof away from the casing, and the cleaning attachment includes a longitudinal handle configured so that vibratory energy in the sonic range transmitted to the attachment causes the bristle head to move elliptically, the major axis of movement being generally longitudinal of the bristles. The bristles thus serve as a driving force creating a sound field that produces acoustic streaming in the liquid medium surrounding the tooth surface to be cleaned.

BACKGROUND OF THE INVENTION
Field of the invention
This application generally relates to the dental arts and more particularly to a power-driven appliance designed to utilize sonic energy in the cleaning of the teeth and in stimulating the gingival tissues.

Description of the prior art
Dental practitioners have long sought satisfactory mechanical toothbrushing implements by reason of their convenience and their enhanced cleaning effectiveness in comparison with manual brushes. Typically, such mechanical brushes have had for their primary objective the production of reciprocating movement of a conventional toothbrush head, most commonly in a vertical direction generally perpendicular to the gingival margin. This form of brushing has found widespread acceptance in the dental profession, and the utilization and effectiveness of automatic toothbrushes has been recognized by the Council on Dental Therapeutics of the American Dental Association (Accepted Dental Remedies, 196 (32d ed., 1967)). Nonetheless, despite this acceptance of power-driven toothbrushes, these devices (which amount to little more than arrangements for automatically simulating manual brushing techniques) have exhibited several disadvantages. A primary disadvantage is that such physical cleaning and polishing is largely ineffective on the exposed tooth surfaces and is relatively ineffective in cleaning the interproximal surfaces between adjacent teeth that cannot be reached by a toothbrush. Moreover, because cleaning is accomplished by a physical rubbing of the tooth surfaces, problems of abrasion of the tooth enamel and dentin are encountered. A still further disadvantage of such conventional electric toothbrushes is that they are relatively ineffective in removing food particles and the like trapped at the gingival margin.

For all of these reasons, it would be desirable to provide a power-driven toothbrush which utilizes a new principle or mode of action and that does not rely on physical rubbing of the tooth surface to accomplish the tooth cleaning purpose.

Acoustic streaming is a sonically induced phenomenon which may be employed to accomplish a cleaning function. The term "acoustic streaming" is used to describe a phenomenon in accordance with which a liquid, under the influence of oscillatory forces (as for example sonic energy), reaches a condition in which steady circulation occurs near the surfaces of obstacles in the liquid resulting in the ejection of steady viscous stresses at the interfaces formed between these obstacles and the liquid. As a result, the natural microscopic liquid barriers present on all surfaces being liquid cleaned may be broken.

Through the utilization of the phenomena of acoustic streaming, oral hard tissues may be quickly and efficiently cleaned without danger of unduly abrading the tooth surface. Moreover, the tooth surfaces beneath the gingival margin can be easily cleaned, as can the interproximal surfaces. Finally, this phenomenon can further be utilized to provide the stimulation of gingival tissue so necessary to avoid periodontal disease.

It has heretofore been proposed to utilize vibratory energy in the sonic range in a power-driven toothbrush. For example, Hübner U.S. Patent No. 3,185,538 describes a portable electric tooth appliance having a driving eccentric as a vibratory energy source. However, Hübner's toothbrush handle is so configured as to produce reciprocal motion in a direction substantially perpendicular to the gingival margin. In other words, the Hübner device operates in the same fashion as conventional mechanical toothbrushes, a mode of operation wholly different from that of the subject invention.

Accordingly, the present invention has for its primary objective the provision of a toothbrushing device utilizing a sonic energy source and adapted to accomplish tooth cleaning and gingival tissue stimulation through the utilization of acoustic streaming.

SUMMARY OF THE INVENTION
In accordance with the present invention, a new and effective cleaning appliance adapted for oral hygiene use has been discovered. The appliance comprises a generally cylindrical casing having a closed bottom sealed thereto in a water-immersible fashion and a parabolically configured nose cone secured to the open end thereof and defining therewith an acoustically tuned parabolic chamber. A source of vibratory energy in the sonic range is mounted within the casing in vibration transmitting relation thereto, and an upwardly projecting tapered mounting post is positioned centrally of the nose cone. A tooth cleaning attachment having an elongated handle member terminating at one end in a tapered, hollow cavity adapted for placement downwardly of the mounting post is provided, and a cleaning member, preferably in the form of a plurality of bristles, is provided at the other end of the handle member. The handle member has a susceptibility to flexion that is greater along a direction generally longitudinal of the bristles than along a direction perpendicular to the bristles. Vibratory energy from the source is transmitted from the source upwardly along the casing and, via the parabolic curvature of the nose cone, to the mounting post from which it is transmitted to the bristles along the handle member. The bristles are thereby caused to vibrate and serve as a driving force creating a sound field in the liquid medium surrounding the oral surfaces to be cleaned. The sound field in turn produces acoustical streaming at the interfaces between the liquid medium and the surface to be cleaned. The acoustic streaming thus created exerts steady viscous stresses at these interfaces. While these stresses are small, cleaning is nonetheless achieved by continuously removing adhering layers of stain, food particles, dental plaque, and dental calculus (tartar).
BRIEF DESCRIPTION OF THE DRAWING

The foregoing and other objects, advantages, and features of the subject invention will hereinafter appear, and, for purposes of illustration, but not of limitation, an exemplary embodiment of the present invention is described in the accompanying drawing, in which:

FIGURE 1 is a side elevational view of a power-driven sonic energy toothbrush produced in accordance with the present invention;

FIGURE 2 is an exploded perspective view thereof;

FIGURE 3 is an enlarged side elevational view, partially in section, of a modified sonic energy toothbrush in accordance with the present invention;

FIGURE 4 is a front elevational view of the toothbrush head utilized with the device of the subject invention;

FIGURE 5 is a side elevational view thereof;

FIGURE 6 is a top plan view thereof;

FIGURE 7 is a perspective view of the eccentric utilized with the device of the present invention;

FIGURE 8 is a plan view of a modified eccentric;

FIGURE 9 is a sectional view of a modified toothbrush handle for use with the present invention; and

FIGURE 10 is a sectional view of yet another modified toothbrush handle.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to the drawing, FIGURE 1 shows a power-driven sonic toothbrushing device 10 comprising a generally cylindrical casing 12 with a bottom 14 provided at one end and a parabolic nose cone 16 at the other end thereof in order to define a generally hollow cavity. Nose cone 16 terminates in an upwardly projecting tapered mounting post 18, onto which is force-fitted a removable shaving attachment 20 comprising a handle 22 and a bristle head 24. Nose cone 16 defines a parabolically turned acoustical cavity for a purpose that will hereinafter be described in detail.

Members 12, 14, and 16 are all preferably molded of a synthetic plastic resin material and are preferably permanently assembled to form a sealed, water-tight unit. In order to achieve this sealed arrangement, bottom 14 is provided with an annular upwardly projecting rim 26 offset inwardly in order to receive the lower portion of cylindrical casing 12. Likewise, parabolic nose cone 16 has an integrally formed depending cylindrical rim 28, the inside diameter of which is substantially the same as the outside diameter of casing 12 whereby a sealed, water-tight fit may be achieved. Nose cone 16 is preferably permanently affixed to case 12 by conventional ultrasonic or spin welding techniques. Alternatively, mating sets of threads may be provided on rim 28 and casing 12 so that the nose cone 16 may be threaded onto the casing. A still further alternative arrangement is shown in FIGURE 3 in which the casing 12, nose cone 16, and post 18 are shown as a single, integral unit molded in one piece.

Disposed within the chamber defined by casing 12, bottom 14, and nose cone 16 is a source of vibratory energy in the sonic range. The source comprises an electric motor 30 having a drive shaft 32 projecting axially upwardly into the acoustically tuned parabolic chamber defined by nose cone 16. Motor 30 may be mounted within casing 12 in any convenient manner so long as a vibration transmitting relation is maintained between motor 30 and casing 12. One possibility is illustrated in FIGURE 3, in which a web 34 is provided extending inwardly and perpendicularly to casing 12. Web 34 has an annular opening into which is fitted a mounting block 36 which in turn fixedly receives a mounting stud 38 provided on motor 30.

Within the lower portion of casing 12, a conventional rechargeable battery 40 (which may be a cadmium cell) is mounted, and an electrical connection 42 extends between rechargeable battery 40 and motor 30. Connection 42 preferably includes an on-off switch (not shown) to permit the user to control operation of motor 30. A recess 44 is provided in bottom 14, and conventional electrical connections, including a prong 46, are provided in recess 44 such that the entire unit may be plugged into a supporting stand (not shown), which is in turn typically connected to a household current source. Alternatively, the rechargeable battery 40 could be eliminated, and motor 30 could directly be connected to a household current source via a cord and plug arrangement (not shown).

An eccentric unit 48 (see FIGURE 7) is mounted on motor shaft 32. Unit 48 has a sleeve portion 50 that fits downwardly over shaft 32. Eccentric unit 48 further comprises a cylindrical disc portion 54 having openings into which suitable weights 56 are force-fitted so as to dynamically unbalance unit 48. Three weights are shown in the unit 48 shown in FIGURE 7, but it will be recognized by those skilled in the art that other arrangements of weights 56 may be provided in order to vary the degree of eccentricity of unit 48. A slight degree of slippage may be provided between sleeve 50 and shaft 32 to perform a clamping function so that immediately following energization of motor 30, unit 48 will not rotate at full speed. In this manner, a smaller, less powerful motor may be used. Alternatively, a more powerful motor and an interlock (e.g., keyway, spline, or set-screw, not shown) between sleeve 50 and shaft 32 may be employed. Indeed, if the clamping function is eliminated, sleeve 50 itself need not even be utilized. Rotation of shaft 32 and eccentric unit 48 provides a source of vibratory energy in the sonic range for a purpose that will hereinafter be discussed in detail.

FIGURE 8 illustrates a modified eccentric unit 74 which takes the form of a disc 76 having an opening 77 adapted for placement over shaft 32. A pie-shaped segment 78 is cut away from disc 76, and a threaded shaft 80 is radially disposed across the cut away segment. A knurled nut 82 is threaded onto shaft 80, and means are provided for locking nut 82 in a given position. The distance of nut 82 from the center of disc 76 (and hence the center of gravity of unit 74) is adjustable by rotation of nut 82. As a result, the amplitude of the sonic energy may be varied simply by varying the position of nut 82. Device 18 may be preset at a given amplitude for certain classes of users (e.g., children) or, where a threaded (i.e., removable) nose cone 16 is employed, the unit may be adjusted by a particular user prior to use.

Toothbrushing attachment 20 is preferably removably mounted on the tapered mounting post 18. To that end, the lower end of attachment handle 22 is hollowed as shown at 58 in FIGURES 4 and 5. Opening 58 is tapered in a manner similar to the taper of post 18. The lower portion of handle 22 is furcated as shown at 60 in order to permit the lower portion of handle 22 to be forced outwardly slightly for a purpose that will hereinafter appear. The sides of handle 22 at the lower edge are interconnected by an integrally molded piece 62, and post 18 preferably has a beveled or flat side (see FIGURE 3) that is contacted by piece 62 when attachment 20 is snapped into place.

A bead 66 (see FIGURES 4 and 5) is provided laterally adjacent the lower end of attachment handle 22, and a similar horizontal groove 68 is provided at an appropriate point on mounting post 18. As handle 22 is forced downwardly over post 18, the furcated lower legs of handle 22 resiliently spread outwardly with bead 66 snapping into groove 68, thereby holding attachment 20 in position.

Handle 22 preferably has a channel 64 formed along its longitudinal direction in order to permit the maximum strength to be achieved with the minimum amount of material. The over-all configuration of handle 22 is such that the side-to-side dimension (as shown in FIGURE 4) is greater than the depth dimension (i.e., as viewed in
FIGURES 1, 2 and 5). Thus, when subjected to oscillatory forces, the handle is caused to move in an elliptical fashion, with the major axis of movement being along a line perpendicular to the widest side of the handle. Alternative handle configurations are shown in FIGURES 9 and 10. In FIGURE 9, a tubular handle member 72 of elliptical cross-section is shown. Similarly, in FIGURE 10 a tubular handle member 72 of elliptical cross-section is shown. In each case the desired resulting elliptical movement of the bristle head 24 is achieved.

Bristle head 24 may comprise a plurality of conventional bristles 25 which may be arranged in tufts, stiff bristles ordinarily being nylon or hog bristle. Alternatively, rather than a conventional bristle head as is ordinarily found on toothbrushes, a sponge or other similar type of pad may also suitably be employed as a cleaning member or work applicator in accordance with the present invention.

In operation, when electrical power is provided to motor 30, unit 48 is caused to rotate and, because of its eccentric character, vibratory energy in the sonic range is produced. This vibratory energy is transmitted through the mounting of motor 30 to the casing 12 thereby causing the bristle head 24 to move in the cone 16 which, via its smoothly curved parabolic surface, focuses substantially all of the sonic energy to mounting post 18, which in turn transmits the vibratory energy to the handle 22 of brushing attachment 20. Best results are achieved where the acoustical conductivity of all of the elements of casing 12, cone 16, post 18, and bristle head 24 are of a similar order of magnitude.

The vibratory energy transmitted along handle 22 to bristle head 24 thus produces ellipsoidal movement of unit 24 as shown by the arrows in FIGURES 4–6. As previously noted, in accordance with the present invention, it is particularly important that the major axis of movement of bristle head 24 occur longitudinally of the bristles 25 (i.e., along a direction substantially perpendicular to the surface of the tooth to be cleaned with the device) with the minor axis of movement lying perpendicularly to the bristles (i.e., along a direction lying in a plane parallel to the surface of the tooth to be cleaned). In this manner, the vibrating bristles create a sound field producing the previously described phenomena of acoustic streaming in the liquid medium (i.e., saliva, water, and dentifrice) surrounding the head 24. In particular, the acoustic streaming effect, which takes the form of continuous viscous stresses, causes the natural microscopic liquid barriers present along the tooth surfaces to be broken, and permits substantial oral hygiene benefits to be achieved, particularly in the inaccessible interproximal areas and along the gingival margin. Further, in addition to the tooth cleaning effects heretofore described, the gingival tissues are stimulated, a major therapeutic aid in the prevention of periodontal disease.

Thus, the device of the present invention permits in a single step both the tooth cleaning and gum massaging. Utilization of the teachings of the present invention provides a novel oral hygiene and therapeutic method. The device 10 is not employed to physically "scrub" the teeth. Rather, the bristle head 24 or other cleaning member is merely placed adjacent the oral surfaces to be treated and is subjected to sonic range oscillatory vibrational movement in order to cause the liquid medium enveloping the bristle head and oral surfaces to undergo acoustic streaming. It is primarily the acoustic streaming at the liquid-oral surface interface that accomplishes the cleaning and gingival stimulation and not the "rubbing" action of the vibrating bristles. Thus, the present invention provides a new and entirely different approach to oral hygiene and therapeutics.

Preferably, vibratory energy of the order of magnitude of 90–100 cycles per second is employed, most advantageous results being achieved at this frequency. However, other frequencies in the sonic range may be successfully employed. Moreover, sources of sonic energy other than motor-driven eccentrics may also be advantageously employed. For example, electromagnet actuators or vibrators may be utilized. A solid state audio oscillator is a particularly useful source of vibratory energy.

The tuned parabolic nose cone 16 effectively provides an efficient acoustical transmission path focusing substantially all of the vibratory energy produced to a single point (post 18) which in turn efficiently transmits the acoustical energy to the brushing attachment 20. Likewise, by virtue of the configuration of handle member 22, a mode of movement of bristle head 24 is achieved which permits the acoustic streaming producing sound field to be directed into the surrounding liquid medium by the vibrating bristles.

The upper portion of casing 12 above web 24 may be acoustically insulated from the lower portion containing battery 40 so that, when the casing is gripped around its lower portion, vibratory energy transmitted to the upper portion of casing 12 is not damped by the holder.

It should be understood that, while the device of the present invention has been particularly described for use as a tooth cleaning appliance, it may also be utilized for other similar cleaning purposes in which the phenomenon of acoustic streaming may be advantageously employed.

It should be understood that various changes, modifications, and variations in the structural and functional features of the present invention may be made without departing from the spirit and the scope of the subject invention, as set forth in the appended claims.

We claim:

1. A cleaning appliance adapted for oral hygiene and therapeutic use, comprising:
   a. a generally cylindrical casing having a closed bottom,
   b. a parabolically configured nose cone secured to the open end of the casing and defining therewith an acoustically tuned parabolic chamber,
   c. a source of vibratory energy in the sonic range mounted within the casing in vibration transmitting relation thereto,
   d. an upwardly projecting tapered mounting post positioned centrally of the nose cone,
   e. a tooth cleaning attachment mounted on the mounting post in vibration transmitting relation thereto, the said attachment comprising:
      i. an elongated handle member having at one end a tapered, cylindrical cavity adapted for downward placement over the mounting post, the other end of the handle member being free,
      ii. the cleaning member being secured to the other end of the handle member, the cleaning member being adapted for application to a surface to be cleaned,
      iii. the handle member having a susceptibility to flexion that is greater along a direction generally perpendicular to the surface to be cleaned than along a direction lying in a plane parallel to the surface to be cleaned,
   whereupon vibratory energy from said source is transmitted to the casing and upwardly therealong to the mounting post via the parabolically curved nose cone, vibratory energy being further transmitted longitudinally from the mounting post along the handle member to the free end thereof thereby causing the free end to undergo elliptical movement such that a liquid medium enveloping the cleaning member and the surface to be cleaned is subjected to acoustic streaming.

2. A cleaning appliance, as claimed in claim 1, wherein the cleaning member comprises a plurality of parallel bristles each fixedly secured at one end to the handle member, the other end of each bristle being free, the major axis of the elliptical movement of the free end of the handle member lying along a direction parallel to the bristles.
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3. A cleaning appliance, as claimed in claim 2, wherein the attachment is removably mounted on the mounting post.

4. A cleaning appliance, as claimed in claim 3, and further comprising interlocking means for normally maintaining the cleaning attachment in a fixed relation to the mounting post.

5. A cleaning appliance, as claimed in claim 2, wherein the handle member takes the form of a channel having substantially greater width than depth, whereby the handle member has a greater susceptibility to flexion along a direction parallel to the bristles than along a direction perpendicular thereto.

6. A cleaning appliance, as claimed in claim 2, wherein the handle member takes the form of a tubular member of generally rectangular cross section, the smaller dimension of which lies along a direction parallel to the bristles, the larger dimension thereof lying along a line perpendicular thereto.

7. A cleaning appliance, as claimed in claim 2, wherein the handle member takes the form of a tubular member of generally elliptical cross section, the minor axis of which lies along a direction generally parallel to the bristles, the major axis of which lying along a line generally perpendicular thereto.

8. A cleaning appliance, as claimed in claim 1, wherein the casing, nose cone, and mounting post are integrally formed as a single unit from synthetic plastic resin material.

9. A cleaning appliance, as claimed in claim 1, wherein the casing, nose cone, and mounting post are integrally formed as a single unit from synthetic plastic resin material.

10. A cleaning appliance, as claimed in claim 1, wherein the nose cone is removable from the casing.

11. A cleaning appliance, as claimed in claim 1, wherein the source of vibratory energy comprises: an electric motor having a shaft projecting axially of the casing into the acoustically tuned parabolic chamber defined by the nose cone; an eccentric disc mounted on the motor shaft for rotation therewith, the center of gravity of the disc being offset outwardly therefrom such that when the disc is rotated vibratory energy is produced; and a source of electric current, electrically connectable to the motor.

12. A cleaning appliance, as claimed in claim 11, and further comprising means for varying the center of gravity of the eccentric disc whereby the amplitude of the vibratory energy thereby produced is adjustable.

13. A cleaning appliance adapted for oral hygienic use comprising a casing, a source of vibratory energy in the sonic range mounted within the casing in vibration transmitting relation therewith, and a toothbrush provided with a bristle head at one end, the improvement comprising providing a parabolically configured nose cone at one end of the casing in order to define therewith an acoustically tuned parabolic chamber, an upwardly projecting tapered mounting post being positioned centrally of the nose cone, the toothbrush being attachable to the post in vibration transmitting relation therewith, whereby vibratory energy is transmitted by the parabolic nose cone and mounting post and transmitted longitudinally of the toothbrush.

14. An improvement, as claimed in claim 13, wherein the toothbrush comprises a handle that has a susceptibility to flexion that is greater along a direction generally parallel with the bristles than along a direction generally perpendicular thereto whereby vibratory energy transmitted to the handle causes the bristle head to undergo elliptical movement.

15. In a cleaning appliance for oral hygienic use comprising a casing, a source of vibratory energy in the sonic range mounted in the casing in vibration transmitting relation therewith, and a nose cone secured to the open end of the casing, and a projecting post positioned centrally of the nose cone, the improvement comprising a tooth cleaning attachment mounted on the post in vibration transmitting relation therewith, the said attachment comprising an elongated handle member having at one end a cylindrical cavity adapted for downward placement over the post, a plurality of parallel bristles being secured to the other end of the handle member, the said bristles being adapted for application to a surface to be cleaned, the handle member having a susceptibility to flexion that is greater along a direction generally parallel with the bristles than along a direction generally perpendicular thereto, whereby vibratory energy from the source is transmitted to the casing and upwardly therealong to the nose cone and post, the said energy being further transmitted longitudinally from the post along the handle member to the bristle end of the attachment thereby causing the said bristle end to undergo elliptical movement such that a sound field is created in the liquid medium surrounding the bristles and the surface to be cleaned such that the surface is subjected to acoustic streaming.

References Cited

UNITED STATES PATENTS

2,282,700 5/1942 Bobbroff. 1
3,183,583 5/1965 Hubner. 2
3,355,445 8/1967 Parisi et al. 15—23 3
3,575,381 5/1971 Tavel. 4

FOREIGN PATENTS

1,216,838 4/1960 France. 5
1,204,187 11/1965 Germany. 6
899,618 6/1962 Great Britain. 7

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