Sept. 16, 1969 S. P. AURELIO ET AL 3,466,689

SONIC ENERGY DENTAL CLEANING DEVICE

Filed Dec. 11, 1967

FIG. 1

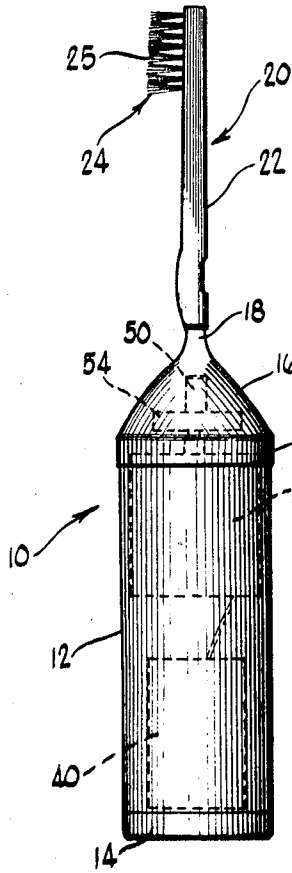

FIG. 2

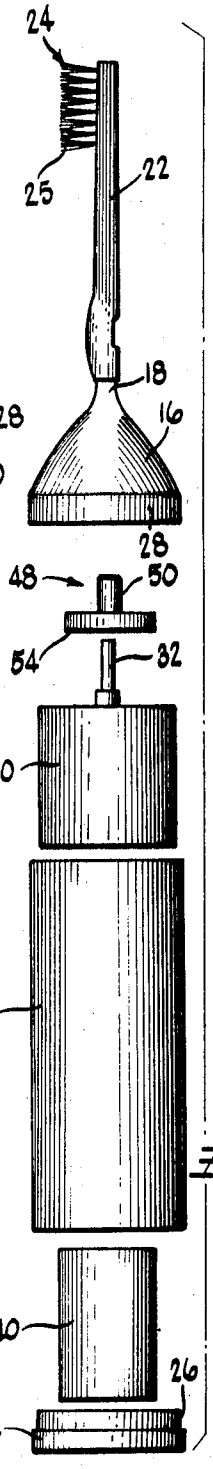

FIG. 3

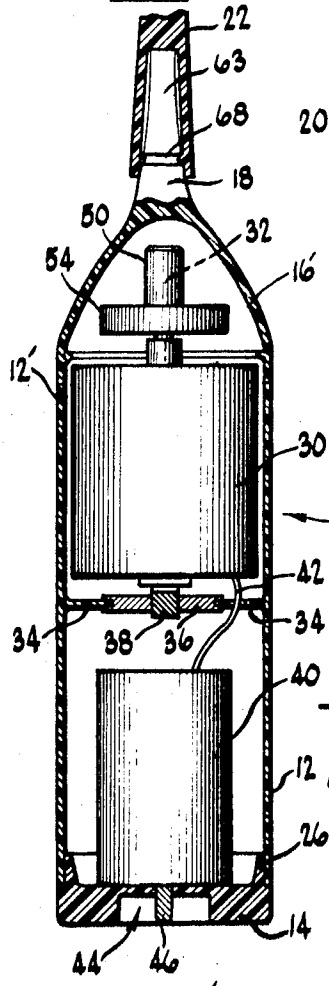

FIG. 4

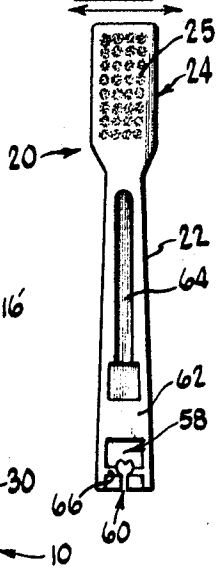

FIG. 5

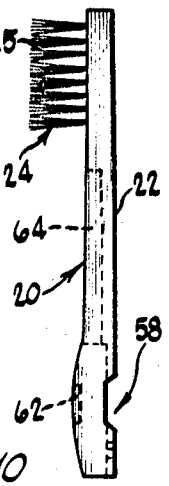

FIG. 8

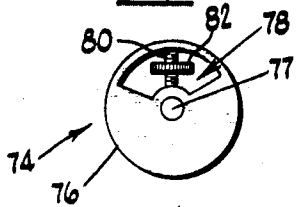

FIG. 7

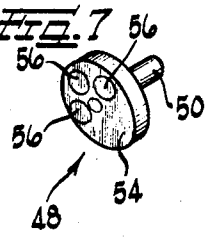

FIG. 6

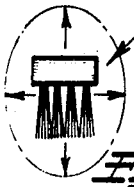

FIG. 9

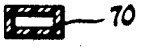

FIG. 10

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3,466,689

SONIC ENERGY DENTAL CLEANING DEVICE

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Int. Cl. A46b 13/02; A61h 9/00
U.S. Cl. 15—22 15 Claims

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. 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 cleaning 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 reciprocal movement of a conventional toothbrush head, most commonly in a vertical direction generally perpendicular to the gingival margin. This form of brushing has found wide 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 effective only 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 can occur. 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 exertion 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. 3,183,538 describes a portable electric toilet apparatus utilizing a motor-driven 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 hygienic use has been discovered. The appliance comprises a generally cylindrical casing having a closed bottom sealed thereto in a water-impervious 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 toothbrushing 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 brushing attachment **20** comprising a handle **22** and a bristle head **24**. Nose cone **16** defines a parabolically tuned 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 rotatably 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 clutching 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 setscrew, not shown) between sleeve **50** and shaft **32** may be employed. Indeed, if the clutching 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 **10** 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, such 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** thence upwardly along casing **12** to nose 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 especially 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 hygienic 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 hygienic 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 vibration 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, electromagnetic 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 **34** 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 structure and function of the foregoing invention may be made without deviating 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 hygienic and therapeutic use, comprising:

a generally cylindrical casing having a closed bottom;

a parabolically configured nose cone secured to the open end of the casing and defining therewith an acoustically tuned parabolic chamber;

a source of vibratory energy in the sonic range mounted within the casing in vibration transmitting relation thereto;

an upwardly projecting tapered mounting post positioned centrally of the nose cone,

a tooth cleaning attachment mounted on the mounting post in vibration transmitting relation thereto, the said attachment comprising

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,

a 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,

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,

whereby 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.

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 and nose cone 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. In 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 in the sonic range is focused 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 ellipitical movemnet.

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.

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EDWARD L. ROBERTS, Primary Examiner

U.S. Cl. X.R.

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