(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 June 2016 (23.06.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/097907 Al

(51) International Patent Classification:
A61B 5/00 (2006.01) *A61C 17/22* (2006.01)

(21) International Application Number:
PCT/IB201 5/059 110

(22) International Filing Date:
25 November 2015 (25.1 1.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/092,33 1 16 December 2014 (16. 12.2014) US

(71) Applicant: KONINKLIJKE PHILIPS N.V. [NL/NL]; High Tech Campus 5, NL-5656 AE Eindhoven (NL).

(72) Inventors: **JOHNSON, Mark Thomas;** c/o High Tech Campus, Building 5, NL-5656 AE Eindhoven (NL). **OUWELTJES, Okke;** c/o High Tech Campus, Building 5, NL-5656 AE Eindhoven (NL). **SPRUIT, Johannes Hendrikus Maria;** c/o High Tech Campus, Building 5, NL-5656AE Eindhoven (NL). **VAN GOOL, Edgar Martinus;** c/o High Tech Campus, Building 5, NL-5656AE Eindhoven (NL). **VAN DEN BIJGAART, Adrianus Wilhelmus Dionisius Maria;** c/o High Tech Campus, Building 5, NL-5656AE Eindhoven (NL). **DEANE, Steven Charles;** c/o High Tech Campus, Building 5, NL-5656AE Eindhoven (NL).

(74) Agent: **VERWEIJ, Petronella Danielle;** High Tech Campus Building 5, NL-5656 AE Eindhoven (NL).

[Continued on nextpage]

(54) Title: CLEANING DEVICE WITH MECHANICAL MOTION AND PLAQUE DETECTION STREAM PROBE

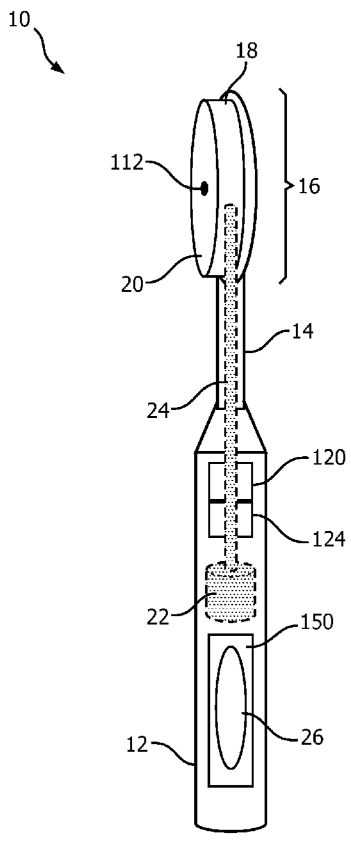

FIG. 1

(57) Abstract: A power toothbrush (10) for dental plaque detection, including a detection component (100) configured to generate an air or fluid stream (30) and enable passage of the generated stream through a stream probe (112) to detect plaque. The head of the toothbrush has a bristle array that is engaged in a mechanical motion during operation of the toothbrush. The stream probe is positioned on or within the bristle array to minimize unwanted movement of the stream probe caused by the mechamcal motion of neighboring bristles. Methods include detecting plaque using a stream probe of a power toothbrush.

WO 2016/097907 A1

(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

CLEANING DEVICE WITH MECHANICAL MOTION AND PLAQUE DETECTION STREAM PROBE

Field of the Invention

[0001] The present disclosure is directed generally to a dental cleaning device with a brush member having bristles with mechanical motion and a stream probe used to detect plaque.

Background

[0002] Periodontal diseases are thought to be infectious diseases caused by bacteria present in dental plaques. Removal of dental plaques is highly important for the health of oral cavities. Tooth brushing is a highly effective method to remove dental plaque from the teeth, provided the toothbrush is actually used in such a fashion to reach all areas where plaque resides.

[0003] Power toothbrushes can enhance the removal of dental plaque. Such power toothbrushes have a set of bristles attached to a brush head which is moved by a driver that causes the bristles to scrub dental surfaces. The brush head of a power toothbrush can be designed to simultaneously exhibit multiple different types of motion, including rotary motion, back and forth motion, and a variety of other forms of motion.

[0004] Further, since users cannot see the presence of dental plaque with the naked eye, a variety of plaque detection apparatuses have been developed to aid in the detection of dental plaque. For example, one type of dental plaque apparatus that is effective in detecting dental plaque utilizes a detection probe through which a flow, such as an air flow, is pumped and of which the pressure modulations in response to contact with dental plaque that temporarily obstructs the probe, or clean surfaces that do not obstruct the probe, can be monitored to detect the presence or absence of dental plaque.

[0005] When using a plaque detection stream probe with a power toothbrush that has moving bristles, the stream probe may produce false positive signals indicating the presence of plaque on clean teeth. These false positive signals can be caused by, among other things, non-optimal movement of the stream probe resulting from movement of neighboring bristles.

[0006] Accordingly, there is a need in the art for methods and apparatus for preventing unwanted movement of a stream probe in a power toothbrush with rapidly moving bristles.

Summary of the Invention

[0007] The present disclosure is directed to inventive methods and apparatus for dental plaque detection using a power toothbrush with rapidly moving bristles. Various embodiments and implementations herein are directed to a plaque detection method and apparatus in which a stream probe is positioned at a location within a bristle array that minimizes unwanted movement and prevents false positive signals. Using the various embodiments and implementations herein, effective detection and removal of dental plaque can be substantially improved by combining a stream probe with a power toothbrush having bristles that exhibit one or more types of mechanical movement.

[0008] For example, in some embodiments, the plaque detection apparatus of the dental cleaning device includes a detection module with an air or fluid stream generator that applies air or fluid to the dental surface via a stream probe, and a pressure sensor that is configured to measure feedback from the air applied to the dental surface in order to characterize the dental surface. The stream probe is positioned within a bristle array on the head member of the dental cleaning device, which can have one or more types of mechanical movement. The stream probe position within the bristle array can be configured to minimize movement of the stream probe which in turn minimizes false signals to the detection module.

[0009] Generally in one aspect, an apparatus for plaque detection includes: (i) a body portion; (ii) an elongated head member extending from the body portion, the elongated head member comprising a bristle array having a plurality of bristles and configured for a mechanical motion, where the bristles comprise a range of bristle velocities when the bristle array is engaged in the mechanical motion; and (iii) a detection component configured to generate an air or fluid stream and allow passage of the air or fluid stream through a stream probe, where passage of the air or fluid stream through the stream probe enables detection of plaque based on measurement of a signal caused by the plaque at least partially obstructing passage of the generated air or fluid stream through the stream probe; (iv) where the stream probe is positioned at a first location on the bristle array where the bristle velocity proximal the stream probe is less than a maximum bristle velocity within the range of bristle velocities.

[0010] According to an embodiment, the bristle velocity proximal the stream probe is substantially zero.

[0011] According to an embodiment, the mechanical motion is a rotational motion, or a back and forth motion.

[0012] Generally in another aspect, an apparatus for plaque detection includes: (i) a body portion; (ii) an elongated head member extending from the body portion, the elongated head member comprising: a first bristle array having a plurality of bristles and configured for a first mechanical motion, and a second bristle array having a second plurality of bristles, where the second bristle array does not engage in mechanical motion; and (iii) a plaque detection component configured to generate an air or fluid stream and allow passage of the air or fluid stream through a stream probe, where passage of the air or fluid stream through the stream probe enables detection of plaque based on measurement of a signal caused by the plaque at least partially obstructing passage of the generated air or fluid stream through the stream probe; (iv) where the stream probe is positioned at a first location within the second bristle array.

[0013] Generally in further aspect, an elongated head member includes: (i) a bristle array including (1) a first bristle sub-array having a plurality of bristles and configured for a first mechanical motion, and (2) a second bristle sub-array having a second plurality of bristles, wherein the second bristle array does not engage in mechanical motion; and (ii) a stream probe configured to allow passage of a generated air or fluid stream, wherein passage of the air or fluid stream through the stream probe enables detection of plaque based on measurement of a signal caused by the plaque at least partially obstructing passage of the generated air or fluid stream through the stream probe; where the stream probe is positioned at a first location within the second bristle sub-array.

[0014] Generally, in another aspect, a method for detecting plaque includes the steps of: (i) providing a power toothbrush having a body portion; a detection component configured to generate an air or fluid stream and allow passage of the air or fluid stream through a stream probe; an elongated head member extending from a body portion, the elongated head member comprising a first bristle array having a plurality of bristles and configured for a first mechanical motion, and a second bristle array having a second plurality of bristles, where the second bristle array does not engage in mechanical motion; where the stream probe is positioned at a first location within the second bristle array; and (ii) detecting, by the detection component of the power toothbrush, the presence of plaque, including the steps of: generating an air or fluid stream;

passing the generated air or fluid stream through the stream probe; and detecting plaque based on measurement of a signal caused by the plaque at least partially obstructing the passage of the generated air or fluid stream through the stream probe.

[0015] According to an embodiment, the apparatus and/or method include a third bristle array having a plurality of bristles and configured for a second mechanical motion, the second mechanical motion different from the first mechanical motion;

[0016] According to an embodiment, the first mechanical motion is a rotational motion or a back and forth motion, and the second mechanical motion is selected from the other of the rotational motion and the back and forth motion.

[0017] As used herein for purposes of the present disclosure, the term "controller" is used generally to describe various apparatus relating to the operation of a stream probe apparatus, system, or method. A controller can be implemented in numerous ways (e.g., such as with dedicated hardware) to perform various functions discussed herein. A "processor" is one example of a controller which employs one or more microprocessors that may be programmed using software (e.g., microcode) to perform various functions discussed herein. A controller may be implemented with or without employing a processor, and also may be implemented as a combination of dedicated hardware to perform some functions and a processor (e.g., one or more programmed microprocessors and associated circuitry) to perform other functions. Examples of controller components that may be employed in various embodiments of the present disclosure include, but are not limited to, conventional microprocessors, application specific integrated circuits (ASICs), and field-programmable gate arrays (FPGAs).

[0018] In various implementations, a processor or controller may be associated with one or more storage media (generically referred to herein as "memory," e.g., volatile and non-volatile computer memory such as RAM, PROM, EPROM, and EEPROM, floppy disks, compact disks, optical disks, magnetic tape, etc.). In some implementations, the storage media may be encoded with one or more programs that, when executed on one or more processors and/or controllers, perform at least some of the functions discussed herein. Various storage media may be fixed within a processor or controller or may be transportable, such that the one or more programs stored thereon can be loaded into a processor or controller so as to implement various aspects of the present invention discussed herein. The terms "program" or "computer program" are used herein in a generic sense to refer to any type of computer code (e.g., software or microcode) that can be employed to program one or more processors or controllers.

[0019] The term "user interface" as used herein refers to an interface between a human user or operator and one or more devices that enables communication between the user and the device(s). Examples of user interfaces that may be employed in various implementations of the present disclosure include, but are not limited to, switches, potentiometers, buttons, dials, sliders, track balls, display screens, various types of graphical user interfaces (GUIs), touch screens, microphones and other types of sensors that may receive some form of human-generated stimulus and generate a signal in response thereto.

[0020] It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent) are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein.

[0021] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

Brief Description of the Drawings

[0022] In the drawings, like reference characters generally refer to the same parts throughout the different views. Also, the drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention.

[0023] FIG. 1 is a schematic representation of a power toothbrush in accordance with an embodiment.

[0024] FIGS. 2A and 2B are schematic representations of a brush head of a power toothbrush in accordance with an embodiment.

[0025] FIG. 3 is a schematic representation of a plaque detection component of a power toothbrush in accordance with an embodiment.

[0026] FIG. 4 is a schematic representation of a stream probe, in accordance with an embodiment.

[0027] FIG. 5 is a schematic representation of a brush head of a power toothbrush in accordance with an embodiment.

[0028] FIG. 6 is a schematic representation of a brush head of a power toothbrush in accordance with an embodiment.

[0029] FIGS. 7A-7C are schematic representations of a brush head of a power toothbrush in accordance with an embodiment.

[0030] FIG. 8 is a flow chart of a method for detecting plaque using a power toothbrush in accordance with an embodiment.

Detailed Description of Embodiments

[0031] The present disclosure describes various embodiments of apparatus, systems, devices, and methods for dental plaque detection using a power toothbrush with rapidly moving bristles. More generally, Applicants have recognized and appreciated that it would be beneficial to prevent false plaque detection signals by minimizing unwanted movement of the stream probe utilized for detection. For example, unwanted movement of the stream probe is substantially improved by positioning the stream probe at a location within a bristle array where motion of the neighboring bristles is at a minimum. A particular goal of utilization of certain embodiments of the present disclosure is to be able to detect plaque within a brush system with multiple bristle arrays each exhibiting a different type of movement.

[0032] In view of the foregoing, various embodiments and implementations are directed to an apparatus and method in which a plaque detection device includes a detection module with an air or fluid stream generator that applies air or fluid to the dental surface via a stream probe, and a pressure sensor that is configured to measure feedback from the air applied to the dental surface in order to characterize the dental surface. The stream probe is positioned with a bristle array on the head member of the dental cleaning device, which can exhibit one or more types of mechanical movement. The stream probe position within the bristle array is selected to minimize movement of the stream probe to minimize false signals to the detection module.

[0033] **Bristle Movement and Plaque Detection**

[0034] Referring to FIG. 1, in one embodiment, a power toothbrush 10 that also detects the presence of plaque on a dental surface. Power toothbrush 10 includes a body portion 12 and an elongated head member 14 mounted on the body portion. Head member 14 includes a brush head 16 at its distal end. Brush head 16 includes a bristle array 18, which has a plurality of bristles 20, and a stream probe 112. According to an embodiment, the bristles extend along an axis substantially perpendicular to the head's axis of elongation, although other configurations are possible. The active (electronic) components of the power toothbrush 10 are incorporated within, or disposed externally on, the body portion 12. More particularly, a pressure sensing portion 120 and a pump portion 124 are incorporated within, or disposed externally on, body portion 12. The pressure sensing portion 120 is in electrical communication with detection electronics 150.

[0035] Bristle array 18 is configured on the brush head 16 so as to be able to move in one or more directions, thereby imparting motion to the plurality of bristles 20. The movement of bristle array 18, thereby bristles 20, can be any of a variety of different movements, including up and down, side to side, and rotational, among others. For example, in accordance with an embodiment, the bristle array 18 moves side-to-side at a first frequency, relative to the body portion 12. The head member 14 can be fixedly mounted onto body portion 12, or it may alternatively be detachably mounted so that head member 14 can be replaced with a new one when the bristles 20 or another component of the device are worn out and require replacement.

[0036] Body portion 12 includes a movement generator 22 for generating movement and a transmission component 24 for transmitting the movement to head member 14. For example, movement generator 22 can comprise a motor or electromagnet(s) that generates movement of the transmission component 24, which is subsequently transmitted to the head member 14. Movement generator 22 may alternatively comprise any other known type of movement mechanism capable of generating movement. The movement generator 22 can include movement electronics such as a power supply, an oscillator, and one or more electromagnets, among other components. In this embodiment the power supply comprises one or more rechargeable batteries, not shown in FIG. 1, which can be electrically charged in a charging holder in which power toothbrush 10 is placed when not in use. In this embodiment, body portion 12 is further provided with an on/off button 26 to activate and de-activate movement generator 22. It is anticipated that head member 14 can be affixed to and used with a body portion 12 of a powered oral care device, such as a power toothbrush, varieties of which are commonly known in the industry.

[0037] Referring to FIGS. 2A and 2B, in one embodiment, a head member 14 is provided, separate from body portion 12. The head member includes a brush head 16 with a stream probe 112 and one or more bristle arrays 18 each having multiple bristles 20. The length of head member 14 is configured to be suitable for cleaning both the anterior and posterior surfaces of a human oral cavity. In FIG. 2A, brush head 16 includes a plurality of generally perpendicular bristle arrays 18 each with a plurality of bristles 20. The generally perpendicular bristle arrays can move together in a similar motion, or can have different motions. For example, every other bristle array can move in a first direction while the neighboring arrays move in a second, opposite direction. Some or all of the bristle arrays 18 on brush head 16 in FIG. 2A may be replaced with a bristle array of another shape. For example, the top third or half, or the middle third, or the bottom third or half, of the bristle arrays 18 may be replaced with a circular, square, or other shaped bristle array. This bristle array can be configured to have a motion of a type, direction, and/or speed different from the remaining generally perpendicular bristle arrays. For example, the remaining generally perpendicular bristle arrays may have a side-to-side motion while a circular array has a rotational motion. In FIG. 2B, brush head 16 includes a generally circular or oval bristle array 18 with a plurality of bristles 20. Although only a few embodiments are depicted, a wide variety of shapes, sizes, and combinations can be utilized to produce maximum plaque removal.

[0038] Referring to FIG. 3, in one embodiment, a detection component 100 of power toothbrush 10 for detecting the presence of plaque on a surface is provided, exemplified by a stream probe that includes a pressure sensor to demonstrate the principle of plaque detection by pressure sensing and measurement. More particularly, detection component 100 of power toothbrush 10 can include a pump portion 124, a pressure sensing portion 120, and a stream probe 112 with an interior channel 115.

[0039] Stream probe 112 has an open port 136 (as shown for example in FIG. 4), which can be a variety of shapes. According to an embodiment, stream probe 112 defines an interior channel 115 through which air or fluid stream 30 can be directed. The stream probe can be configured, for example, such that air or fluid stream 30 is brought in contact with a dental surface 33, such as a tooth, at stream probe 112. Under normal operating circumstances, the detection component 100 will direct air or fluid stream 30 through interior channel 115 and out through open port 136 to come in contact with dental surface 33. The interaction of the air or fluid stream 30 with the dental surface 33 will cause a change in the flow of the air or fluid stream, which can be detected by pressure sensing portion 120. For example, a signal indicating the presence of plaque can be caused by the plaque at least partially obstructing the passage of the generated air or fluid stream through open port 136 of the stream probe 112.

[0040] For example, referring to FIG. 4, according to one embodiment, an apparatus and accompanying method of detecting the presence of a substance on a surface is provided. The pressure sensing portion 120 detects a change in the pressure in the detection component 100 which can change due to the surface being contacted by the air or fluid stream 30 in the stream probe 112 at the open port 136.

[0041] **Location of the Stream Probe**

[0042] Referring to FIG. 5, in one embodiment, a head member 14 is provided, separate from body portion 12. The head member includes a brush head 16 with one or more bristle arrays 18 each having a plurality of bristles 20. Stream probe 112 is depicted in the center of the bristle array in FIG. 5, although the location of stream probe 112 can vary, as discussed in detail below.

[0043] The bristle array 18 in FIG. 5, for example, can rotate back-and-forth in the direction of arrow *a*. According to an embodiment, the bristle array does not complete a full rotation but first rotates in a first direction, stops, and then rotates in the reverse direction, accomplishing a back-and-forth motion multiple times per second and/or per minute. As the bristle array rotates back and forth, the plurality of bristles similarly rotate back and forth in the same direction. However, the velocity of each bristle can vary as depicted by the dotted arrow, which shows velocity v increasing from a minimum at the center of the bristle array to a maximum at the outer edge of the bristle array. The bristle velocity increases in an essentially liner manner as the distance of the bristles form the axis of rotation increases.

[0044] According to an embodiment, the stream probe 112 is positioned within bristle array 18 to minimize unwanted movement and thus minimize the occurrence of false positive signals. For example, the stream probe can be positioned within a location where the probe velocity is less than 50% of the maximum bristle velocity, approximately depicted by the dotted circle in FIG. 5. According to another embodiment, the stream probe 112 is positioned within a location where the probe velocity is less than 20% of the maximum bristle velocity, within a location where the probe velocity is less than 10% of the maximum bristle velocity. According to yet another embodiment, the stream probe 112 is positioned within a location where the velocity is substantially zero.

[0045] Referring to FIG. 6, in one embodiment, a head member 14 is provided, separate from body portion 12. The head member includes a brush head with multiple bristle arrays each having a plurality of bristles 20. In this embodiment, the brush head includes a bristle array 20a that rotates back and forth around an axis of rotation, as well as one or more bristle arrays 20b that move back and forth. Stream probe 112 is depicted in the center of bristle array 20a in FIG. 6, although the location of stream probe 112 can vary, as discussed in detail below minimize unwanted movement and thus minimize the occurrence of false positive signals. Here, the stream probe 112 is positioned within a location where the velocity is as close to zero as possible, although it will still experience some minimal rotational velocity.

[0046] Referring to FIGS. 7A-7C, are variations of a head member 14 which each include a brush head 16, each brush head including a bristle array 18. Each bristle array 18 has three bristle sub-arrays 18a, 18b, and 18c, each of which has a plurality of bristles 20. In these embodiments, first bristle array 18a with the plurality of bristles 20a rotates around an axis of rotation. According to an embodiment, a bristle array may not complete a full rotation but can first rotate in a first direction, stop, and then rotate in the reverse direction, accomplishing a back-and-forth motion multiple times per second and/or per minute. The second bristle arrays 18b has a plurality of bristles 20b that move back and forth. As the bristle array rotates back and forth, the plurality of bristles similarly rotate back and forth in the same direction, with varying velocities. The brush heads in FIGS. 7A-7C further include one or more third bristle arrays 18c with a plurality of bristles 20c that are not powered by the toothbrush and thus do not undergo mechanical motion.

[0047] In FIG. 7A, the stream probe 112 is placed within bristle array 18, but at or near an intersection of two or more bristle sub-arrays each having a different type, angle, and/or speed of movement. By offsetting the stream probe 112 from center, the stream probe can be used to detect plaque at or near the gum line, for example. Similarly, the stream probe 112 in FIG. 7B is positioned at or near an intersection of two or more bristle sub-arrays each having a different type, angle, and/or speed of movement. In FIG. 7C, stream probe 112 is placed within the plurality of bristles of one of the bristle sub-arrays 20c in order to minimize unwanted movement and thus minimize the occurrence of false positive signals.

[0048] In addition to the embodiments depicted in FIG. 7, a wide variety of shapes, sizes, and combinations of the brush head, the bristle arrays, and/or the bristles can be utilized to maximize plaque removal while placing the stream probe 112 in a location that minimizes movement and prevents false positive signals. For example, stream probe 112 can be located within, near, or otherwise in proximity to a bristle array 18 in a first location where the velocity of the bristles is at a minimum. For example, a bristle array 18 can rotate back-and-forth, among many other forms of motion. According to an embodiment, the bristle array does not complete a full rotation but first rotates in a first direction, stops, and then rotates in the reverse direction, accomplishing a back-and-forth motion multiple times per second and/or per minute. As the bristle array rotates back and forth, the plurality of bristles similarly rotate back and forth in the same direction. However, the velocity of each bristle can vary, increasing from a minimum at the center of the bristle array to a maximum at the outer edge of the bristle array. The bristle velocity increases in an essentially liner manner as the distance of the bristles form the axis of rotation increases. In this embodiment, the stream probe 112 could be positioned within bristle array 18 to minimize unwanted movement and thus minimize the occurrence of false positive signals. For example, the stream probe can be positioned within a location where the probe velocity is less than 50% of the maximum bristle velocity, in order to minimize motion of the stream probe. According to another embodiment, the stream probe 112 is positioned within a location where the probe velocity is less than 20% of the maximum bristle velocity, or within a location where the probe velocity is less than 10% of the maximum bristle velocity. According to yet another embodiment, the stream probe 112 is positioned within a location where the velocity is substantially zero, thereby most efficiently minimizing the motion of the stream probe.

[0049] As another example, a bristle array 18 can move back-and-forth rather than rotating, among many other forms of motion. As the bristle array moves back-and-forth, the plurality of bristles similarly moves back-and-forth. However, the velocity of each bristle can vary depending on the location of the bristle in the array and other factors. In this embodiment, the stream probe 112 could be positioned within bristle array 18 to minimize unwanted movement and thus minimize the occurrence of false positive signals. For example, the stream probe can be positioned just outside the moving bristle array in order to minimize motion of the stream probe or within a non-driven portion of the bristle array to minimize motion.

[0050] **Detection Methods**

[0051] Referring to FIG. 8, a flow chart illustrating a method 200 for detecting plaque on a dental surface in accordance with an embodiment of the invention is disclosed. In step 210, a power toothbrush 10 is provided. Power toothbrush 10 may be any of the embodiments described herein or otherwise envisioned. For example, power toothbrush 10 can include a detection component 100 with stream probe 112 according to any of the embodiments described herein or otherwise envisioned. The stream probe of power toothbrush 10 is positioned within a first location of the brush head's bristle array such that the velocity of bristles proximal the stream probe is minimized. For example, the location of the stream probe 112 is such that the velocity of bristles proximal the stream probe is less than a maximum bristle velocity within the range of bristle velocities exhibited by the bristle array.

[0052] In step 220, an air or fluid stream 30 is generated by the detection component 100. In step 230, air or fluid stream 30 is passed through the stream probe 112 of power toothbrush 10. In step 240, the power toothbrush 10 detects plaque on the dental surface caused by the measurement of a signal resulting from the plaque at least partially obstructing the passage of generated air or fluid stream 30 through stream probe 112.

[0053] All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms.

[0054] The indefinite articles "a" and "an," as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean "at least one."

[0055] The phrase "and/or," as used herein in the specification and in the claims, should be understood to mean "either or both" of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with "and/or" should be construed in the same fashion, i.e., "one or more" of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the "and/or" clause, whether related or unrelated to those elements specifically identified.

[0056] As used herein in the specification and in the claims, "or" should be understood to have the same meaning as "and/or" as defined above. For example, when separating items in a list, "or" or "and/or" shall be interpreted as being inclusive, i.e., the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as "only one of or "exactly one of," or, when used in the claims, "consisting of," will refer to the inclusion of exactly one element of a number or list of elements. In general, the term "or" as used herein shall only be interpreted as indicating exclusive alternatives (i.e. "one or the other but not both") when preceded by terms of exclusivity, such as "either," "one of," "only one of," or "exactly one of."

[0057] As used herein in the specification and in the claims, the phrase "at least one," in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily including at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifically identified within the list of elements to which the phrase "at least one" refers, whether related or unrelated to those elements specifically identified.

[0058] It should also be understood that, unless clearly indicated to the contrary, in any methods claimed herein that include more than one step or act, the order of the steps or acts of the method is not necessarily limited to the order in which the steps or acts of the method are recited.

[0059] In the claims, as well as in the specification above, all transitional phrases such as "comprising," "including," "carrying," "having," "containing," "involving," "holding," "composed of," and the like are to be understood to be open-ended, i.e., to mean including but not limited to. Only the transitional phrases "consisting of and "consisting essentially of shall be closed or semi-closed transitional phrases, respectively.

Claims

What is claimed is:

1. An apparatus (10) for plaque detection, the apparatus comprising:

a body portion (12);

an elongated head member (14) extending from the body portion, the elongated head member comprising a bristle array (18) having a plurality of bristles (20) and configured for a mechanical motion, wherein the bristles comprise a range of bristle velocities when said bristle array is engaged in said mechanical motion; and

a detection component (100) configured to generate an air or fluid stream (30) and allow passage of the air or fluid stream through a stream probe (112), wherein passage of the air or fluid stream through the stream probe enables detection of plaque based on measurement of a signal caused by the plaque at least partially obstructing passage of the generated air or fluid stream through the stream probe;

wherein the stream probe is positioned at a first location on the bristle array where the bristle velocity proximal the stream probe is less than a maximum bristle velocity within said range of bristle velocities.

2. The apparatus of claim 1, wherein the bristle velocity proximal the stream probe is substantially zero.

3. The apparatus of claim 1, wherein said mechanical motion is a rotational motion.

4. The apparatus of claim 1, wherein said mechanical motion is a back and forth motion.

5. An apparatus (10) for plaque detection, the apparatus comprising:

a body portion (12);

an elongated head member (14) extending from the body portion, the elongated head member comprising: (i) a first bristle array (18a) having a plurality of bristles (20a) and configured for a first mechanical motion; and (ii) a second bristle array (18b) having a second plurality of bristles (20b), wherein the second bristle array does not engage in mechanical motion; and

a detection component (100) configured to generate an air or fluid stream (30) and allow passage of the air or fluid stream through a stream probe (112), wherein passage of the air or fluid stream through the stream probe enables detection of plaque based on measurement of a signal caused by the plaque at least partially obstructing passage of the generated air or fluid stream through the stream probe;

wherein the stream probe is positioned at a location within the second bristle array.

6. The apparatus of claim 5, further comprising a third bristle array (18c) having a third plurality of bristles (20c) and configured for a second mechanical motion, the second mechanical motion different from the first mechanical motion.

7. The apparatus of claim 5, wherein said first mechanical motion is a rotational motion or a back and forth motion.

8. The apparatus of claim 7, wherein said second mechanical motion is selected from the other of the rotational motion and the back and forth motion.

9. An elongated head member (14) comprising:

a bristle array (18), the bristle array comprising: (i) a first bristle sub-array having a plurality of bristles (20a) and configured for a first mechanical motion; and (ii) a second bristle sub-array (18b) having a second plurality of bristles (20b), wherein the second bristle sub-array does not engage in mechanical motion; and

a stream probe (112) configured to allow passage of a generated air or fluid stream (30), wherein passage of the air or fluid stream through the stream probe enables detection of plaque based on measurement of a signal caused by the plaque at least partially obstructing passage of the generated air or fluid stream through the stream probe;

wherein the stream probe is positioned at a location within the second bristle sub-array.

10. The elongated head member of claim 9, wherein the bristle array further comprises a third bristle sub-array having a plurality of bristles (20b) and configured for a second mechanical motion, the second mechanical motion different from the first mechanical motion.

11. The elongated head member of claim 9, wherein said first mechanical motion is a rotational motion or a back and forth motion.

12. The elongated head member of claim 11, wherein said second mechanical motion is selected from the other of the rotational motion and the back and forth motion.

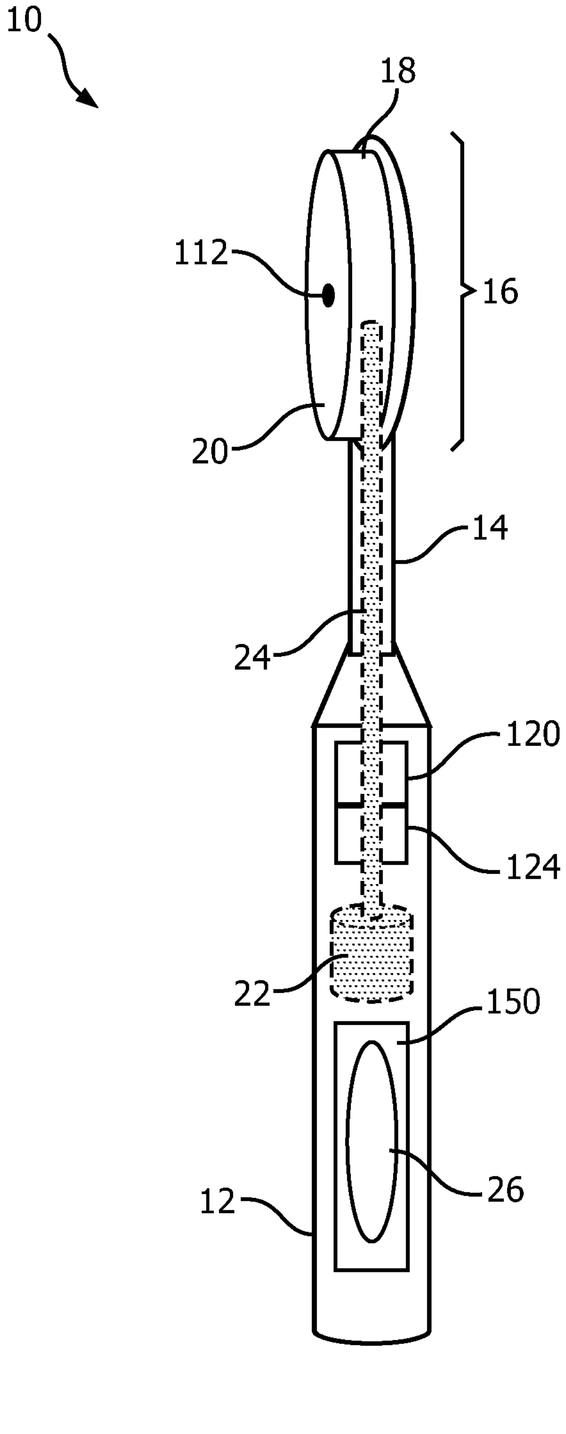

FIG. 1

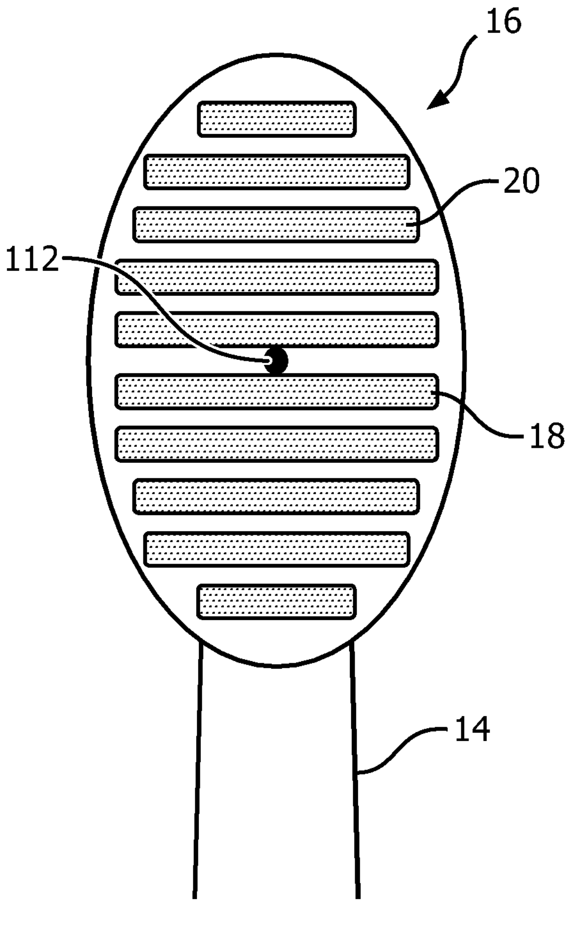

FIG. 2A

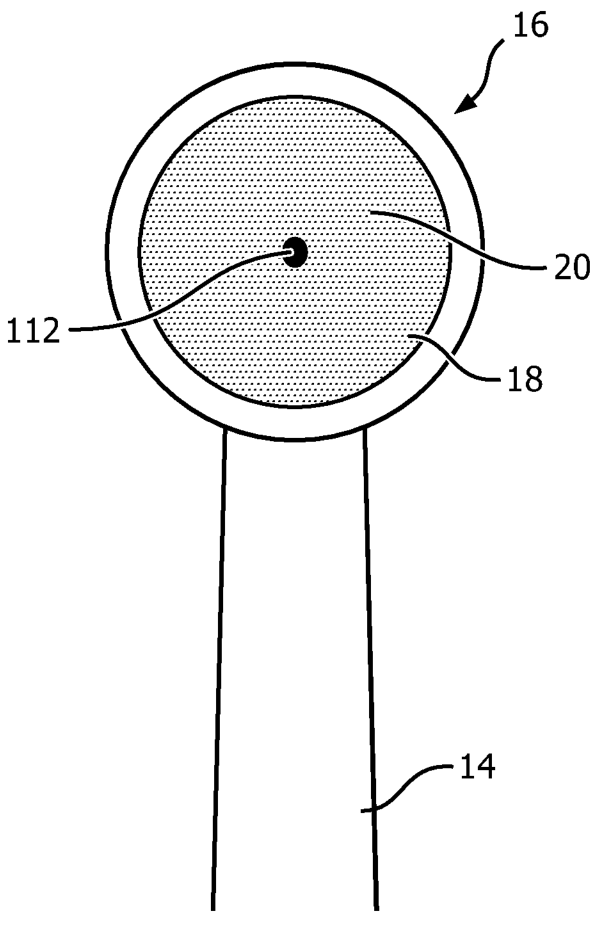

FIG. 2B

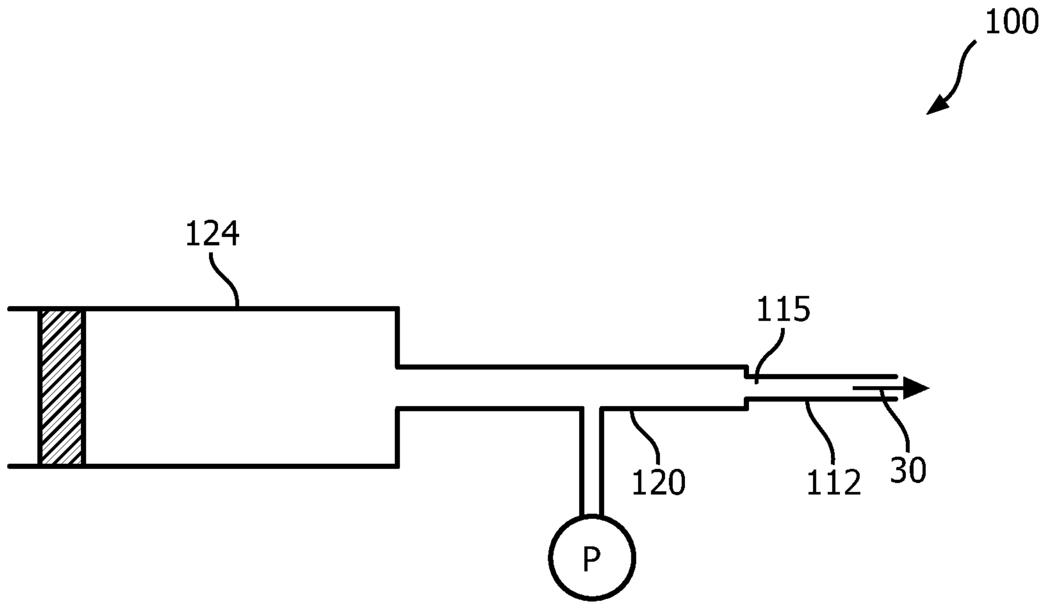

FIG. 3

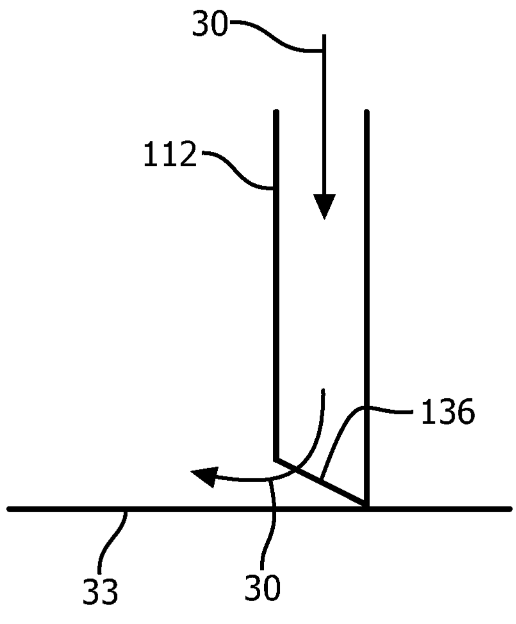

FIG. 4

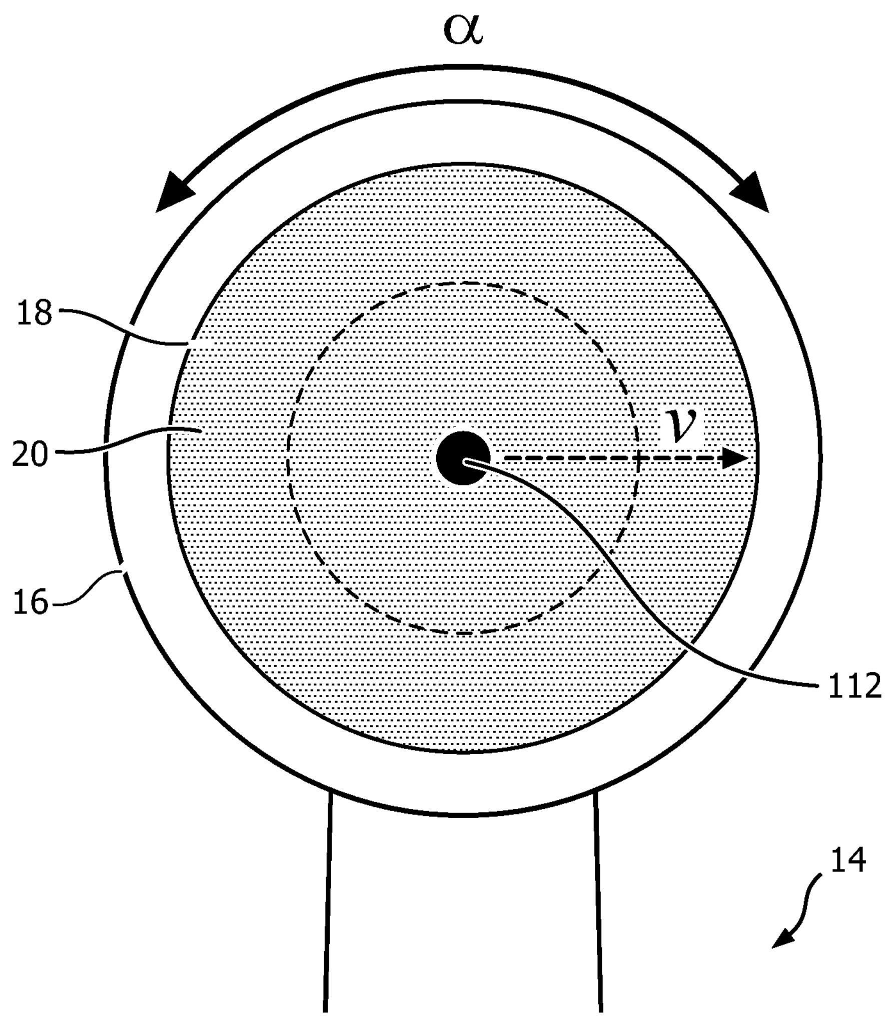

FIG. 5

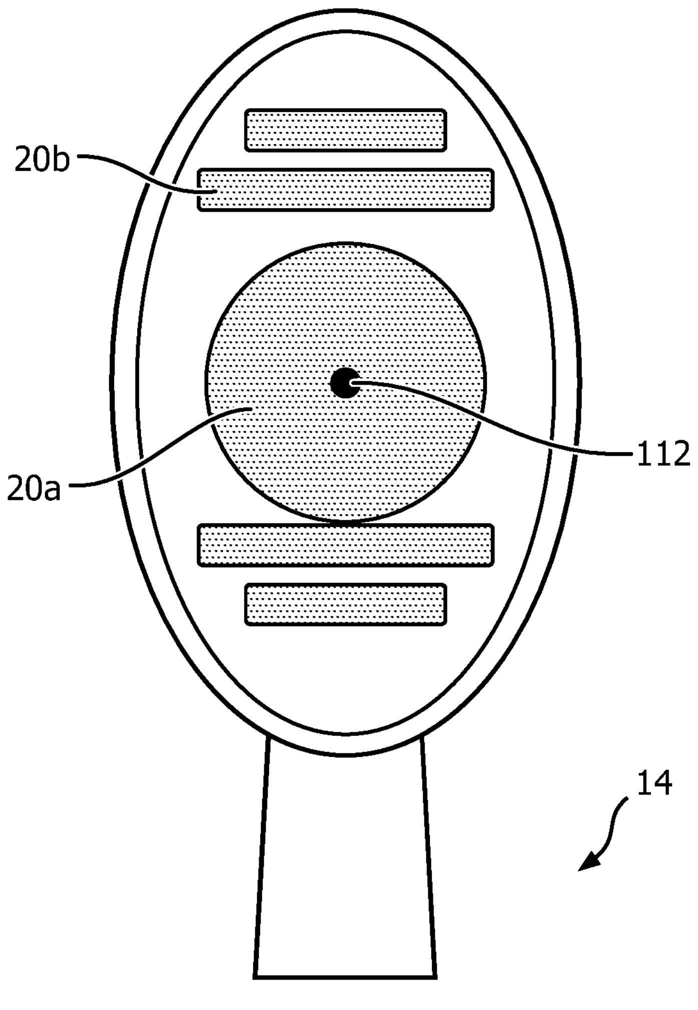

FIG. 6

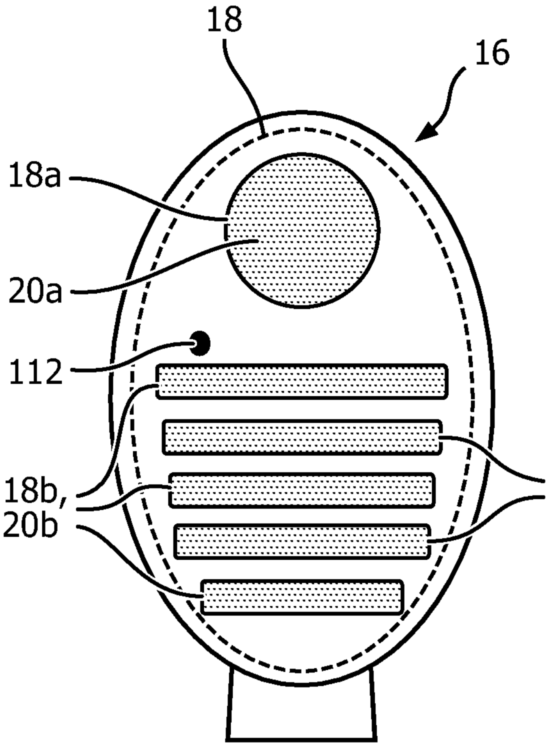

FIG. 7A

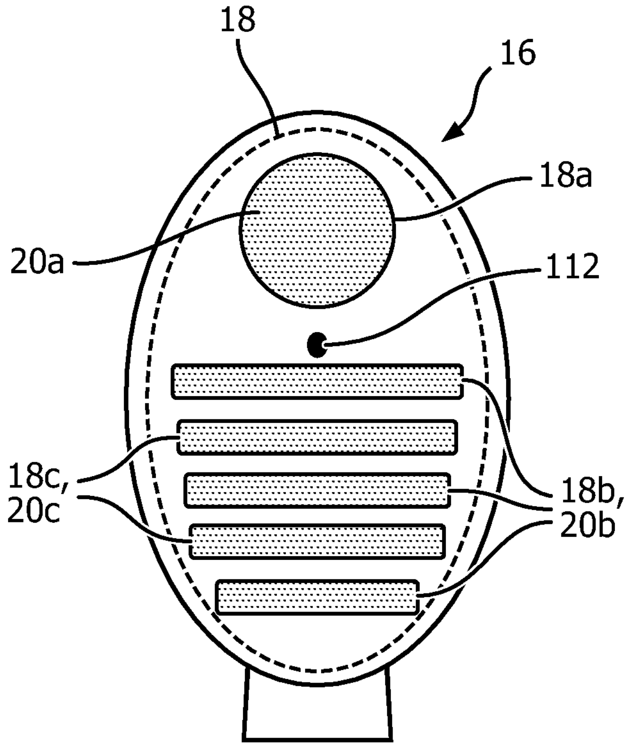

FIG. 7B

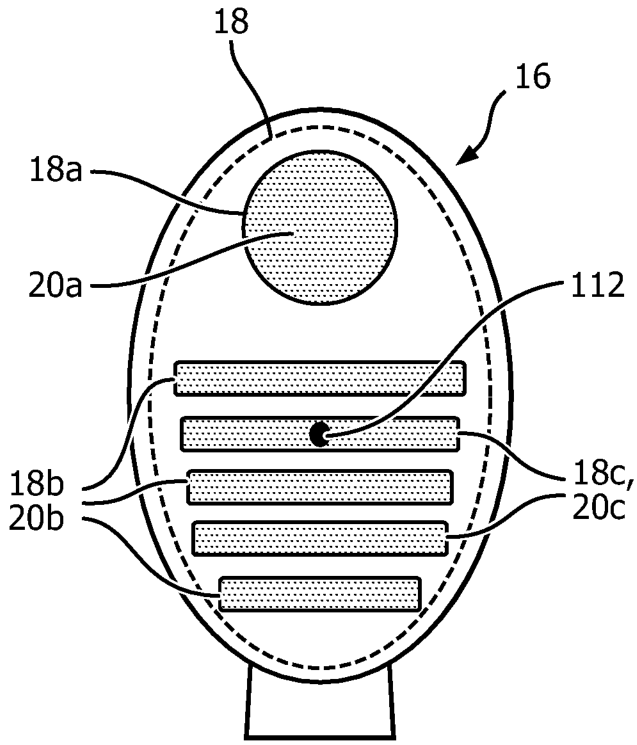

FIG. 7C

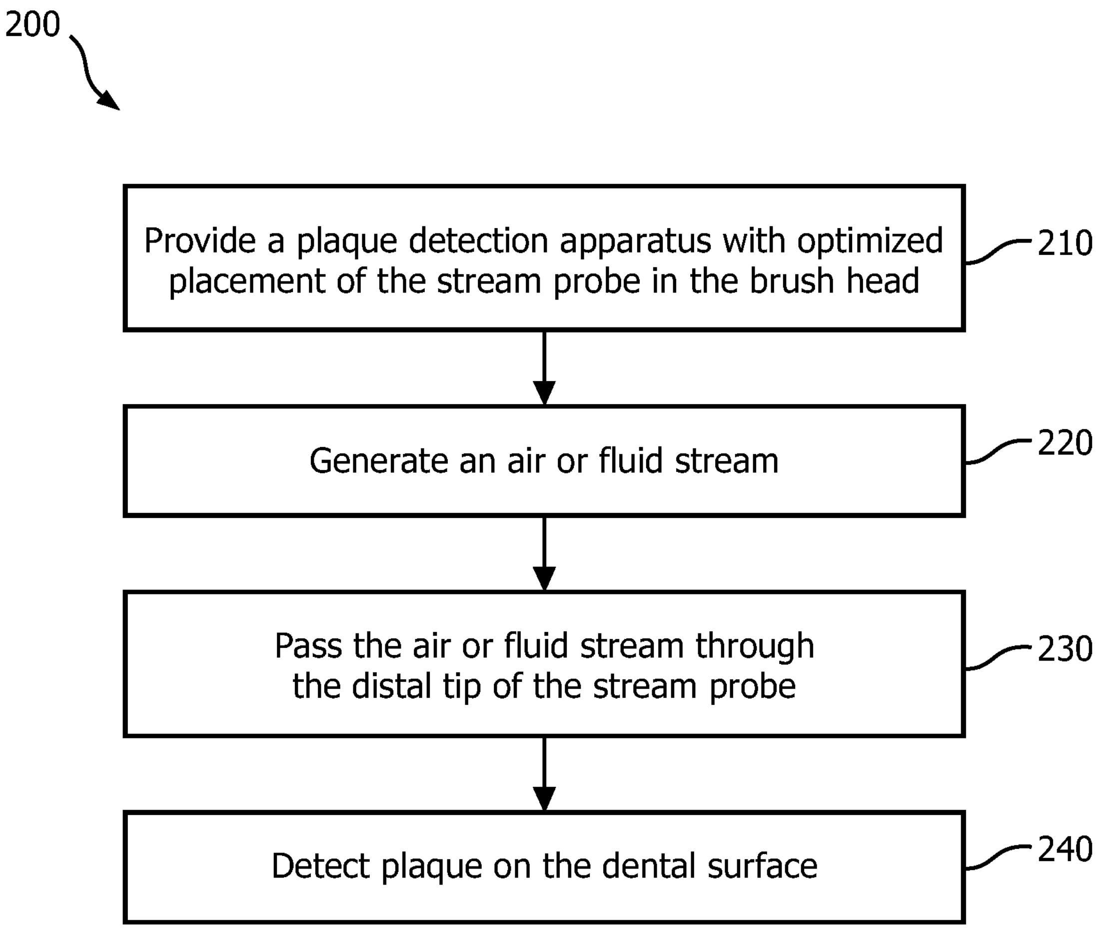
200
Provide a plaque detection apparatus with optimized placement of the stream probe in the brush head
210
Generate an air or fluid stream
220
Pass the air or fluid stream through the distal tip of the stream probe
230
Detect plaque on the dental surface
240

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/059110

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61C17/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B A61C A46B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2014/097238 A1 (KONINK PHILIPS ELECTRONICS NV) 26 June 2014 (2014-06-26) abstract paragraphs [0027], [0079] - paragraph [0082] paragraphs [0140], [0142], [0153], [0155] paragraphs [0156], [0159], [0161], [0162] figures 10-12 -----	1-12

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 February 2016	26/02/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Doyle, Aidan

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2006/098719 A1 (PROCTER & GAMBLE [US]; PINYAYEV ALEKSEY MIKHAILOVICH [US]; GOULBOURNE) 21 September 2006 (2006-09-21) page 3, line 27 - line 31 page 6, line 33 - line 34 page 8, line 17 - line 26 page 8, line 30 - page 9, line 2 page 11, line 18 - line 31 page 12, line 8 - line 16 page 13, line 15 - page 14, line 35 page 15, line 11 - line 34 page 30, line 31 - line 33 page 82, line 33 - page 83, line 15 figures 2,5-11 -----	1-12
Y	US 2004/177458 A1 (CHAN JOHN GEOFFREY [US] ET AL) 16 September 2004 (2004-09-16) paragraph [0034] - paragraph [0069] figures 1-12B -----	1-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2015/059110

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014097238 A1	26-06-2014	CN 104869891 A	26-08-2015
		CN 104869893 A	26-08-2015
		CN 104869894 A	26-08-2015
		CN 104869895 A	26-08-2015
		CN 104902807 A	09-09-2015
		EP 2934294 A1	28-10-2015
		EP 2934295 A2	28-10-2015
		EP 2934296 A1	28-10-2015
		EP 2934297 A1	28-10-2015
		EP 2934298 A1	28-10-2015
		EP 2934299 A1	28-10-2015
		JP 2016501610 A	21-01-2016
		US 2015305670 A1	29-10-2015
		US 2015320353 A1	12-11-2015
		US 2015320531 A1	12-11-2015
		US 2015327966 A1	19-11-2015
		US 2015366645 A1	24-12-2015
		WO 2014097238 A1	26-06-2014
		WO 2014097240 A2	26-06-2014
		WO 2014097241 A1	26-06-2014
		WO 2014097242 A1	26-06-2014
		WO 2014097243 A1	26-06-2014
		WO 2014097244 A1	26-06-2014
W0 2006098719 A1	21-09-2006	AU 2005329104 A1	21-09-2006
		CA 2600855 A1	21-09-2006
		CN 101193605 A	04-06-2008
		EP 1855612 A1	21-11-2007
		JP 2008532619 A	21-08-2008
		US 2008060148 A1	13-03-2008
		W0 2006098719 A1	21-09-2006
US 2004177458 A1	16-09-2004	CA 2518405 A1	23-09-2004
		CN 1758886 A	12-04-2006
		EP 1601308 A1	07-12-2005
		JP 4391994 B2	24-12-2009
		JP 2006513827 A	27-04-2006
		MX PA05009658 A	20-10-2005
		RU 2318471 C2	10-03-2008
		US 2004177458 A1	16-09-2004
		US 2006185105 A1	24-08-2006
		WO 2004080330 A1	23-09-2004