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(54) **PHOTOCATALYSIS PROCESS TOOTHBRUSH**

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(52) **U.S. Cl.** **15/105**; 15/167.1; 300/21

(57) **ABSTRACT**

A photocatalysis process manual light emitting toothbrush comprising a handle with a grip at a proximal end and a replaceable brush head at a distal end thereof. The replaceable brush head has at least one group of bristles permanently affixed to the replaceable brush head and at least one blue light emitter is provided on an upper surface of the replaceable brush head for emitting blue light in a direction generally parallel to the bristles permanently affixed to the replaceable brush head. At least one blue light source is provided for radiating blue light, in a wavelength band between 420 nm to 480 nm, and a power source is provided for energizing the at least one blue light source. The blue light is at least one of modulated emission with an average optical output power level of less than 5 watts.

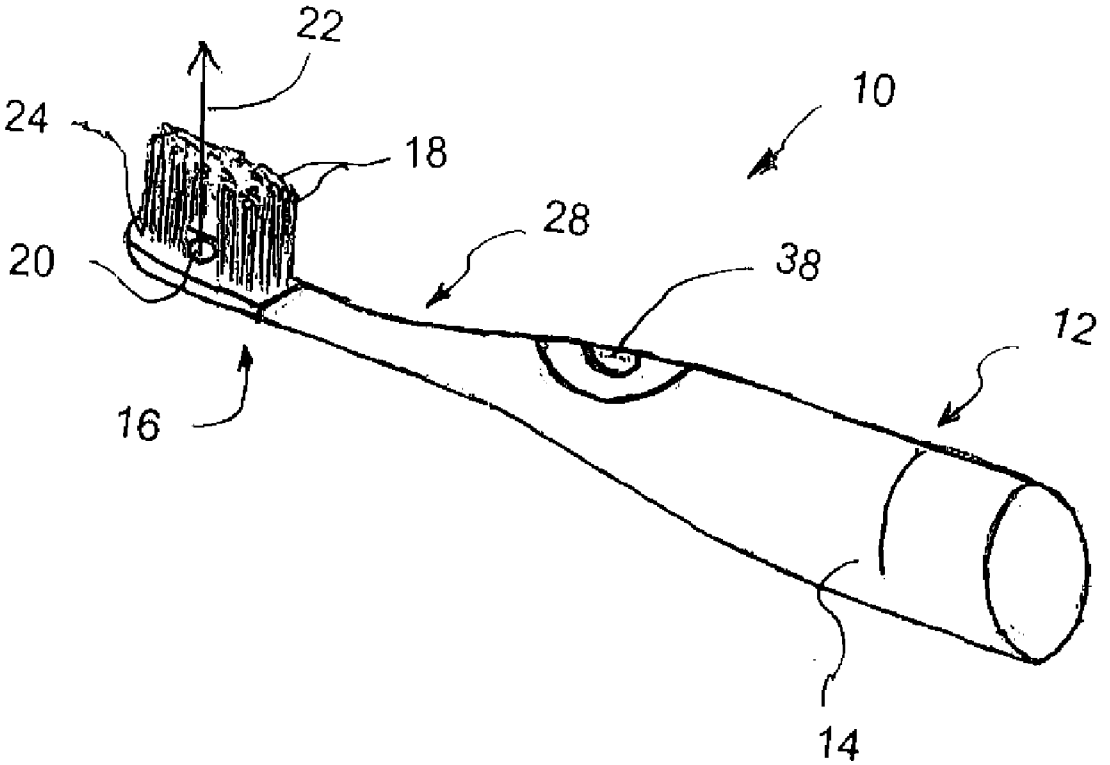


Fig. 1

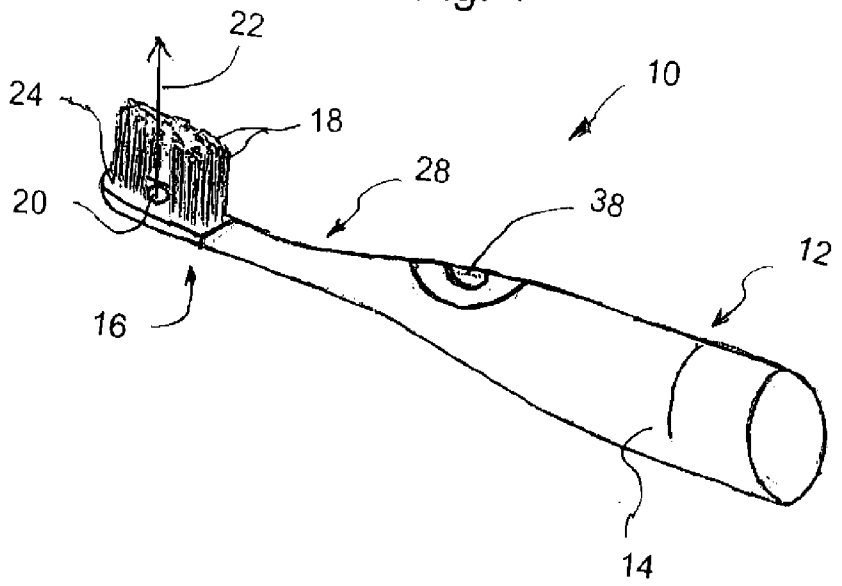


Fig. 2A

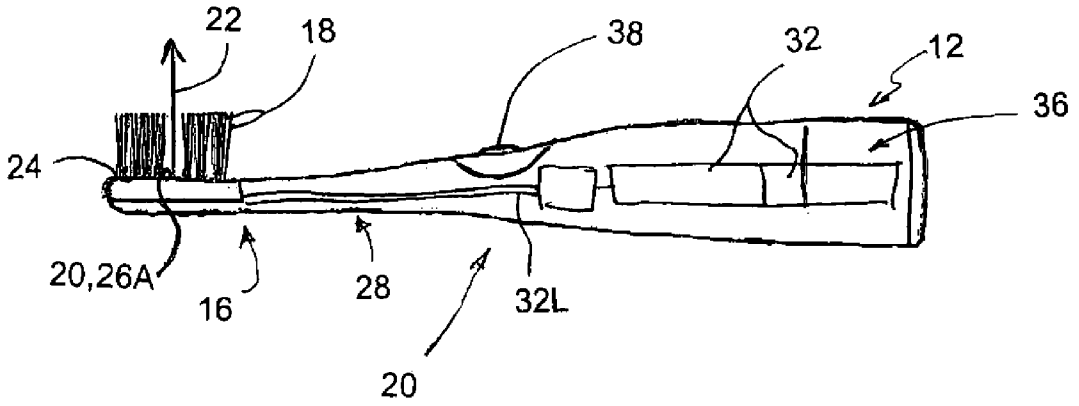


Fig. 2B

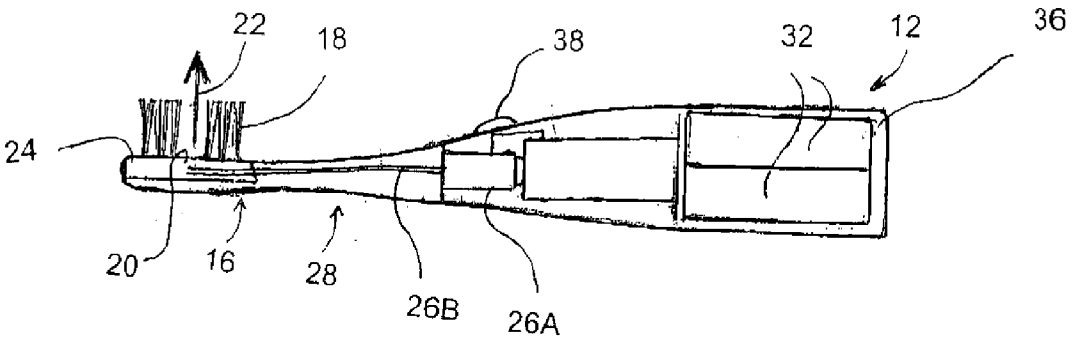


Fig. 3A

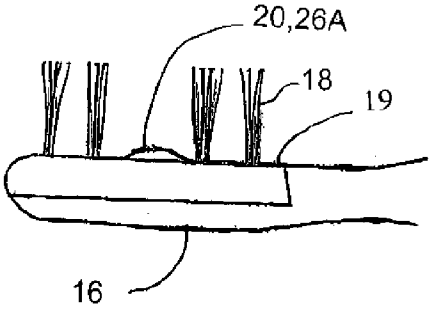


Fig. 3B

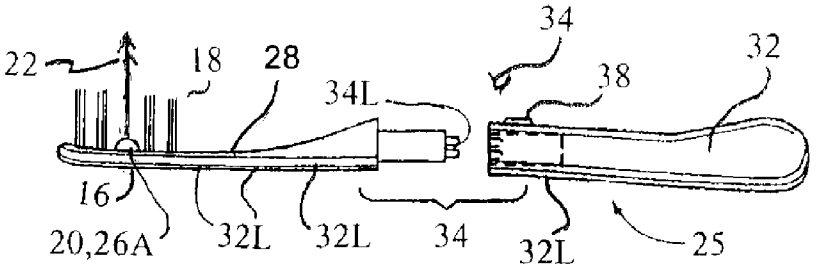


Fig. 3C

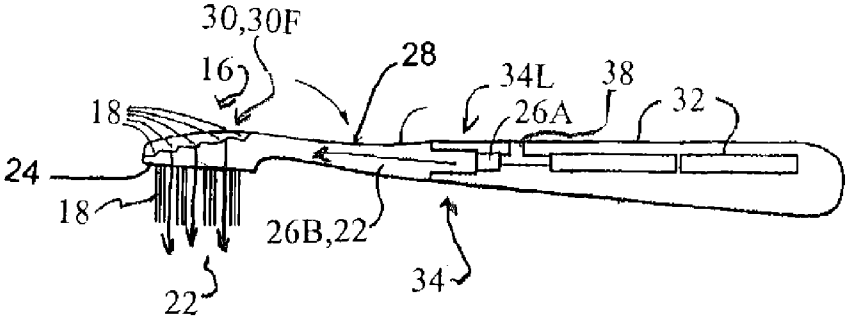


Fig. 3D

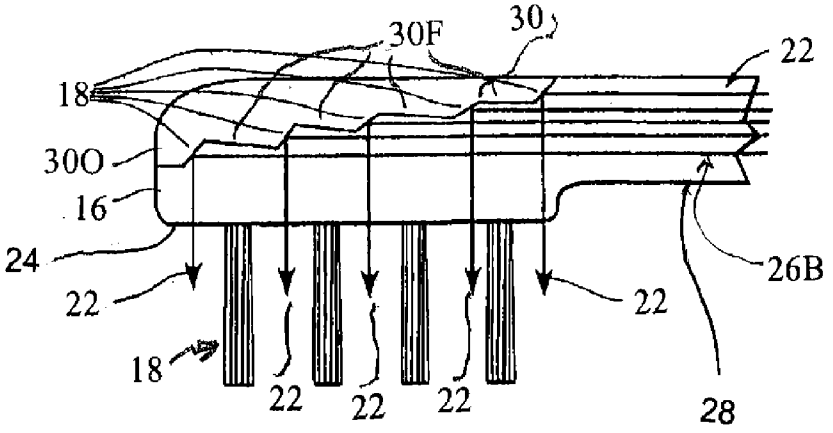


Fig. 4A

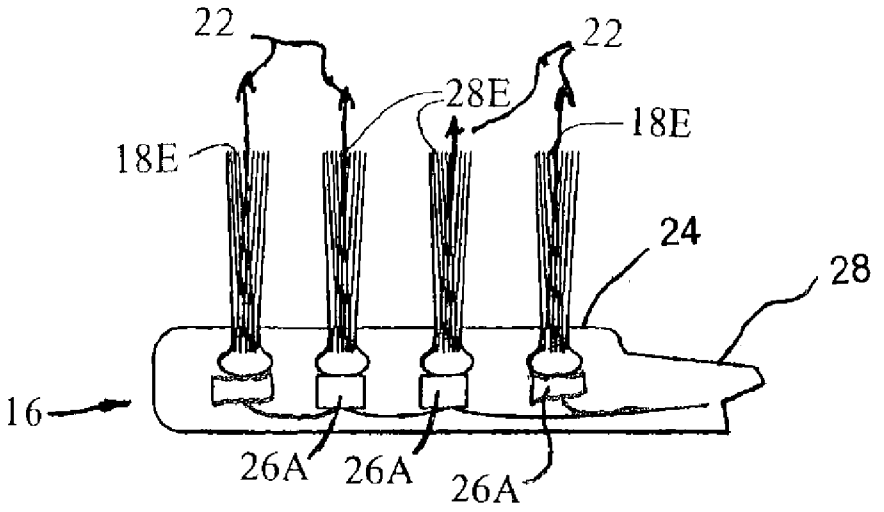
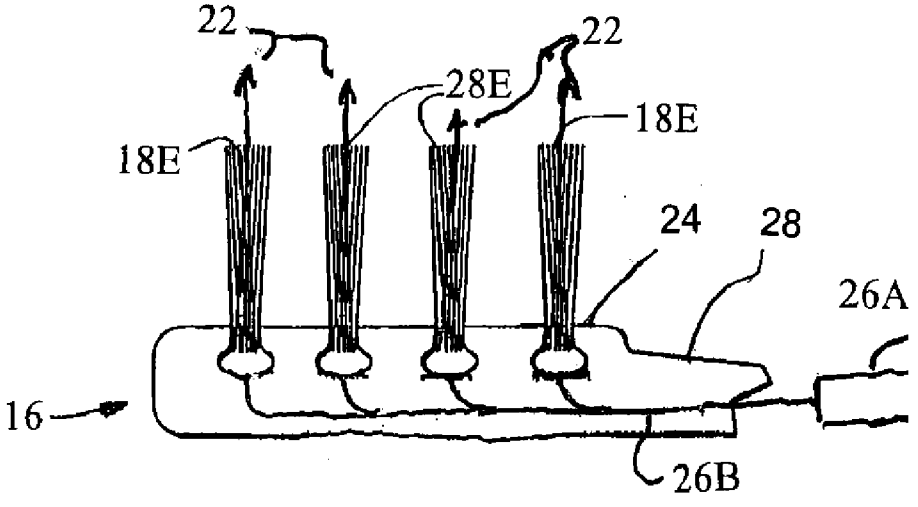

22
22
28E
18E
18E
24
28
16
26A
26A
26A

Fig. 4B


22
22
28E
18E
18E
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28
26A
16
26B

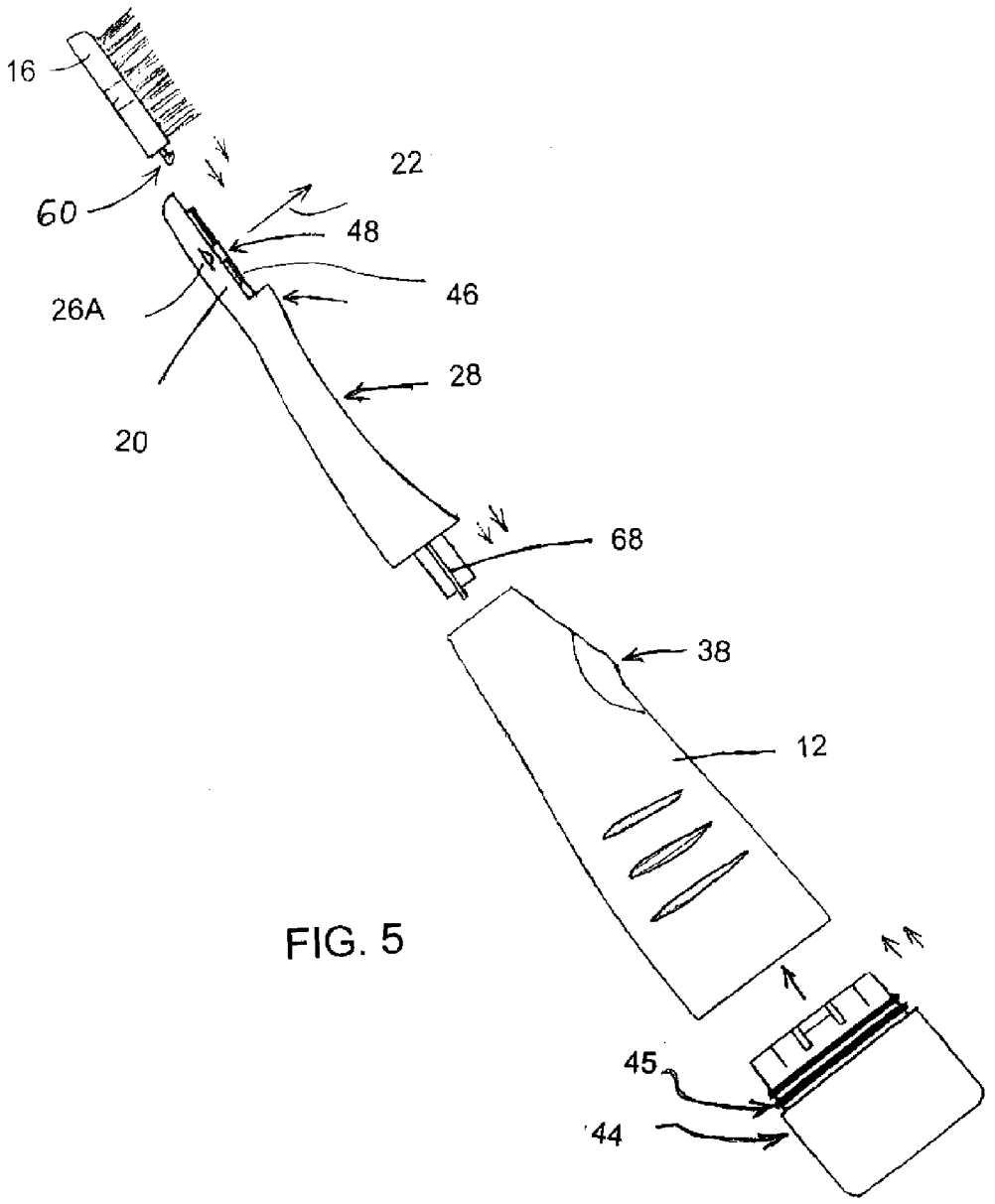

FIG. 5

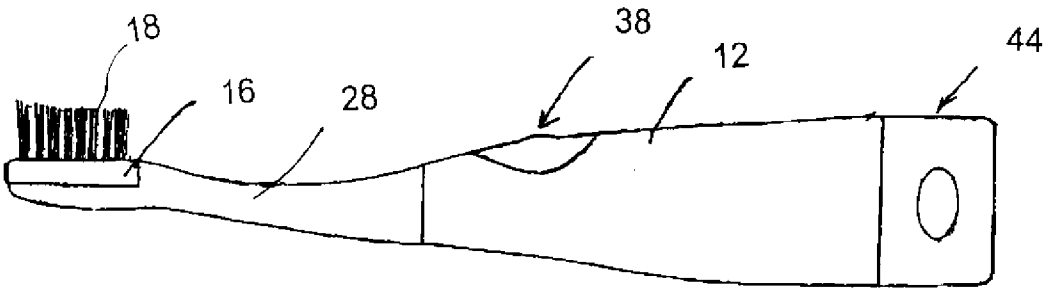

FIG. 5A

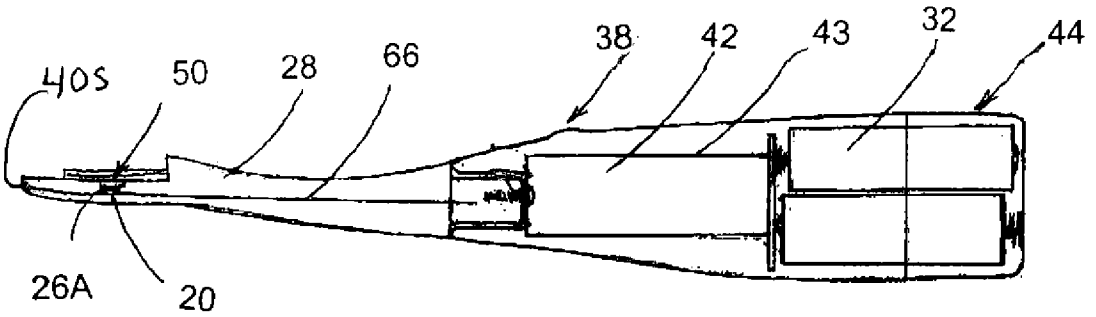

FIG. 5B

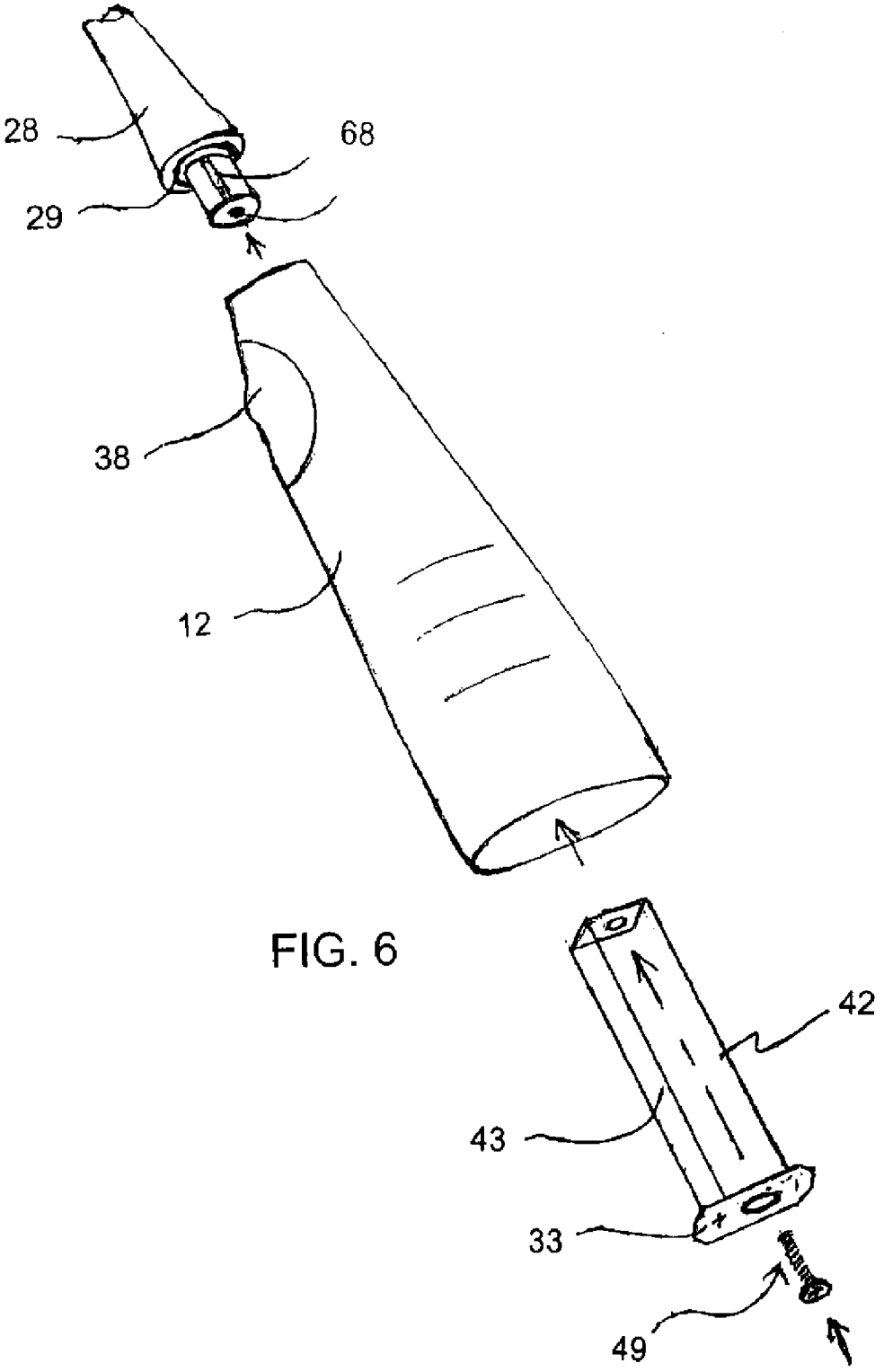

FIG. 6

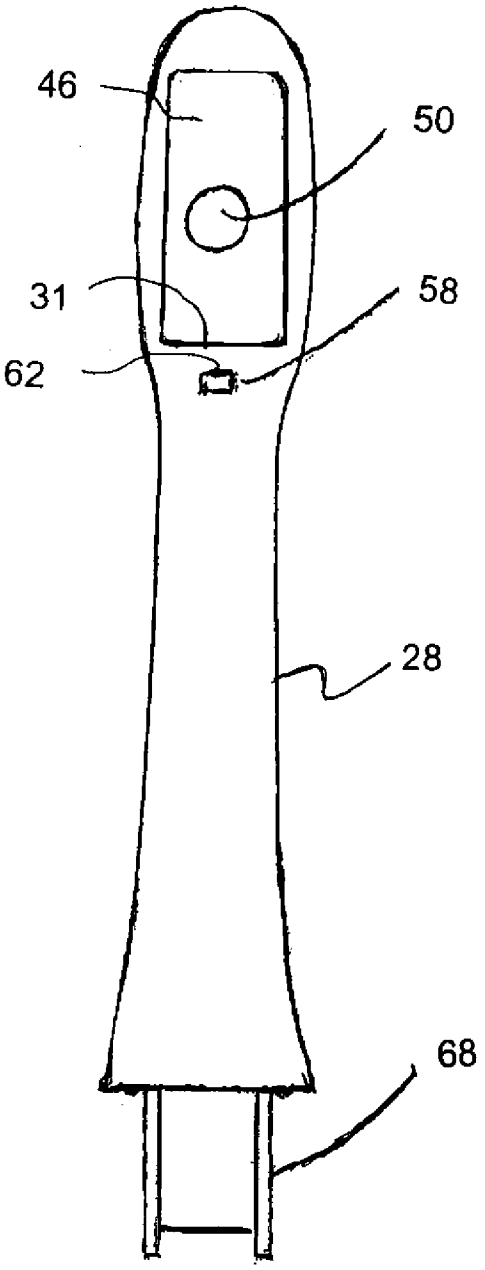

FIG. 7

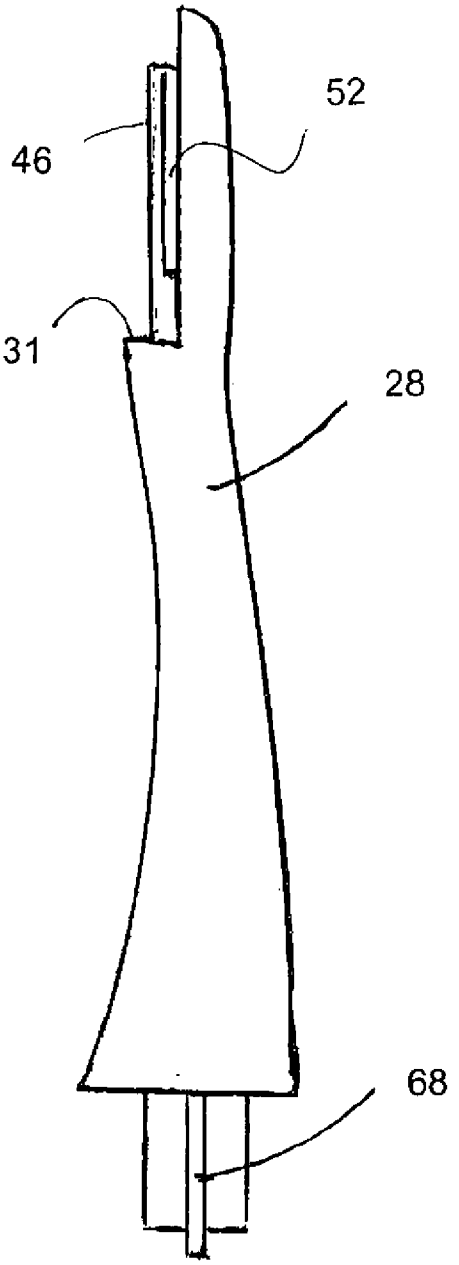

FIG. 7A

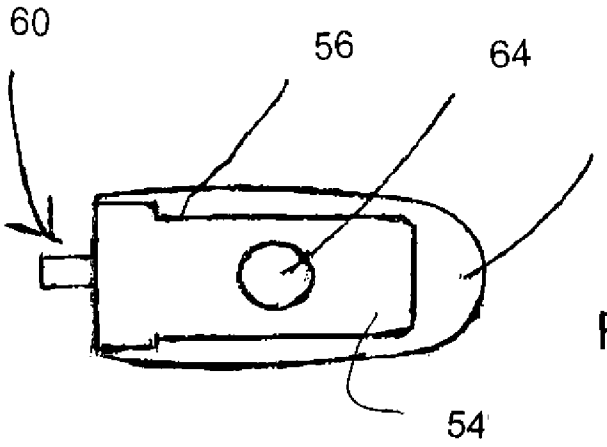

FIG. 8B

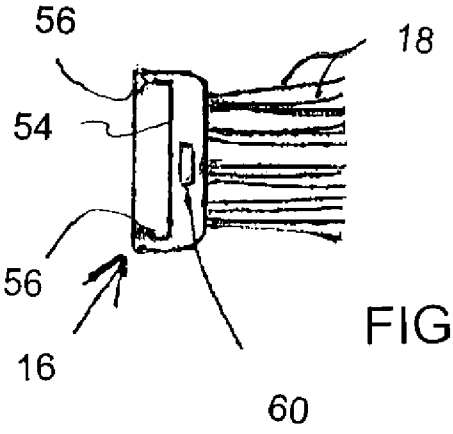

FIG. 8A

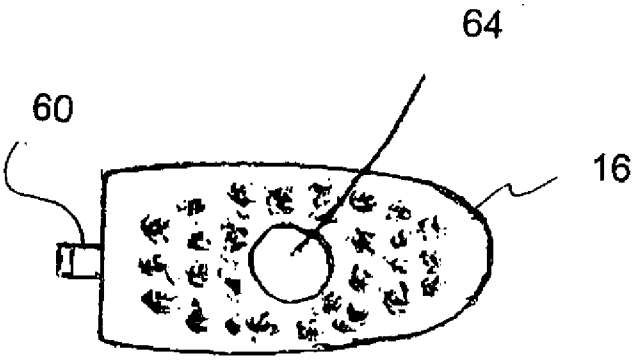

FIG. 8

PHOTOCATALYSIS PROCESS TOOTHBRUSH

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application is related to and is a continuation-in-part of U.S. patent application Ser. No. 11/946,263 filed on Nov. 28, 2007 which claims the benefit of U.S. Provisional Patent Application No. 60/872,761 filed on Dec. 4, 2006 and such teachings and disclosures are hereby incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to dental hygiene and, in particular, to a manual light emitting toothbrush which emits radiation, near ultraviolet region of the electromagnetic spectrum, in order to oxidize and destroy potentially harmful bacteria and/or other contaminants or compounds contained within the mouth without harming or destroying human cells and also activate a photo catalyst that may be deposited on the teeth and the gums of the person utilizing the toothbrush during normal brushing.

BACKGROUND OF THE INVENTION

[0003] The use of photocatalysis in dental hygiene processes is well established and stems from processes for purifying gases and liquids and for controlling bacteria and other microorganisms in gases and liquids and on the surfaces of solid objects. In general, photocatalysis methods involve the photoexcitation of photocatalytic compounds, for example, catalytic n-type semiconductor particles such as TiO_2 particles, with ultraviolet (UV) light to activate the photocatalyst, which then participates in reduction/oxidation reactions with matter adsorbed to or in the near vicinity of the surface of the particles. The reduction/oxidation reactions produce highly reactive hydroxyl radicals which oxidize and destroy bacteria and organic compounds in the gas or liquid or on the surface(s) being treated, such as bacteria and other organic substances associated with, for example, tooth decay, gum disease, denture stomatitis and halitosis/malodor.

[0004] In the past, photocatalysis methods have generally only been performed in a dentist's offices by either a dentist or a dental hygienist using a specialized UV laser(s) or some other optical device(s) which emits a controllable, directed beam of UV light. More recently, however, there have been proposals to manufacture and sell UV photocatalysis devices to the general public, e.g., a toothbrush containing a UV light radiating device, together with toothpastes and/or mouthwashes containing photocatalytic particles, such as TiO_2. In such toothbrushes, the UV light emitted by a UV laser diode, for example, passes through a light guide to the end of the toothbrush which brushes the teeth where this light is emitted into the user's mouth by, for example, lenses implanted among the bristles or through fiber optic bristles that form at least part of the brush bristles. The bristles mechanically facilitate removal of plaque and/or other organic materials from the teeth and the gums during brushing, similar to brushing with a conventional toothbrush, while the UV light is emitted directly to illuminate photocatalytic particles distributed on the surfaces of the teeth and the gums, thereby providing both a conventional cleaning mechanism as well as a photocatalytic cleaning mechanism.

[0005] The currently UV photocatalytic toothbrushes which are marketed to consumers, however, have a number of significant problems, not the least being the potential hazards associated with such devices. For example, in the generally preferred wavelength range of 280 mm to 400 mm, UV light at any power level is typically capable of damaging human skin including the tissue of human eyes. Compounding this problem is the fact that UV light within this wavelength range is nearly invisible to a user or patient, so that it is difficult to determine where the emitted UV beam is directed or aimed. In addition, the duration of irradiation of the catalytic particles, at any particular location within the mouth, is typically very short during the normal toothbrushing process, thus requiring higher power levels of UV radiation in order to obtain effective catalytic reactions. This problem is further compounded by the normal deterioration of the light transmission capability of the brush end elements, such as the lenses and the fiber optic elements, over time. Higher emitted power levels are generally called for in order to achieve satisfactory performance.

[0006] Up until now it is in fact the potential hazards of UV radiation that has limited the use of the UV dental hygiene processes to dentists and oral hygienists and the practical application of these methods to consumer toothbrushes and devices accordingly faces significant hurdles. For example, all medical or dental devices emitting ultraviolet light, and in particular within the wavelength range of 280 mm to 400 mm, are under Food and Drug Administration (FDA) control and licensing. In addition, all laser devices emitting coherent radiation of 1 milliwatt or more in the visible wavelengths, and all devices emitting laser radiation at any power level in the non-visible wavelengths, such as the UV and IR wavelengths, are presently prohibited from being sold to the general public.

[0007] Still a further problem with light emitting toothbrushes and other devices employing high power light emitting diodes was that these high power light emitting diodes require very special electronically controlled constant current circuitry. Such control circuitry has only recently been available in the form of an economical integrated circuit. Failure to use electronically controlled constant current circuitry to drive a high power light emitting diodes, will result in uncontrolled light output, degraded high power light emitting diode performance, and possible catastrophic failure.

[0008] A further problem with the proposed light emitting electric toothbrushes employing movable bristle segments, while this seems to be a logically sound idea, the electro mechanical requirements necessary to completely seal the light emitting diode and control electronics from any moisture intrusion, make this electric toothbrush idea with movable bristles impossible to economically manufacture and sell as a commercially viable product.

[0009] The present invention, however, provides a solution to the above described as well as other related problems associated with the prior art products and methods.

SUMMARY OF THE INVENTION

[0010] Wherefore, it is an object of the present invention to overcome the above mentioned shortcomings and drawbacks associated with the prior art.

[0011] A primary object of the invention is to provide a manual light emitting toothbrush which emits radiation, near ultraviolet region of the electromagnetic spectrum, to oxidize and destroy potentially harmful bacteria and/or other contaminants or compounds contained within the mouth.

[0012] Another object of the invention is to provide a manual light emitting toothbrush that will activate a photo catalyst deposited on the teeth and the gums of the person utilizing the manual light emitting toothbrush during normal brushing.

[0013] A further object of the invention is to provide a manual light emitting toothbrush which emits blue light within the 420 nm to 480 nm wavelength band, of the electromagnetic spectrum, to avoid the normal hazards associated with using UV radiation as well as the corresponding FDA restrictions.

[0014] Yet another object of the invention is to provide a manual light emitting toothbrush in which the radiated blue light emissions may be amplitude modulated from 0% to 100% at a frequency of between about two (2) and about two hundred (200) Hertz, more preferably between about 6 and about 60 Hertz and most preferably between about 10 and about 30 Hertz, with an average optical output power level of less than 5 watts.

[0015] A still further object of the invention is to provide a manual light emitting toothbrush which is relatively inexpensive to manufacture which has a power source that is light weight and can be readily recharged or replaced as needed.

[0016] Yet another object of the present invention is to provide a toothbrush having a handle with a neck permanently affixed thereto with a light source embedded in an upwardly facing surface of the neck of the toothbrush with a replaceable brush head having an aperture formed therein which is aligned with the light emitting diode once the replaceable brush head is installed on the remote end of the neck.

[0017] A further object of the present invention is to ensure that the lighting emitting diode, as well as all the remaining electrical components of the toothbrush, are permanently sealed with respect to the external environment so as to prevent any water, moisture, toothpaste and/or other contaminants from entering into an interior compartment or area of the neck or the toothbrush and causing a malfunction of the toothbrush.

[0018] Still a further object of the present invention is to provide a replaceable brush head which has an aperture provided therein with the aperture being designed so that it is slightly larger than the emitting surface of the light emitting source so that, when the replaceable brush head is installed on the remote end of the neck, the aperture is concentric with and aligned with the light emitting diode to allow all of the light to pass through the brush head and interact with the teeth end or gums of the patient during brushing.

[0019] As used herein, the term "average optical output power level" means that the optical output power may briefly exceed 5 watts on modulation peeks how ever the total integrated power level over a time period of 1 second will not exceed 5 watts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The invention will now be described, by way of example, with reference to the accompanying drawings in which:

[0021] FIG. **1** is a diagrammatic perspective view of a toothbrush according with the teachings of the present invention;

[0022] FIG. **2**A is a diagrammatic transverse cross sectional side view of the toothbrush of FIG. **1**;

[0023] FIG. **2**B is a diagrammatic transverse cross sectional side view of the toothbrush of FIG. **1**;

[0024] FIG. **3**A is an enlarged diagrammatic side elevational view of a brush head with the blue light source extending further away from the base of the head, then the embodiments of FIGS. **2**A and **2**B, so that the light is emitted adjacent the free ends of the bristles of the toothbrush;

[0025] FIG. **3**B is a diagrammatic transverse cross sectional side view of an alternative embodiment of a toothbrush which comprises a handle having a removal brush head;

[0026] FIG. **3**C is a diagrammatic transverse cross sectional side view of an alternative embodiment of a toothbrush in which the handle is integral with the brush head;

[0027] FIG. **3**D is a diagrammatic enlarged view of the brush head of FIG. **3**C;

[0028] FIG. **4**A is a diagrammatic enlarged view of an alternative embodiment of the brush head in which each individual blue light source is associated with a group of bristles attached to the brush head to supply the blue light along the length of the bristles;

[0029] FIG. **4**B is a diagrammatic enlarged view of a further embodiment of a brush head having each blue light source associated with a group of bristles attached to the brush head;

[0030] FIG. **5** is a diagrammatic exploded view showing assembly of a completely manual toothbrush which has a replaceable brush head;

[0031] FIG. **5**A is a diagrammatic side elevational view showing the assembled completely manual toothbrush with the replaceable brush head;

[0032] FIG. **5**B is a diagrammatic cross sectional view of the assembled completely manual toothbrush of FIG. **6**A prior to installation of the replaceable brush head;

[0033] FIG. **6** is a partial diagrammatic exploded perspective view showing the assembly the neck to the handle and assembly of the circuit driver within a base section of the handle;

[0034] FIG. **7** is a diagrammatic top plan view showing of the neck of the completely manual toothbrush prior to installation of the replaceable brush head;

[0035] FIG. **7**A is a diagrammatic side elevational view of the neck of FIG. **7**;

[0036] FIG. **8** is a diagrammatic top plan view of the replaceable brush head for attachment to the neck;

[0037] FIG. **8**A is a diagrammatic left end elevational view of the replaceable brush head of FIG. **8**; and

[0038] FIG. **8**B is a diagrammatic bottom plan view of the replaceable brush head of FIG. **8**,

DETAILED DESCRIPTION OF THE INVENTION

[0039] Turning now to FIG. **1**, a diagrammatic representation of a toothbrush **10**, according to the present invention, is shown. As illustrated therein, the toothbrush **10** includes a handle **12** having a grip **14** at its proximal end to be held in the user's hand while using the toothbrush **10** and a brush head **16**, typically including one or more groups of bristles **18**, located at the distal or working end of the handle **12**. As also illustrated in FIG. **1**, the head **16** further includes one or more blue light emitters **20** that emit blue light **22** in the 450 nm+/−30 nm (nanometer) wavelength band, that is, in the wavelengths between 420 nm and 480 nm and at an average power level of less than 5 watts. Preferably the blue light has an average power level of between about 0.25 and about 1 watt and more preferably an average power level of between about 0.5 and about 0.95 watts.

[0040] An important aspect is to always have the bristles **18** affixed to the brush head of the toothbrush. In addition, the light emitting source or diode **26**A can be either fixed and sealed to the brush head **16** adjacent the bristles **18**, alternatively, the light emitting source or diode can be fixed and sealed with respect to the neck **26** of the handle **12**.

[0041] In some applications, the blue light output from the emitters **20** may comprise solely a continuous emission of blue light having a combined power level of less than 5 watts, while in other applications the blue light output from the emitters **20** may comprise a modulated blue light emission having a frequency of between about two (2) and about two hundred (200) Hertz, more preferably between about 6 and about 60 Hertz and most preferably between about 10 and about 30 Hertz, having an average combined power level of less than 5 watts. For other applications, the blue light output from the emitters **20** may comprise a first blue light component which is a continuous emission of blue light and a second blue light component which is a pulsed blue light emission at a frequency typically between two (2) and two hundred (200) Hertz a few Hertz and a few hundred Hertz, more preferably between about 6 and about 60 Hertz and most preferably between about 10 and about 30 Hertz. For such combined continuous and pulsed blue light emission, the combined total emission must not exceed an average output which is greater that 5 watts. It is to be appreciated that the 420 nm to 480 nm wavelength band is within the visible "blue light" portion of the electromagnetic spectrum and is, therefore, above the UV light spectrum normally employed during conventional dental hygiene processes conventionally carried out by dentists and dental hygienist, thereby avoiding the normal hazards associated with using UV radiation as well as the corresponding FDA restrictions.

[0042] The presently preferred photocatalytic agents, for use with radiation within the 420 nm to 480 nm "blue light" band include, for example, modified TiO_2 semiconductor type materials and possibly other catalytic n-type semiconductor particles as well as various organic dyes already known in the art as being photocatalytically responsive to blue light radiation.

[0043] As illustrated in FIGS. **1**, **2**A, **3**A and **3**B and as will be described further in the following description, the blue light emitters **20** emit blue light **22** in a direction generally perpendicular to an upper surface **24** of the head **16** thereby to radiate the blue light **22** into the mouth cavity of the person brushing his or her teeth, that is, the blue light is generally directed toward the teeth, the gums, and the tongue, being contacted by the bristles **18** as the toothbrush is used to brush the teeth. The blue light emitters **20** may comprise one or more blue light sources **26**A, such as blue light emitting diodes or blue light emitting organic light emitting diodes, or any other type of blue light emitting device located either on, within or partially recessed within the upper surface **24** of the head **16** to facilitate directly emitting the blue light **22**. Alternatively, the blue light source(s) **26**A may be located within the body of the head **16** or within handle **12** with the blue light **22** being conducted along the handle and/or body to the blue light emitters **20** where the blue light is finally emitted. One or more internal passages or light conductive elements, such as reflective surfaces, blue conductive fiber optics, lenses and/or any combination thereof are provided in the handle and/or body to facilitate transmission of the blue light to the blue light emitters **20**. In such embodiments of a toothbrush **10**, the blue light source or sources **26**A will be described or defined as being located contiguous to the head **16**, such as at the top surface **19** of head **16** or within the body of head **16**, and it should be noted that for purposes of the present descriptions, the term "contiguous" is taken as meaning "in physical contact with" or "near, next to, or adjacent".

[0044] In other embodiments, such as is illustrated in FIGS. **2**B, **3**C and **3**D, the blue light source or sources **26**A may be located non-contiguously with head **16**, such as in handle **12**, with the blue light **22** being conducted along the handle to blue light emitters **20** located within the head **16** by means of blue light optical conductors **26**B comprising, for example, of blue conductive fiber optic elements or lenses, reflective surfaces, passages or conductive "pipes" comprising blue conductive materials, and/or any combination thereof, which form a one or more paths that conduct the blue light **22** from the blue light source or sources **26**A to the blue light emitters **20** where the light is emitted.

[0045] For example, one or more blue light sources **26**A may be located in handle **12** at a position just below a neck **28**, formed at a junction between the handle **12** and the head **16**. According to one exemplary embodiment, such as illustrated in FIGS. **3**C and **3**D, the neck **28**, the head **16** and possibly portions of the handle **12** are constructed, for example, of a blue transparent material or with one or more blue transparent passage(s) or blue light conductive "pipe" which facilitate passage of the blue light **22** through the neck **28** to the head **16** and thereafter radiated from the blue light emitters **20**. In the embodiment illustrated in FIGS. **3**C and **3**D, the portions of the neck **28** through which blue light **22** is transmitted comprises a suitable blue transparent material, as does the body of the head **16**. The interior of head **16** includes a blue reflective surface **30** formed as facets **30**F wherein the blue light reflective properties of reflective surface **30** is formed, for example, by a coating applied at least between the surfaces of facets **30**F and an over-mold **300** of a different material forming the back regions of the head **16**. The reflective surface **30** may also be formed, for example, by the optical interface of the body **16** and the over-mold **300** materials in the region of facets **30**F.

[0046] As indicated in FIGS. **3**C and **3**D, the blue light **22** passing through neck **28** is reflected by facets **30**F and redirected by the facets **30**F from an arrival path, supplied along and co-linear with the neck **28**, to a direction generally parallel to the bristles **18**, that is, to and through the upper surface **24** of the head **16**. It should be noted with regard to this embodiment that other scattering of the blue light **22** in other directions, such as through the distal end of head **16**, would provide catalytic activity in other areas of the mouth, but would require attention during design to avoid unwanted emissions of blue light from toothbrush.

[0047] It will be recognized that the reflection of the blue light from its arrival path from handle **12** to the direction parallel with the bristles **18** may also be accomplished by curved or flat surfaces, rather than by faceted surfaces.

[0048] In an alternate embodiment, as illustrated in FIG. **2**B, the blue light source or sources **26**A are again located in the handle **12** which illuminate the blue light emitters **20** provided in the head **16**, via a blue light conductive path, wherein the blue light conductive path comprises blue light optical conductors **26**B including, for example, blue conductive fiber optic elements or lenses, tunnel-like passages or conductive "pipes" comprising blue conductive materials and/or any combination thereof.

[0049] Turning now to the bristles **18**, it has been described above that the bristles **18** may comprise either conventional bristles **18**, such as found in conventional toothbrushes, and the blue light **22** may be radiated the from blue light emitters **20** located on or in the top surface **24** of the head **16**, as was discussed above. In other embodiments, however, the blue light emitters **20** in or on the top surface **24** of the head **16** may comprise wholly, or in part, blue light emitting bristles **18**E containing a blue light conductive material. As illustrated in FIG. **4**A, the blue light source of sources **26**A may be located either in the head **16**, at the bases of emitting bristles **18**E, to illuminate emitting bristles **18**E directly, or, as illustrated in FIG. **4**B, may be located in handle **12** with the blue light **22** being conducted to the bases of the emitting bristles **18**E by blue light optical conductors **26**B. In the latter case, the emitting bristles **18**E may comprise the same material as the blue light optical conductors **26**B or may be continuations of the blue light optical conductors **26**B. It should also be noted that the emitting bristles **18**E may be coated or otherwise provided with a reflecting outer surface to prevent or minimize the loss or escape of the blue light **22** out through the sides of the emitting bristles **18**E, and the head **16** may likewise be provided with a reflective blue light containment surface to prevent or minimize leakage or loss of the blue light **22**.

[0050] It will be noted from the above descriptions of the manual light emitting toothbrush **10** that while the blue light emitters **20** are located in or on the head **16**, the blue light source or sources **26**A may be located either in the head **16** or in the handle **12**. In one instance, therefore, blue light **22** must be conducted from the blue light source or sources **26**A located within the handle **12** to the head **16** and, in the other instance, electrical power, such as from a battery **32**, must be conducted from the handle **12** to the head **16** for supplying electrical power to the blue light source or sources **26**A. It must also be noted, however, that in certain implementations, such as those illustrated in FIGS. **2**B, **3**C and **3**D for example, the neck **28** which is formed between the head **16** and the handle **12** may form a disconnectable junction or connection **34** between the head **16** and the handle **12** to allow the head **16** to be removed from the handle **16**. This is a common feature in many conventional toothbrushes, particularly in conventional battery powered toothbrushes wherein a battery **32** and an electric motor vibrate or rotate the toothbrush head. This design facilitates replacement of a worn or old head **16** with a new head **16** or a different head **16** having, for example, a different function, a different arrangement, a different type of bristles **18**, etc.

[0051] In those instances wherein the blue light source or sources **26**A are located in handle **12**, the path between the blue light source or sources **26**A and the head **16** will include the appropriate blue light optical connectors **34**L, at junction **34**, to allow the optical path to be repeatedly disconnected and reconnected in a reliable manner. Connectors **34**L may, for example, comprise lenses, fiber optic connectors or appropriately shaped ends in those implementations wherein the optical light path comprises the material of the handle **12** and the head **16** or a tunnel passage therethrough.

[0052] In those instances wherein the blue light source or sources **26**A are located in the head **16**, the blue light source (s) **26**A will typically be provided with electrical power from one or more batteries **32** located within an internal cavity **36** of the handle **12** and the supply of electrical power to the blue light source or sources **26**A will typically be controlled by a switch **38**, e.g., a "on/off" switch or an a "on" switch with the toothbrush being turned "off" by the control circuitry **42**, located at an appropriate position on the handle **12**. The circuitry will further include leads **32**L running from the handle **12** and through the neck to the head **16** and the leads **32**L will typically include appropriate electrical connectors **34**L at junction **34** which facilitate repeated disconnection and reconnection in a reliable manner.

[0053] In this regard, it should be noted that batteries **32** may be of any type meeting the power, storage and/or size requirements while still being small enough to reside in within the handle **12** and to provide the necessary levels of current to the blue light sources **20** for the required duration, such a NiCad, NiMiH, lithium ion, or lithium polymer batteries which typically may be rechargeable by electrical current supplied from a wall socket. For this reason, the handle **12** may also include a charging circuit **32**C that can be connected to a direct or indirect source of electrical current supplied from a conventional wall socket, such as by a connector or by an induction coupling device. An active and passive interlock system will be employed to prevent normal operation during battery recharge. This interlock system may consist of mechanical keying of electrical connections and or electronic control of the toothbrush electronics by the charging circuit. It should also be noted that advances in battery technology may allow one or more batteries **32** to be located within the handle **12** to facilitate the use of interchangeable heads **16**, with the corresponding connections for the switch **38** and the recharging circuits **32**C passing through the neck **28** to the handle **12**. As an alternative source, the power source or batteries may be AA or AAA alkaline, lithium, or carbon zinc batteries which are commercially available and readily replaceable by the user of the toothbrush.

[0054] Turning now to FIG. **5** through FIG. **8**B, a further embodiment of a solely manual toothbrush, except for the electrically power light source **26**A, is shown and will be now described. According to this embodiment, the toothbrush generally comprises a handle **12** which has a neck **28** securely affixed to one end thereof, e.g., by a snap in self-locking engagement or connection, an adhesive, etc. Typically at least one seal **29**, such as a silicon O-ring, is located at the interface (see FIG. **6**) of the neck **28** with the handle **12** for preventing any water, moisture, toothpaste or any other contaminant from entering therebetween. An interior area or compartment of the handle **12** contains the control circuitry **42**, which is carried by a removal circuit board **43** (see FIGS. **5**B and **6**), which generates a desired intensity and duration of the blue light **22**, e.g., a timed "on/off" operation of the light source for two (2) minutes for example, as well as a power source such as a pair of AA batteries **32** for powering the control circuitry **42** for powering the blue light source **26**A. A further detailed discussion concerning the attributes of the control circuitry **42** will follow below.

[0055] To facilitate turning the control circuitry **42** "on" for a timed duration, the exterior surface of the handle **12** is provided with an activation switch **38**. The end of the handle **12**, opposite from the neck **28**, has a removable cover **44** which facilitates both replacing the batteries **32**, when necessary, as well as installation of the board **43** within a base section of the handle **12** by a fastener **49**, such as a screw. One or more seals **45**, such as a silicon O-ring, is located on a leading end of the removable cover **44** for preventing any water, moisture, toothpaste or any other contaminant from entering between the handle **12** and the removable cover **44**.

[0056] As can be seen in FIGS. **5**, **5**B, **7** and **7**A, the free end of the neck **28** has a planar brush head receiving surface **46** which mates with the replaceable brush head **16** and a further description concerning the same will follow below. An opening **48** is formed in this receiving surface **46** and a "blue light" source **26**A, such as blue light emitting diode or blue light emitting organic light emitting diode, is located within and completely fills the opening **48** in the receiving surface **46**. A fluid tight seal is formed between the outer perimeter of exterior surface of the light emitting source or diode **26**A and the inner perimeter surface of the opening **48** in the receiving surface **46** to prevent any water, moisture, toothpaste or any other contaminant from entering, between the interface between those components, into an interior area of the neck **28**. For example, the outer perimeter of exterior surface of the light emitting source or diode can be welded, glue, etc. to the inner perimeter surface of the opening **48** to form the fluid tight seal therebetween. To further assist with preventing any water, moisture, toothpaste or any other contaminant from hindering operation of the control circuitry **42**, the control circuitry **42** is spaced from the opening **48** in the receiving surface **46** by a remainder of the neck **28**, e.g., between about 1 and 3 inches for example, and completely accommodated within the handle **12**.

[0057] As can be seen in FIGS. **5**, **5**B and **7**A, the light emitting surface **50** of the light emitting source **26**A is preferably slightly recessed below the planar receiving surface **46** of the neck **28** so as not hinder sliding movement of the replaceable brush head **16** relative to the neck **28** and thereby facilitate replacement of the replaceable brush head **16** when required, as will be discussed below in further detail.

[0058] To facilitate secure attachment as well as replacement of the replaceable brush head **16**, a U-shaped annular groove **52** is formed in a sidewall of the receiving surface **46** and this U-shaped annular groove **52** extends around three (3) adjacent sides of the receiving surface **46** of the neck **28** (see FIGS. **5** and **6**A). A bottom surface of the replaceable brush head **16** is provided with a downwardly facing mating flat surface **54** (see FIGS. **8**A and **8**B) which mates with and slides along the upwardly facing receiving surface **46** of the neck **28**. A U-shaped protrusion **56** is formed in a sidewall extending normal to the mating flat surface **54** and this U-shaped protrusion **56** extends around three (3) adjacent sides of the mating flat surface **54** of the replaceable brush head **16**. When the replaceable brush head **16** is placed on the receiving surface **46** such that the mating flat surface **54** engages with the receiving surface **46** and the replaceable brush head **16** is slide toward the handle **12**, the U-shaped protrusion **56** is received by and mates with the U-shaped annular groove **52** of the neck **28** to secure the replaceable brush head **16** to the neck **28**. That is, as the flat bottom surface of the replaceable brush head **16** slides along the upwardly facing flat face of the neck **28**, the U-shaped protrusion **56** of the replaceable brush head **16** is received within the U-shaped annular groove **52** of the neck **28** and this facilitates a locking engagement between the replaceable brush head **16** and the neck **28**.

[0059] In order to retain the relative locked position, between the replaceable brush head **16** and the neck **28**, an end wall **31** of the neck **28** has a passageway **58** which opens to the external environment while a leading end of the replaceable brush head **16** has a spring clip **60** which is positioned to be aligned with and sized to readily pass through the passageway **58** and latch onto a latching surface **62** of the passageway **58** which is formed where the passageway **58** opens to the external environment and, once the clip **60** latches with the latching surface **62** of the passageway **58**, such latching engagement captively retains the replaceable brush head **16** on the neck **28** during normal use of the toothbrush. In order to remove the replaceable brush head **16** from the neck **28**, the user must bias the remote end of the clip **60** out of engagement with the latching surface **62** while, at the same time, sliding or moving the replaceable brush head **16** away from the end wall of the neck **28** until the clip **60** is clear of the latching surface **62**. Once this occurs, the user then continues sliding the replaceable brush head **16** away from the end wall until the U-shaped protrusion **56** completely disengages from the U-shaped annular groove **52**. Thereafter, a new replaceable brush head **16** is then secured to the neck **28** by reversing the above procedure.

[0060] Each replaceable brush head **16** has an aperture **64** formed in a base surface thereof and this aperture **64**, once the replaceable brush head **16** is securely attached to the neck **28** such that the clip **60** engages with the latching surface **62**, is properly aligned with the light emitting source **26**A secured within the opening **48** in the receiving surface **46** of the neck **28** so that the aperture **64** in the replaceable brush head **16** precisely overlies and is concentric with the light emitting source **26**A. Preferably, the aperture **64** is slightly larger in size than the light emitting source **26**A so as to permit all of the blue light **22**, emitted from the light emitting source **26**A, to pass readily through the aperture **64** and treat the teeth, gums and mouth of the individual utilizing the toothbrush during brushing.

[0061] The exterior upwardly facing surface of the replaceable brush head **16**, which is opposite to the mating flat surface **54**, is provided with a plurality of bristles **18** and the base of each of the plurality of bristles **18** is securely embedded and permanently affixed to the replaceable brush head **16** so that the bristles **18** remain permanently attached to the replaceable brush head **16**. Preferably, a plurality of bristles **18** are grouped together in a clump and each clump of bristles **18** is spaced from one another and located about the aperture **64** provided in the replaceable brush head **16**. As is well known in the art, some or all of the bristles **18** may be coated with a wear indicator which indicates to the end user when it is time to replace the replaceable brush head **16**.

[0062] Once the bristles **18** of the replaceable brush head **16** become sufficiently worn, the user removes the replaceable brush head **16** by dislodging the clip **60** from its engagement with the latching surface **62** and sliding the replaceable brush head **16** away from the end wall and the handle **12** until the replaceable brush head **16** becomes completely separated from the neck **28**. Thereafter, the user inserts a new replaceable brush head **16** onto the neck **28** so that the clip **60** passes through the passageway **58** and engages with the latching surface **62** of the neck **28** and the aperture **64** of the replaceable brush head **16** is aligned with the light emitting source **26**A.

[0063] It will be noted in the above embodiment of the manual light emitting toothbrush **10** that the blue light emitter **20** is located in the remote end of the neck **28**. As a result of this, the electrical power from the power source, such as the batteries **32** and the electrical circuitry **42**, to the blue light emitter **20** must be conducted from the handle **12** and through the neck **28** to the blue light emitter **20** located within the neck **28**. To facilitate such conduction, a pair of electrical leads **66** are embedded within the neck **28** and each electrical lead is connected to the blue light emitter **20** in a conventional man-

ner. The opposite end of each electrical lead terminates in a respective pin **68**. The control circuitry **42** is support by the plug-in board **43** which is accommodated within the handle **12** such that a pair of pin apertures (not shown in detail) are located at the leading end of the board **43** and arranged to receive and mate with a respective one of the pins **68** connected to the blue light emitter **20** when the neck **28** is attached to the handle **12** and thereby complete the electrical circuit for powering the blue light emitter **20**. As can be seen in FIG. **6**, the trailing end of the plug in board **43** has a pair of spaced apart "+" and "−" contacts **33** which are located to mate with the respective "+" and "−" contacts of the batteries **32**.

[0064] The manual light emitting toothbrush **10**, according to the present invention, will typically further include a control circuitry **42** which will typically be located in the handle **12** and normally include functions such as a timer circuitry, which times the duration(s) of use of the toothbrush **10** while brushing, an on/off duty cycle of the blue light source or sources **26**A, a replace battery indicator, and so on. Preferably the driver, for driving the blue light source **26**A, is equipped with constant electrical current control electronics and a suitable driver is supplied by Linear Technology, of San Jose Calif., as part no. LTC3454 which is an integrated circuit high current LED driver. The control circuitry **42** may also include blue light source **26**A control circuitry, which may be connected with one or more sensors **40**S (see FIG. **5**B), located in the neck **28**, for detecting when the neck **28** is actually located within a user's mouth, thereby reducing the possibility of the blue light being inadvertently emitted except when the toothbrush is actually located within the mouth of the user. The sensor(s) **40**S could include, for example, sensors for measuring or detecting conductivity, temperature, ambient light, or some other parameter indicating that the head **16** is in the mouth of a user, and the handle **12** may include a sensor for sensing the warmth or pressure of the user's hand before the blue light source or sources **20** can be activated.

[0065] It should also be noted that the toothbrush **10** may further include a motor (not shown) which moves, vibrates and/or rotates the head **16** in the manner of conventional powered toothbrushes, which may, in turn. effect the arrangements for supplying the blue light **22** to the blue light emitters **20** in as much as the mechanical structure between the handle **12** and the head **16** in such toothbrushes includes a moving mechanical joint. In such implementations, therefore, it may be preferable to place the blue light source or sources **26**A in the handle **12** and communicate the blue light **22** to the blue light emitters **20** in the head **16** by optical paths that are typically less affected by moving mechanical joints than are electrical conductors.

[0066] Lastly, it should be noted that the provision of the replaceable head **16** permits the use of other forms of blue light emitting heads **16** containing blue light emitters **20** as described herein above, but shaped for other purposes than specifically as a toothbrush, such as a wand specifically designed and/or intended for blue light irradiation of a photocatalytic agent distributed on the surfaces of the teeth and the gums. In a further example of an alternate arrangement of the head **16**, the head **16** may be designed to hold and manipulate flossing thread or string, thereby allowing flossing to be carried out at the same time as a blue light photocatalytic process.

[0067] It will be appreciated that various changes and/or modifications to the present invention may be made by those of ordinary skill in the art without departing from the spirit and scope of the present invention which is set out in more particular detail in the appended claims. Furthermore, those of ordinary skill in the art will appreciate that the foregoing description is supplied by way of example only, and is not intended to be limiting of the invention as described in the appended claims.

Wherefore, I/We claim:

1. A manual toothbrush having a light source which facilitates a photocatalysis process while brushing, the manual toothbrush comprising:

a handle having a grip at a proximal end and a neck at a distal end thereof, the distal end of the neck having an opening therein, and a blue light emitting source being located within the opening for emitting blue light in a direction generally normal to the neck and the handle;

a completely manual and replaceable brush head having an aperture formed therein and at least one group of bristles being permanently secured to the replaceable brush head, and the aperture of the replaceable brush head, once the replaceable brush head is installed on neck, overlies and is concentric with the blue light emitting source to permit the blue light to pass though the aperture and be emitted generally parallel to the bristles;

a power source for energizing the blue light emitting source and for radiating blue light in a wavelength band between 420 nm to 480 nm; and

a perimeter of a blue light emitting surface of the blue light emitting source being sealed with respect to the opening to form a fluid tight seal therewith to prevent any water, moisture, toothpaste or other contaminant from entering therebetween.

2. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **1**, wherein the neck has a planar brush head receiving surface and the opening is formed therein, and the emitting surface of the blue light source completely fills the opening and is recessed below receiving surface so as not hinder sliding movement of the replaceable brush head relative to the neck and thereby facilitate replacement of the replaceable brush head.

3. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **1**, wherein a U-shaped annular groove is formed in a sidewall of the receiving surface and the U-shaped annular groove extends around three adjacent sides of the receiving surface of the neck, and the replaceable brush head has a mating flat surface which mates with and slides along the receiving surface of the neck, and the replaceable brush head has a mating U-shaped protrusion which is received by the U-shaped annular groove to secure the replaceable brush head to the neck.

4. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **3**, wherein the neck has a passageway while a leading end of the replaceable brush head has a clip which is aligned with and sized to readily pass through the passageway, and the clip latches with a latching surface of the passageway to captively retain the replaceable brush head on the neck during use of the toothbrush.

5. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **4**, wherein the aperture of the replaceable brush head is larger in size than the blue light emitting source.

6. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **1**, wherein the replaceable brush head supports a plurality of bristles and a base of each of the plurality of bristles is embedded within the replaceable brush head so that the bristles remain permanently attached to the replaceable brush head.

7. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **6**, a plurality of bristles are grouped together into a plurality of clumps of bristles and the plurality of clumps of bristles are spaced from one another and located about the aperture of the replaceable brush head.

8. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **1**, wherein the blue light radiated by the blue light source has an average power level of less than 1 watt.

9. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **8**, wherein the blue light radiated by the blue light source is a continuous blue light emission.

10. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **8**, wherein the blue light radiated by the blue light source is a modulated blue light emission.

11. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **10**, wherein the modulated blue light emission is at a frequency of between about 6 and about 60 Hertz.

12. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **1**, wherein the blue light radiated by the at least one blue light source comprises a combination of a continuous blue light emission and a modulated blue light emission and the combination blue light emission has an average power level of less than 5 watts.

13. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **1**, wherein the photocatalytic agent is one of a modified TiO_2 semiconductor type materials, a catalytic n-type semiconductor material, and an organic dye which photocatalytically responsive to blue light radiation.

14. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **1**, wherein the power source is one of a non-rechargeable battery and a rechargeable battery.

15. A manual toothbrush having a light source which facilitates a photocatalysis process while brushing, the manual toothbrush comprising:

a handle having a grip at a proximal end and a neck at a distal end thereof, the distal end of the neck having opening therein, and a blue light emitting source being located within the opening for emitting blue light in a direction generally normal to the neck and the handle;

a completely manual and replaceable brush head having an aperture formed therein and at least one group of bristles being permanently secured to the replaceable brush head, and the aperture of the replaceable brush head, once the replaceable brush head is installed on neck, overlies and is concentric with the blue light emitting source to permit the blue light to pass though the aperture and be emitted generally parallel to the bristles;

a power source equipped with constant electrical current control electronics for energizing the blue light source and for radiating blue light with the blue light being modulated from 0% to 100% at a frequency of between a two (2) and two hundred (200) Hertz with an average optical output power level of less than 5 watts for radiating blue light in a wavelength band between 420 nm to 480 nm;

a perimeter surface of the blue light emitting source being sealed with respect to the opening to form a fluid tight seal therewith; and

the handle at least partially accommodating at least one of control circuitry and a power source for the blue light source.

16. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **15**, wherein the neck has a planar brush head receiving surface and the opening is formed therein, and the emitting surface of the blue light source completely fills the opening and is recessed below receiving surface so as not hinder sliding movement of the replaceable brush head relative to the neck and thereby facilitate replacement of the replaceable brush head.

17. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **16**, wherein a U-shaped annular groove is formed in a sidewall of the receiving surface and the U-shaped annular groove extends around three adjacent sides of the receiving surface of the neck, and the replaceable brush head has a mating flat surface which mates with and slides along the receiving surface of the neck, and the replaceable brush head has a mating U-shaped protrusion which is received by the U-shaped annular groove to secure the replaceable brush head to the neck.

18. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **15**, wherein the neck has a passageway while a leading end of the replaceable brush head has a clip which is aligned with and sized to readily pass through the passageway, and the clip latches with a latching surface of the passageway to captively retain the replaceable brush head on the neck during use of the toothbrush; and

the aperture of the replaceable brush head is larger in size than the blue light emitting source and the replaceable brush head supports a plurality of bristles and a base of each of the plurality of bristles is embedded within the replaceable brush head so that the bristles remain permanently attached to the replaceable brush head.

19. The manual toothbrush having the light source which facilitates the photocatalysis process while brushing according to claim **15**, wherein the blue light radiated by the at blue light source comprises a blue light emission wherein the modulated blue light emission is modulated at a frequency of between about 6 and about 60 Hertz.

20. A method of forming a manual toothbrush having a light source which facilitates a photocatalysis process while brushing, the method comprising the steps of:

providing a handle having a grip at a proximal end and a neck at a distal end thereof, forming an opening in the distal end of the neck, and locating a blue light emitting source within the opening for emitting blue light in a direction generally normal to the neck and the handle;

forming an aperture in a completely manual and replaceable brush head and permanently securing at least one group of bristles to the replaceable brush head, and installing the replaceable brush head on the neck so that the aperture overlies and is concentric with the blue light

emitting source to permit the blue light to pass though the aperture and be emitted generally parallel to the bristles;

energizing the blue light source with a power source for radiating blue light which is modulated from 0% to 100% at a frequency of between a two (2) and two hundred (200) Hertz with an average optical output power level of less than 5 watts for radiating blue light in a wavelength band between 420 nm to 480 nm;

sealing a perimeter surface of the blue light emitting source with respect to the opening to form a fluid tight seal therewith; and

at least partially accommodating, within the handle, at least one of control circuitry and a power source for the blue light source.

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