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(54) **Title**: INTEGRATED DUAL FUNCTION NOZZLE FOR A BIOFILM REMOVAL DEVICE

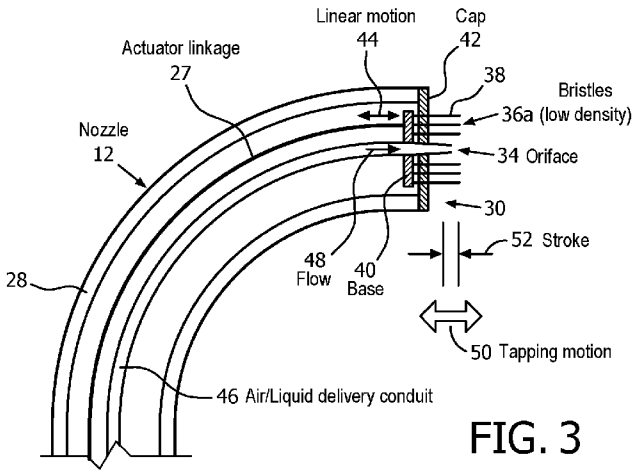

FIG. 3

(57) **Abstract**: An integrated dual function physical assistance and fluid exhaust nozzle (12) for a biofilm removal device (10) comprises an elongated body (28) having a proximal end (30) that includes an orifice (34) and a biofilm removal physical assistance member (36, 36a, 36b, 36c).The orifice is configured to exhaust a fluid as a jet, a spray, a burst jet, a burst spray, or combination thereof. The biofilm removal physical assistance member comprises one of a tuft, tufts, bristles or combination thereof. Responsive to (a)(i) coupling of a distal end of the elongated body to a proximal end of a handle of the biofilm removal device and (a)(ii) activation of an activation button to at least one activation ON state, (b)(i) the biofilm removal physical assistance member is actuated with a desired motion, via an actuator (26, 26a) coupled to the biofilm removal physical assistance member, and (b)(ii) the orifice exhausts the fluid.

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INTEGRATED DUAL FUNCTION NOZZLE FOR A BIOFILM REMOVAL DEVICE

[0001] The present embodiments relate generally to flossing devices in the field of oral healthcare and more particularly, to an integrated dual function nozzle for a biofilm removal device and method.

[0002] In order to maintain one's oral health, it is critical to manage the oral biofilm on a person's teeth. In particular, it is important to manage the oral biofilm in areas where the bristles of a toothbrush cannot reach, such as along a person's gumline and between the teeth (i.e., interproximal spaces). Since toothbrush bristles cannot easily reach along the gumline or between the teeth, some other means of cleaning, besides mechanical removal by bristles, needs to be employed. One option for cleaning is to use high speed hydrodynamic/spraying droplets. High speed spraying droplets impact and break oral biofilm and hence improve plaque removal efficacy.

[0003] For example, to help clean between teeth, a flossing device has been developed, e.g., Sonicare AirFloss by Philips Sonicare. The flossing device is based upon a microburst technology that delivers a quick burst of air and water to effectively yet gently clean between teeth.

[0004] The flossing device includes a power ON/OFF button, an activation button, a slim, angled nozzle with a guidance tip, an ergonomic handle, a water reservoir, and a microburst pump. With water (or mouthwash) in the reservoir and the flossing device power switched ON, a user holds the handle and points the nozzle in a desired direction and presses the activation button. In response to pressing the activation button, water (or mouthwash) in the reservoir is dispensed, via the microburst pump, in a quick burst of air and water out of an orifice of the guidance tip of the nozzle. In addition, the guidance tip glides along the user's gum line until the tip settles in between teeth. Furthermore, the slim, angled nozzle provides the user with access to all areas of the mouth.

[0005] The above-mentioned flossing device has been determined to remove up to 99% more plaque between teeth than brushing with a manual toothbrush alone. While the flossing device has been found to be tough on plaque, it is also safe and gentle on gum tissue, teeth and enamel. However, users of a microburst technology flossing device may not be confident with this spray technology when utilized to remove the plaque. This is particularly true for those having tight teeth and/or those wearing dental braces.

[0006] Accordingly, an improved method and apparatus for plaque removal applications for overcoming the problems in the art is desired.

[0007] In accordance with one aspect, an integrated dual function physical assistance and fluid exhaust nozzle for a biofilm removal device comprises an elongated body and a biofilm removal physical assistance member. The elongated body has a proximal end and a distal end, the proximal end including an orifice, wherein the orifice is configured to exhaust a fluid as one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof. The biofilm removal physical assistance member is disposed at the proximal end of the elongated body, wherein the biofilm removal physical assistance member comprises one selected from the group consisting of a tuft, tufts, bristles and any combination thereof. Responsive to (a)(i) coupling of the distal end of the elongated body to a proximal end of a handle of the biofilm removal device and (a)(ii) activation of an activation button of the biofilm removal device, operable between an OFF state and at least one activation ON state, to the at least one activation ON state, (b)(i) the biofilm removal physical assistance member is actuated with a desired motion, via an actuator that is disposed within one of the handle or the elongated body of the nozzle and coupled to the biofilm removal physical assistance member, and (b)(ii) the orifice exhausts the fluid. According to another aspect, the at least one activation ON state controls both an actuating of the biofilm removal physical assistance member and an exhausting by the orifice according to one selected from the group consisting of (c)(i) a concurrent control, (c)(ii) an intermittent control, (c)(iii) a simultaneous control, and (c)(iv) any combination thereof.

[0008] In another embodiment, the biofilm removal physical assistance member comprises elongated flexible bristles (i) having first ends coupled to a base member and (ii) opposite ends free, wherein the opposite free ends of the bristles are disposed about the orifice, and wherein the orifice is located centrally with respect to the bristles. The opposite free ends of the bristles extend through openings in a cap, wherein the cap is disposed at a proximal end of the nozzle. In addition, the actuator couples to the base member of the biofilm removal physical assistance member. In one embodiment, the opposite free ends of the bristles form at least one selected from the group consisting of (i) a flat formation, (ii) an angled formation, (iii) a rippled formation, and (iv) any combination thereof. For

example, the opposite free ends of the bristles can form an angled formation, wherein bristles closest to the orifice are longest and bristles farthest from the orifice are shortest.

[0009] According to further embodiments, the tuft comprises a cluster of elongated flexible bristles (i) having first ends attached in close proximity at a base of the tuft and (ii) opposite ends free. In addition, each of the bristles have a bristle diameter in a range of 3 to 6 mils and a bristle length in a range of 5 to 15 mm. The tuft or tufts comprise a tuft diameter in a range of 2 to 10 mm, and wherein the tuft or tufts further comprise a number of bristles in a range of 10 to 130 bristles. The actuator comprises one selected from the group consisting of (i) a linear actuator, (ii) a rotational actuator, (iii) a reciprocating spring actuator and (iv) any combination thereof. The desired motion comprises one selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof.

[0010] In one embodiment, the desired motion comprises a tapping motion. For example, the tapping motion can include a tapping stroke in a range of 0.1 to 5 mm, a tapping frequency in a range of 1 to 100 Hz, and a tapping force in a range of 0.1 to 1 N. In another embodiment, the desired motion comprises a reciprocating rotational motion, and wherein the reciprocating rotational motion includes an oscillation back and forth at a rate of 1,000 to 10,000 strokes per minute, and a rotational force in a range of 0.1 to 4 N.

[0011] In yet another embodiment, the actuator comprises a reciprocating spring actuator, further wherein the orifice comprises a manifold of orifices within the nozzle. The manifold of orifices is configured to exhaust at least a portion of the fluid intermittently against a base of the biofilm removal physical assistance member. Responsive to the fluid being exhausted intermittently against the base, the reciprocating spring actuator imparts the desired motion to the biofilm removal physical assistance member.

[0012] According to another embodiment, a biofilm removal device includes the dual function physical assistance and fluid exhaust nozzle as discussed above. The biofilm removal device further comprises: a handle; an activation button disposed on the handle operable between an OFF state and at least one activation ON state; a fluid reservoir for holding a fluid; and a pump coupled to the fluid reservoir, wherein the distal end of the dual function physical assistance and fluid exhaust nozzle couples to a proximal end of the handle. Response to disposing the activation button to the at least one activation ON state, (i) the pump is operable to pump the fluid to the orifice and the orifice exhausts the fluid as

one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof, and (ii) the actuator is operable to impart the biofilm removal physical assistance member with the desired motion selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof.

[0013] In a further aspect, a method of integrating dual function physical assistance and fluid exhaust in a nozzle for biofilm removal comprises providing an elongated body having a proximal end and a distal end, and providing a biofilm removal physical assistance member disposed at the proximal end of the elongated body. The proximal end of the elongated body includes an orifice, wherein the orifice is configured to exhaust a fluid as one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof. The biofilm removal physical assistance member comprises one selected from the group consisting of a tuft, tufts, bristles and any combination thereof. Responsive to (a)(i) coupling of the distal end of the elongated body to a proximal end of a handle of a biofilm removal device and (a)(ii) activation of an activation button of the biofilm removal device, operable between an OFF state and at least one activation ON state, to the at least one activation ON state, (b)(i) the biofilm removal physical assistance member is actuated with a desired motion, via an actuator that is disposed within one of the handle or the elongated body of the nozzle and coupled to the biofilm removal physical assistance member, and (b)(ii) the orifice exhausts the fluid. In addition, the method further includes controlling, via the at least one activation ON state, both an actuating of the biofilm removal physical assistance member and an exhausting by the orifice according to one selected from the group consisting of (c)(i) a concurrent control, (c)(ii) an intermittent control, (c)(iii) a simultaneous control, and (c)(iv) any combination thereof. Furthermore, the desired motion of the method comprises one selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof.

[0014] The embodiments of the present disclosure advantageously provide an enhanced feature biofilm removal nozzle that can effectively manage oral biofilm, especially for tight teeth or hard-to-reach area. Additionally, the embodiments enable a user experience to be greatly enhanced, including proper alignment of the nozzle tip when in use. The embodiments include an integration of tufts and/or bristles to a biofilm removal

nozzle. Tufts and/or bristles can be arranged through different mechanisms to provide various motions according to various embodiments. In one embodiment, a combined effectiveness of high speed hydrodynamic droplets and tapping bristles on plaque removal efficacy is improved over prior methods.

[0015] Still further advantages and benefits will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description.

[0016] The embodiments of the present disclosure may take form in various components and arrangements of components, and in various steps and arrangements of steps. Accordingly, the drawings are for purposes of illustrating the various embodiments and are not to be construed as limiting the embodiments. In the drawing figures, like reference numerals refer to like elements. In addition, it is to be noted that the figures may not be drawn to scale.

[0017] Figure 1 is a perspective view of a biofilm removal device including the dual function physical assistance and fluid exhaust nozzle according to an embodiment of the present disclosure;

[0018] Figure 2 is a schematic view of components of one function of the dual function physical assistance and fluid exhaust nozzle according to an embodiment of the present disclosure;

[0019] Figure 3 is a sectional view of a proximal end of the dual function physical assistance and fluid exhaust nozzle that includes use of linear motion and wherein free ends of bristles form a flat formation according to one embodiment of the present disclosure;

[0020] Figure 4 is a sectional view of a proximal end of the dual function physical assistance and fluid exhaust nozzle that includes use of linear motion and wherein free ends of bristles form an angled formation according to another embodiment of the present disclosure;

[0021] Figure 5 is a sectional view of a proximal end of the dual function physical assistance and fluid exhaust nozzle that includes use of linear motion and wherein free ends of bristles form a rippled formation according to an embodiment of the present disclosure;

[0022] Figure 6 is a sectional view of a proximal end of the dual function physical assistance and fluid exhaust nozzle that includes use of linear motion via a reciprocating

spring actuator and wherein free ends of bristles form a rippled formation according to another embodiment of the present disclosure; and

[0023] Figure 7 is a sectional view of a proximal end of the dual function physical assistance and fluid exhaust nozzle that includes use of a combination of linear and/or rotational motion and wherein free ends of bristles form a rippled formation according to yet another embodiment of the present disclosure.

[0024] The embodiments of the present disclosure and the various features and advantageous details thereof are explained more fully with reference to the non-limiting examples that are described and/or illustrated in the drawings and detailed in the following description. It should be noted that the features illustrated in the drawings are not necessarily drawn to scale, and features of one embodiment may be employed with other embodiments as the skilled artisan would recognize, even if not explicitly stated herein. Descriptions of well-known components and processing techniques may be omitted so as to not unnecessarily obscure the embodiments of the present disclosure. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments of the present may be practiced and to further enable those of skill in the art to practice the same. Accordingly, the examples herein should not be construed as limiting the scope of the embodiments of the present disclosure, which is defined solely by the appended claims and applicable law.

[0025] It is understood that the embodiments of the present disclosure are not limited to the particular methodology, protocols, devices, apparatus, materials, applications, etc., described herein, as these may vary. It is also to be understood that the terminology used herein is used for the purpose of describing particular embodiments only, and is not intended to be limiting in scope of the embodiments as claimed. It must be noted that as used herein and in the appended claims, the singular forms “a,” “an,” and “the” include plural reference unless the context clearly dictates otherwise.

[0026] Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which the embodiments of the present disclosure belong. Preferred methods, devices, and materials are described, although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the embodiments.

[0027] According to the embodiments of the present disclosure, the inventor has recognized that persons having tight teeth and/or those wearing dental braces might prefer some "physical contacts" for those hard-to-reach areas of the teeth. The embodiments of the present disclosure advantageously achieve "physical contacts" via integrating a tuft and/or bristles into a nozzle of a flossing device, wherein the nozzle exhausts bursts of high speed spraying droplets delivered via a microburst pump. The integration of a tuft and/or bristles with the nozzle is advantageously implemented in various embodiments. Accordingly, the embodiments of the present disclosure are beneficial to an improved flossing device function (i.e. both bristles and spraying droplets provide for improved plaque removal efficacy) and provide for an enhanced user experience.

[0028] According to another embodiment of the present disclosure, a tuft and/or bristles integrated nozzle transports fluid through an orifice and provides a desired spray that is generated sufficient to effectively manage a biofilm through induced force removal and an inactivation of microorganisms. In addition, the tuft and/or bristles integrated nozzle provides benefits beyond that which can be provided by spray alone. Various additional benefits are also provided by the embodiments of the present disclosure, as will be discussed and understood from the disclosure herein.

[0029] In one embodiment, the enhanced tuft and/or bristles integrated flossing device nozzle provides for high speed spraying droplets and a desired physical tapping motion. Different embodiments offer different advantages in terms of spray patterns and characteristics (e.g., droplet size, distribution, droplet velocity, spraying angle, coverage area, flow rate, force generated and turbulence, etc.) and tapping force and stroke. The enhanced tuft and/or bristles integrated flossing device nozzle thus effectively addresses the concern to users, for example, tight teeth, dental braces or hard-to-reach areas, while concurrently providing a high speed spraying fluid from the tuft and/or bristles integrated nozzle. Both mechanisms together effectively manage biofilm and improve plaque removal efficacy.

[0030] Figure 1 is a perspective view of a biofilm removal device 10 including the dual function physical assistance and fluid exhaust nozzle 12 according to an embodiment of the present disclosure. The biofilm removal device 10 includes a power ON/OFF button 14, a charge indicator 16, an activation button 18, an ergonomic handle 20, a water reservoir 22, a microburst pump 24, and an actuator 26. The dual function physical assistance and fluid

exhaust nozzle 12 includes an elongated body 28 having a proximal end, generally indicated by reference numeral 30, and a distal end, generally indicated by reference numeral 32. The proximal end 30 includes an orifice 34, wherein the orifice 34 is configured to exhaust a fluid as one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof, to be discussed further herein below. In one embodiment, the orifice 34 includes a guidance tip with the orifice. In addition, the proximal end 30 comprises a generally circular cross-section or shape. Furthermore, the distal end 32 of the elongated body 28 is configured for being coupled to a proximal end of the handle 20 of the biofilm removal device 10. Responsive to coupling of the distal end 32 of the elongated body 28 of the dual function physical assistance and fluid exhaust nozzle 12 to the proximal end of the handle 20, an appropriate connection between the actuator 26 and the biofilm removal physical assistance member 36 (FIG. 2), via the actuator coupling or linkage 27 (FIG. 2 and 3), and an appropriate connection between the reservoir 22 and the orifice 34, via the air/liquid delivery conduit 46 (FIG. 3), are made for a given implementation. In the embodiments of the present disclosure, the actuator 26 comprises one selected from the group consisting of (i) a linear actuator, (ii) a rotational actuator, (iii) a reciprocating spring actuator and (iv) any combination thereof, as discussed further herein.

[0031] In one embodiment, the activation button 18 of the biofilm removal device 10 is operable between (a)(i) an OFF state and (a)(ii) at least one activation ON state. The at least one activation ON state can comprise one or more states for causing (b)(i) the pump 24 to be operable to pump the fluid from the reservoir 22 to the orifice 34 and the orifice 34 exhausts the fluid as one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof, and (b)(ii) the actuator 26 to be operable to impart the biofilm removal physical assistance member 36 with the desired motion selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof, as discussed further herein. In addition, the at least one activation ON state controls both an actuating of the biofilm removal physical assistance member 36 and an exhausting by the orifice 34 according to one selected from the group consisting of (c)(i) a concurrent control, (c)(ii) an intermittent control, (c)(iii) a simultaneous control, and (c)(iv) any combination thereof, as discussed further herein. For example, concurrent control can be understood to mean a control operating or occurring at

the same time, i.e., running in parallel. Intermittent control can be understood to mean a control that is in intervals, i.e., not continuous. Lastly, simultaneous control can be understood to mean control existing or occurring at the same time, i.e., exactly coincident. Furthermore, the desired motion comprises one selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof, as discussed further herein.

[0032] Turning now to Figure 2, there is shown a schematic view of components of one function of the dual function physical assistance and fluid exhaust nozzle 12 according to an embodiment of the present disclosure. The dual function physical assistance and fluid exhaust nozzle 12 includes the elongated body 28 having a biofilm removal physical assistance member of tufts and/or bristles, generally indicated by reference numeral 36. The biofilm removal physical assistance member 36 is disposed at the proximal end 30 of nozzle 12, the proximal end 30 further including a guidance tip with orifice 34 (FIG. 1). In one embodiment, the actuator 26 comprises a linear actuator that is integrated with or coupled to the nozzle tip via a suitable actuator coupling or linkage 27. In addition, actuator 26 can be housed within handle 20 (FIG. 1) or within the elongated body 28 of nozzle 12, for example, as discussed herein with respect to the embodiments of Figures 6 and 7.

[0033] In one embodiment, the biofilm removal physical assistance member of tufts and/or bristles 36 comprises bristles, wherein each of the bristles have a bristle diameter in a range of 3 to 6 mils and a bristle length in a range of 5 to 15 mm. In another embodiment, the biofilm removal physical assistance member of tufts and/or bristles 36 comprises a tuft, wherein the tuft includes a cluster of elongated flexible bristles (i) having first ends attached in close proximity at a base of the tuft and (ii) opposite ends free of attachment. In yet another embodiment, the biofilm removal physical assistance member of tufts and/or bristles 36 comprises a tuft or tufts, wherein the tuft or tufts comprise a tuft diameter in a range of 2 to 10 mm, and wherein the tuft or tufts further comprise a number of bristles in a range of 10 to 130 bristles. In addition, free ends of the biofilm removal physical assistance member of tufts and/or bristles 36 form at least one selected from the group consisting of (i) a flat formation, (ii) an angled formation, (iii) a rippled formation, and (iv) any combination thereof, as discussed further herein.

[0034] With reference now to Figure 3, there is shown a sectional view of a proximal end 30 of the dual function physical assistance and fluid exhaust nozzle 12 that includes use of linear motion and wherein free ends of bristles form a flat formation according to one embodiment of the present disclosure. In particular, the biofilm removal physical assistance member of tufts and/or bristles, generally indicated by reference numeral 36a, comprise elongated flexible bristles 38 (i) having first ends coupled to a base member 40 and (ii) opposite ends free (i.e., not attached). The opposite free ends of the bristles 38 are disposed about the orifice 34, wherein the orifice 34 is located centrally with respect to the bristles 38. In addition, the opposite free ends of the bristles 38 extend through a suitable opening and/or openings in cap 42 disposed at the proximal end 30 of the nozzle 12. Furthermore, in this embodiment, the opposite free ends of the bristles 38 form a flat formation as shown in Figure 3.

[0035] With reference still to Figure 3, the actuator 26 (FIGs. 1 and 2) couples to the base member 40 of the biofilm removal physical assistance member of tufts and/or bristles 36a via the actuator coupling or linkage 27. In addition, the base member 40 includes a suitable aperture, the aperture being larger than a cross-sectional dimension of an air/liquid delivery conduit 46 that supplies a flow 48 to orifice 34. The aperture in base member 40 enables linear motion 44 of the biofilm removal physical assistance member of tufts and/or bristles 36a with respect to the orifice 34 at the proximal end 30 of the elongated body 28 of nozzle 12, which are stationary. In this embodiment, the desired motion comprises a linear motion that is supplied to the biofilm removal physical assistance member of tufts and/or bristles 36a via actuator 26 and actuator coupling or linkage 27.

[0036] In one embodiment, the desired motion comprises a tapping motion, for example, as indicated by the double-headed arrow 50 in Figure 3. The tapping motion 50 includes a tapping stroke 52, for example, in a range of 0.1 to 5 mm. In addition, the tapping motion 50 includes a tapping frequency in a range of 1 to 100 Hz and a tapping force in a range of 0.1 to 1 N.

[0037] In operation, with reference to the embodiment of Figures 1 and 3, water (or mouthwash) is inserted into the reservoir 22 and the biofilm removal device 10 power is switched ON via the power ON/OFF button 14. A user holds the handle 20 and points the orifice 34 and the biofilm removal physical assistance member of tufts and/or bristles 36a of the dual function physical assistance and fluid exhaust nozzle 12 in a desired direction

and proximity to the teeth and presses the activation button 18. As indicated herein above, the activation button 18 is operable between an OFF state and at least one activation ON state. In response to pressing the activation button 18 to the at least one activation ON state, (i) the biofilm removal physical assistance member 36 is actuated with a desired motion, via an actuator 26 that is disposed within the handle 20 (or in another embodiment, disposed within the elongated body 28 of the nozzle 12) and coupled to the biofilm removal physical assistance member 36, and (b)(ii) the orifice 34 exhausts the fluid, i.e., the water (or mouthwash) in the reservoir 22 is dispensed, via the microburst pump 24, in a quick burst of air and water out of the orifice 34 of the guidance tip of the nozzle 12. Accordingly, the measures/device features of nozzle 12 provide for both high speed hydrodynamic droplets near the nozzle orifice as well as movement of a tuft and/or bristles. The embodiment advantageously provides desired spray characteristics of the orifice 34 and motion characteristics of the biofilm removal physical assistance member 36 for a given biofilm removal application, which characteristics include various spraying droplets and tuft and/or bristle motions.

[0038] With reference now to Figure 4, there is shown a sectional view of a proximal end of the dual function physical assistance and fluid exhaust nozzle that includes use of linear motion and wherein free ends of bristles form an angled formation according to another embodiment of the present disclosure. The embodiment of Figure 4 is similar to that of Figure 3 and thus only differences will be discussed herein below. In particular, the biofilm removal physical assistance member of tufts and/or bristles, generally indicated by reference numeral 36b, comprise elongated flexible bristles 38 (i) having first ends coupled to a base member 40 and (ii) opposite ends free (i.e., not attached). The opposite free ends of the bristles 38 are disposed about the orifice 34, wherein the orifice 34 is located centrally with respect to the bristles 38. In addition, the opposite free ends of the bristles 38 extend through a suitable opening and/or openings in cap 42 disposed at the proximal end 30 of the nozzle 12. Furthermore, in this embodiment, the opposite free ends of the bristles 38 form an angled formation. In particular, the opposite free ends of the bristles 38 form an angled formation in which bristles closest to the orifice 34 are longest and bristles farthest from the orifice are shortest, as is shown in Figure 4.

[0039] With reference now to Figure 5, there is shown a sectional view of a proximal end of the dual function physical assistance and fluid exhaust nozzle that includes use of

linear motion and wherein free ends of bristles form a rippled formation according to an embodiment of the present disclosure. The embodiment of Figure 5 is similar to that of Figure 3 and thus only differences will be discussed herein below. In particular, the biofilm removal physical assistance member of tufts and/or bristles, generally indicated by reference numeral 36c, comprise elongated flexible bristles 38 (i) having first ends coupled to a base member 40 and (ii) opposite ends free (i.e., not attached). The opposite free ends of the bristles 38 are disposed about the orifice 34, wherein the orifice 34 is located centrally with respect to the bristles 38. In addition, the opposite free ends of the bristles 38 extend through a suitable opening and/or openings in cap 42 disposed at the proximal end 30 of the nozzle 12. Furthermore, in this embodiment, the opposite free ends of the bristles 38 form a rippled formation. In particular, the opposite free ends of the bristles 38 form a rippled formation in which alternating (i) bristles, (ii) pairs of bristles, (iii) groups of bristles, or (iv) any combination thereof in the rippled formation have different bristle lengths. It is the different bristle lengths that collectively form ripples along an end portion of the biofilm removal physical assistance member 36c, i.e., along the free ends of the bristles 38, as is shown in Figure 5.

[0040] With reference now to Figure 6, there is shown a sectional view of a proximal end of the dual function physical assistance and fluid exhaust nozzle 12 that includes use of linear motion via a reciprocating spring actuator and wherein free ends of bristles form a rippled formation according to another embodiment of the present disclosure. The embodiment of Figure 6 is similar to that of Figure 5 and thus only differences will be discussed herein below. In particular, the actuator comprises a reciprocating spring actuator 26a. The reciprocating spring actuator 26a is coupled between a manifold plate 54 and the base member 40 of the biofilm removal physical assistance member 36c. The manifold plate 54 is disposed and/or located within the elongated body 28 near the proximal end 30 of the nozzle 12. In addition, the orifice comprises a manifold of orifices 34a coupled to the manifold plate 54 within the elongated body 28 of the nozzle 12. The manifold of orifices 34a is configured to exhaust at least a portion of the fluid (e.g., air/liquid) intermittently against the base member 40 of the biofilm removal physical assistance member 36c. The at least a portion of the fluid exhausted intermittently against the base member 40 is sufficient to cause the reciprocating spring actuator 26a to oscillate and thus impart the desired motion to the biofilm removal physical assistance member 36c. In other words, responsive

to the fluid being exhausted intermittently against the base member 40, the reciprocating spring actuator 26a imparts the desired motion to the biofilm removal physical assistance member 36c. In one embodiment, the desired motion comprises a linear motion.

[0041] In another embodiment, the desired motion could comprise a combination of linear motion and rotational motion, wherein a mounting of the biofilm removal physical assistance member 36c with respect to the reciprocating spring actuator 26a or to the manifold plate 54 allows for the member 36c to rotate about an axis that is generally perpendicular to proximal end 30 of the nozzle 12. In addition, the manifold of orifices can include at least a number of orifices positioned and oriented to also impart a rotation to the base member 40 and thus to the biofilm removal physical assistance member of tufts and/or bristles 36c.

[0042] Turning our attention now to Figure 7, there is shown a sectional view of a proximal end of the dual function physical assistance and fluid exhaust nozzle 12 that includes use of a combination of linear and/or rotational motion and wherein free ends of bristles form a rippled formation according to yet another embodiment of the present disclosure. The embodiment of Figure 7 is similar to that of Figure 5 and thus only differences will be discussed herein below. In particular, the actuator can comprise a combination linear and rotational actuator, or two actuators, i.e., a linear actuator and a rotational actuator operating in combination. For example, the actuator coupling 27 couples the actuator 26 (FIG. 2) to a translation/rotation gear box 56, wherein the actuator coupling 27 imparts both translation (linear motion 44) and rotation (rotational motion 58) to the translation/rotation gear box 56, which is coupled to the base member 40. A plate 60 can be disposed and/or located within the elongated body 28 near the proximal end 30 of the nozzle 12 for providing appropriate support and for physically locating the air/liquid delivery conduit 46 and the actuator coupling 27 within the elongated body 28 of nozzle 12. The combination linear and rotational actuator 26 and thus imparts the desired motion to the biofilm removal physical assistance member 36c. For example, in this embodiment, the desired motion can include linear motion, rotational motion, and/or a combination of linear and rotational motion, as appropriate for the requirements of a given biofilm removal application. In a further embodiment, the desired motion comprises a reciprocating rotational motion, and wherein the reciprocating rotational motion includes an oscillation

back and forth at a rate of 1,000 to 10,000 strokes per minute, and a rotational force in a range of 0.1 to 4 N.

[0043] According to another embodiment, a biofilm removal device 10 (FIG. 1) includes the dual function physical assistance and fluid exhaust nozzle 12 as disclosed in various embodiments herein. The biofilm removal device 10 further comprises a handle 20, an activation button 18 disposed on the handle operable between an OFF state and at least one activation ON state, a fluid reservoir 22 for holding a fluid, and a pump 24 coupled to the fluid reservoir 22. The distal end 32 of the dual function physical assistance and fluid exhaust nozzle 12 couples to a proximal end of the handle 20. Response to disposing the activation button 18 to the at least one activation ON state, (i) the pump 24 is operable to pump the fluid to the orifice 34 and the orifice exhausts the fluid as one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof, and (ii) the actuator 26 is operable to impart the biofilm removal physical assistance member (36, 36a, 36b and 36c in FIGs. 2-7) with the desired motion selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof.

[0044] In another embodiment, a method of integrating dual function physical assistance and fluid exhaust in a nozzle for biofilm removal comprises: (i) providing an elongated body having a proximal end and a distal end, the proximal end including an orifice, wherein the orifice is configured to exhaust a fluid as one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof; and (ii) providing a biofilm removal physical assistance member disposed at the proximal end of the elongated body, wherein the biofilm removal physical assistance member comprises one selected from the group consisting of a tuft, tufts, bristles and any combination thereof, wherein responsive to (a)(i) coupling of the distal end of the elongated body to a proximal end of a handle of a biofilm removal device and (a)(ii) activation of an activation button of the biofilm removal device, operable between an OFF state and at least one activation ON state, to the at least one activation ON state, (b)(i) the biofilm removal physical assistance member is actuated with a desired motion, via an actuator that is disposed within one of the handle or the elongated body of the nozzle and coupled to the biofilm removal physical assistance member, and (b)(ii) the orifice exhausts the fluid. In another embodiment, the controlling, via the at least one activation ON state, controls both an actuating of the

biofilm removal physical assistance member and an exhausting by the orifice according to one selected from the group consisting of (c)(i) a concurrent control, (c)(ii) an intermittent control, (c)(iii) a simultaneous control, and (c)(iv) any combination thereof. In a still further embodiment, the desired motion comprises one selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof.

[0045] The measures/device features which are disclosed herein to solve the identified problems, and provide resulting advantages, include both high speed hydrodynamic droplets near the nozzle orifice as well as movement of a tuft and/or bristles. The embodiments advantageously provide desired spray characteristics of the orifice and motion characteristics of the biofilm removal physical assistance member for a given user and/or a given biofilm removal application, which characteristics include various spraying droplets and tuft and/or bristle motions. Additional characteristics comprise output performance of the tuft and/or bristles, including stroke (i.e., tapping displacement) and force (i.e., tapping force). The embodiments also advantageously facilitate improved plaque removal efficacy and provide for an improved alignment of the nozzle tip when in use.

[0046] Although only a few exemplary embodiments have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of the embodiments of the present disclosure. Accordingly, all such modifications are intended to be included within the scope of the embodiments of the present disclosure as defined in the following claims. For example, it is to be understood that the present invention contemplates that, to the extent possible, one or more features of any embodiment can be combined with one or more features of any other embodiment. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures.

[0047] In addition, any reference signs placed in parentheses in one or more claims shall not be construed as limiting the claims. The word “comprising” and “comprises,” and the like, does not exclude the presence of elements or steps other than those listed in any claim or the specification as a whole. The singular reference of an element does not

exclude the plural references of such elements and vice-versa. One or more of the embodiments may be implemented by means of hardware comprising several distinct elements, and/or by means of a suitably programmed computer. In a device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to an advantage.

CLAIMS:

1. An integrated dual function physical assistance and fluid exhaust nozzle (12) for a biofilm removal device (10), comprising:

an elongated body (28) having a proximal end (30) and a distal end (32), the proximal end (30) including an orifice (34,34a), wherein the orifice is configured to exhaust a fluid as one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof; and

a biofilm removal physical assistance member (36,36a,36b,36c) disposed at the proximal end (30) of the elongated body (28), wherein the biofilm removal physical assistance member comprises one selected from the group consisting of a tuft, tufts, bristles and any combination thereof, wherein responsive to (a)(i) coupling of the distal end (32) of the elongated body (28) to a proximal end of a handle (20) of the biofilm removal device (10) and (a)(ii) activation of an activation button (18) of the biofilm removal device (10), operable between an OFF state and at least one activation ON state, to the at least one activation ON state, (b)(i) the biofilm removal physical assistance member (36,36a,36b,36c) is actuated with a desired motion, via an actuator (26,26a) that is disposed within one of the handle (20) or the elongated body (28) of the nozzle (12) and coupled to the biofilm removal physical assistance member (36,36a,36b,36c), and (b)(ii) the orifice (34,34a) exhausts the fluid.

2. The nozzle of claim 1, wherein the at least one activation ON state controls both an actuating of the biofilm removal physical assistance member (36,36a,36b,36c) and an exhausting by the orifice (34,34a) according to one selected from the group consisting of (c)(i) a concurrent control, (c)(ii) an intermittent control, (c)(iii) a simultaneous control, and (c)(iv) any combination thereof.

3. The nozzle of claim 1, wherein the biofilm removal physical assistance member (36,36a,36b,36c) comprises elongated flexible bristles (38) (i) having first ends coupled to a base member (40) and (ii) opposite ends free, wherein the opposite free ends of the bristles (38) are disposed about the orifice (34), and wherein the orifice (34) is located centrally with respect to the bristles (38).

4. The nozzle of claim 3, further wherein the opposite free ends of the bristles (38) extend through openings in a cap (42), wherein the cap is disposed at a proximal end (30) of the nozzle (12).

5. The nozzle of claim 3, further wherein the actuator (26) couples to the base member (40) of the biofilm removal physical assistance member (36,36a,36b,36c).

6. The nozzle of claim 3, wherein the opposite free ends of the bristles (38) form at least one selected from the group consisting of (i) a flat formation, (ii) an angled formation, (iii) a rippled formation, and (iv) any combination thereof.

7. The nozzle of claim 3, wherein the opposite free ends of the bristles (38) form an angled formation, further wherein bristles closest to the orifice (34) are longest and bristles farthest from the orifice are shortest.

8. The nozzle of claim 1, wherein the tuft comprises a cluster of elongated flexible bristles (i) having first ends attached in close proximity at a base of the tuft and (ii) opposite ends free.

9. The nozzle of claim 1, wherein each of the bristles have a bristle diameter in a range of 3 to 6 mils and a bristle length in a range of 5 to 15 mm.

10. The nozzle of claim 1, wherein the tuft or tufts comprise a tuft diameter in a range of 2 to 10 mm, and wherein the tuft or tufts further comprise a number of bristles in a range of 10 to 130 bristles.

11. The nozzle of claim 1, wherein the actuator (26,26a) comprises one selected from the group consisting of (i) a linear actuator, (ii) a rotational actuator, (iii) a reciprocating spring actuator and (iv) any combination thereof.

12. The nozzle of claim 1, wherein the desired motion comprises one selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof.

13. The nozzle of claim 1, wherein the desired motion comprises a tapping motion (50).

14. The nozzle of claim 13, wherein the tapping motion (50) includes a tapping stroke (52) in a range of 0.1 to 5 mm, a tapping frequency in a range of 1 to 100 Hz, and a tapping force in a range of 0.1 to 1 N.

15. The nozzle of claim 1, wherein the desired motion comprises a reciprocating rotational motion (58), and wherein the reciprocating rotational motion includes an oscillation back and forth at a rate of 1,000 to 10,000 strokes per minute, and a rotational force in a range of 0.1 to 4 N.

16. The nozzle of claim 1, wherein the actuator (26a) comprises a reciprocating spring actuator, further wherein the orifice (34a) comprises a manifold of orifices within the nozzle (12), wherein the manifold of orifices is configured to exhaust at least a portion of the fluid intermittently against a base (40) of the biofilm removal physical assistance member (36c), wherein responsive to the fluid being exhausted intermittently against the base, the reciprocating spring actuator imparts the desired motion to the biofilm removal physical assistance member (36c).

17. A biofilm removal device (10) including the dual function physical assistance and fluid exhaust nozzle (12) according to claim 1, the biofilm removal device further comprising:

a handle (20);

an activation button (18) disposed on the handle operable between an OFF state and at least one activation ON state;

a fluid reservoir (22) for holding a fluid; and

a pump (24) coupled to the fluid reservoir, wherein the distal end (32) of the dual function physical assistance and fluid exhaust nozzle (12) couples to a proximal end of the

handle (20), and wherein response to disposing the activation button (18) to the at least one activation ON state, (i) the pump (24) is operable to pump the fluid to the orifice (34,34a) and the orifice exhausts the fluid as one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof, and (ii) the actuator is operable to impart the biofilm removal physical assistance member (36,36a,36b,36c) with the desired motion selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof.

18. A method of integrating dual function physical assistance and fluid exhaust in a nozzle (12) for biofilm removal, the method comprising:

providing an elongated body (28) having a proximal end (30) and a distal end (32), the proximal end including an orifice (34,34a), wherein the orifice is configured to exhaust a fluid as one selected from the group consisting of a jet, a spray, a burst jet, a burst spray, and any combination thereof; and

providing a biofilm removal physical assistance member (36,36a,36b,36c) disposed at the proximal end (30) of the elongated body (28), wherein the biofilm removal physical assistance member (36,36a,36b,36c) comprises one selected from the group consisting of a tuft, tufts, bristles and any combination thereof, wherein responsive to (a)(i) coupling of the distal end (32) of the elongated body (28) to a proximal end of a handle (20) of a biofilm removal device (10) and (a)(ii) activation of an activation button (18) of the biofilm removal device, operable between an OFF state and at least one activation ON state, to the at least one activation ON state, (b)(i) the biofilm removal physical assistance member (36,36a,36b,36c) is actuated with a desired motion, via an actuator (26,26a) that is disposed within one of the handle (20) or the elongated body (28) of the nozzle (12) and coupled to the biofilm removal physical assistance member (36,36a,36b,36c), and (b)(ii) the orifice (34,34a) exhausts the fluid.

19. The method of claim 18, wherein controlling, via the at least one activation ON state, controls both an actuating of the biofilm removal physical assistance member (36,36a,36b,36c) and an exhausting by the orifice (34,34a) according to one selected from the group consisting of (c)(i) a concurrent control, (c)(ii) an intermittent control, (c)(iii) a simultaneous control, and (c)(iv) any combination thereof.

20. The method of claim 18, wherein the desired motion comprises one selected from the group consisting of translation, rotation, reciprocating translation, reciprocating rotation, and any combination thereof.

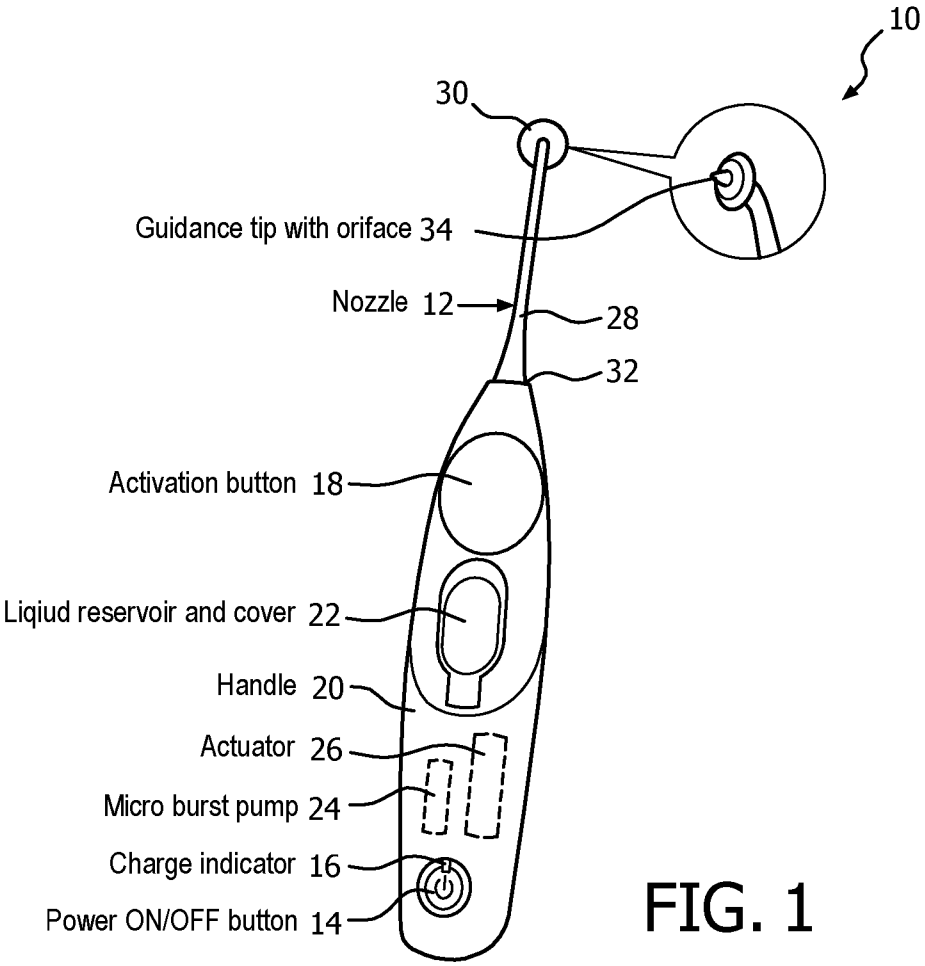
10
30
Guidance tip with oriface 34
Nozzle 12
28
32
Activation button 18
Liqiud reservoir and cover 22
Handle 20
Actuator 26
Micro burst pump 24
Charge indicator 16
Power ON/OFF button 14

FIG. 1

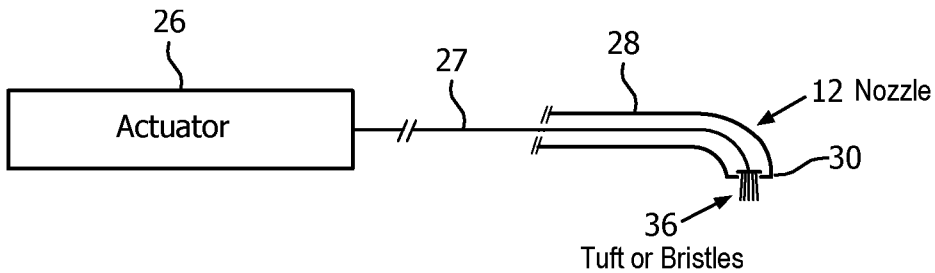
26
Actuator
27
28
12 Nozzle
30
36
Tuft or Bristles

FIG. 2

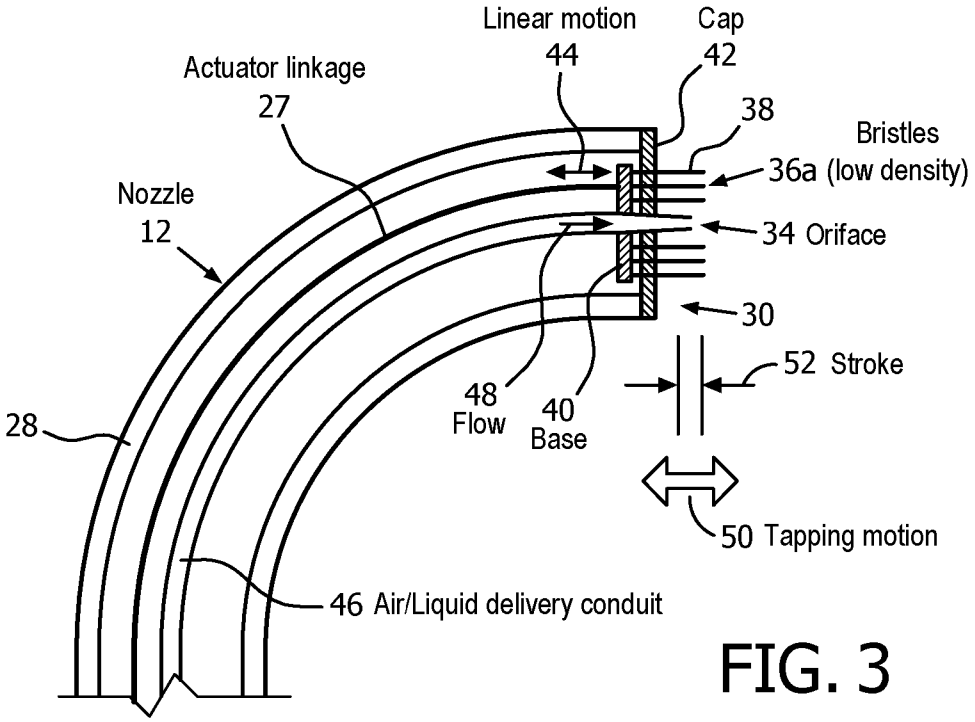
Linear motion
44
Cap
42
Actuator linkage
27
38
Bristles
36a (low density)
Nozzle
12
34 Oriface
30
52 Stroke
48
Flow
40
Base
28
50 Tapping motion
46 Air/Liquid delivery conduit

FIG. 3

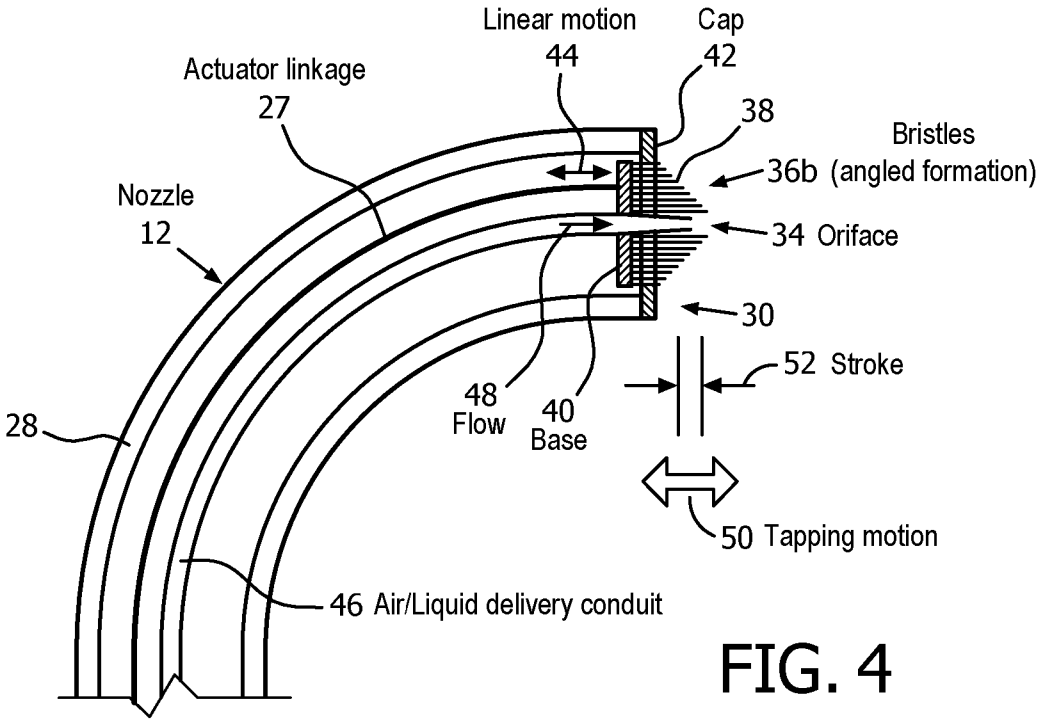
Linear motion
44
Cap
42
Actuator linkage
27
38
Bristles
36b (angled formation)
Nozzle
12
34 Oriface
30
52 Stroke
48
Flow
40
Base
28
50 Tapping motion
46 Air/Liquid delivery conduit

FIG. 4

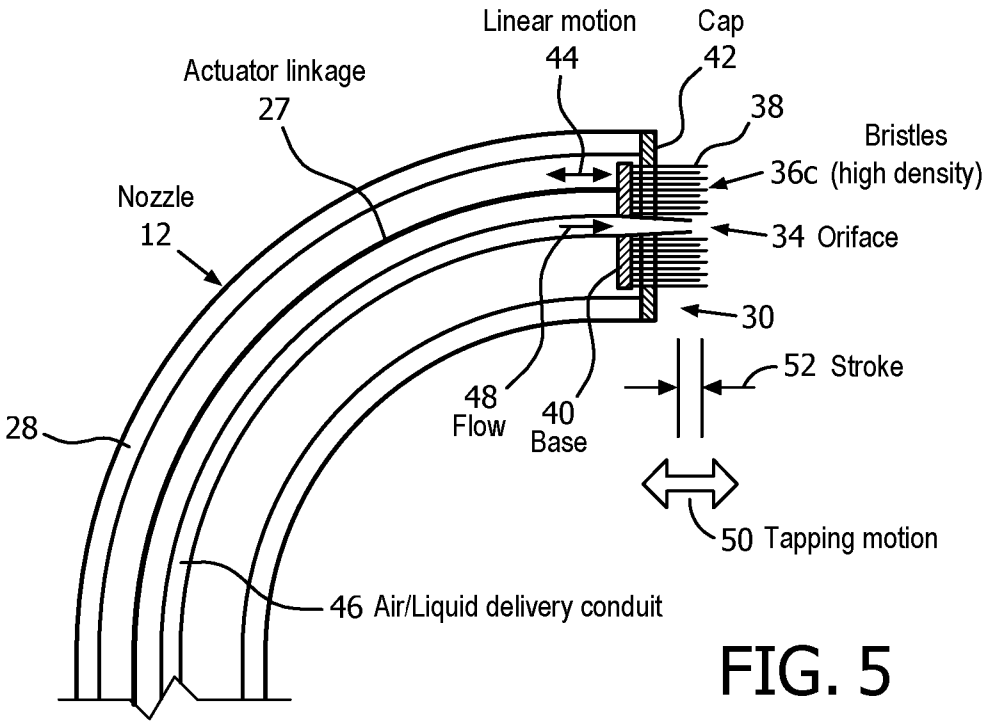
Linear motion
44
Cap
42
Actuator linkage
27
38
Bristles
36c (high density)
Nozzle
12
34 Oriface
30
52 Stroke
48
Flow
40
Base
28
50 Tapping motion
46 Air/Liquid delivery conduit

FIG. 5

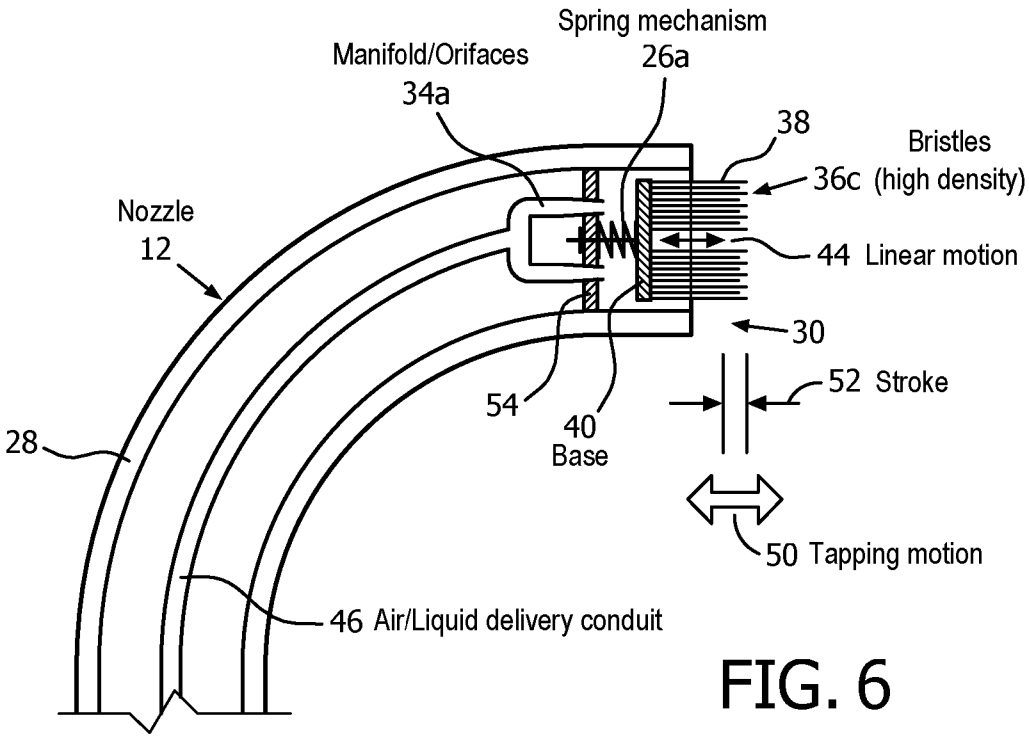
Spring mechanism
26a
Manifold/Orifaces
34a
38
Bristles
36c (high density)
Nozzle
12
44 Linear motion
30
52 Stroke
54
40
Base
28
50 Tapping motion
46 Air/Liquid delivery conduit

FIG. 6

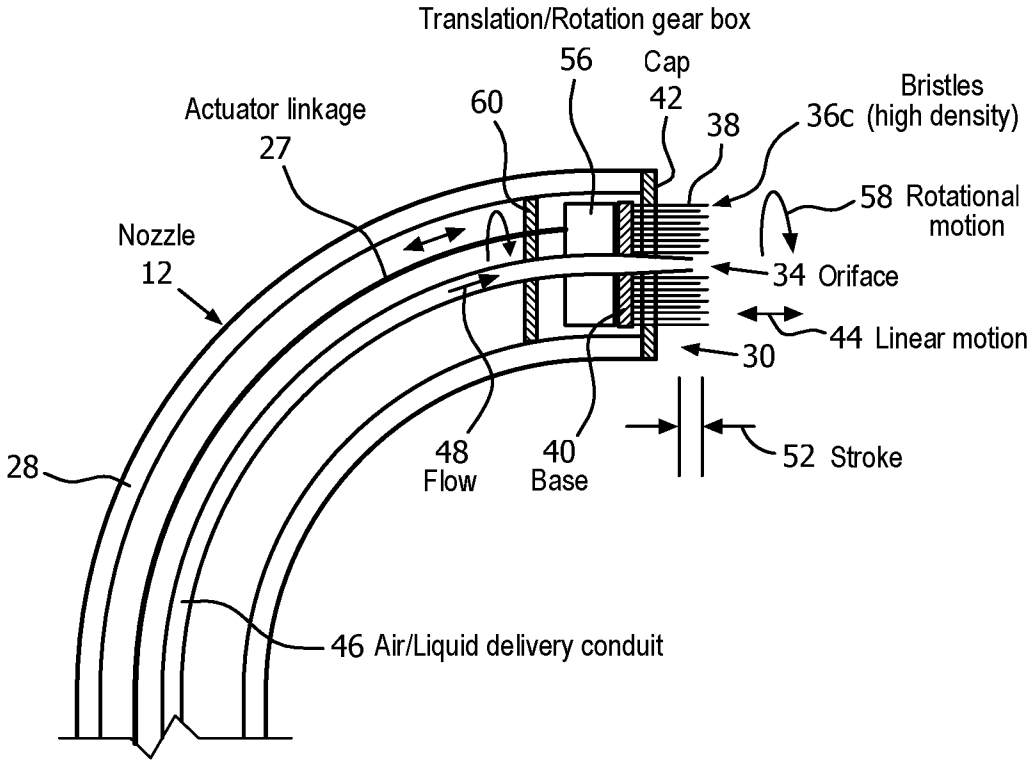
Translation/Rotation gear box
56
Cap
42
Bristles
(high density)
36c
38
Actuator linkage
27
60
58 Rotational
motion
Nozzle
12
34 Oriface
44 Linear motion
30
28
48
Flow
40
Base
52 Stroke
46 Air/Liquid delivery conduit

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/065703

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61C17/028 A61C17/32
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)
A61C

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, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/093717 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]) 27 June 2013 (2013-06-27)	1-6, 8-12, 17-20
Y	page 1, line 4 - page 4, line 8; figures	7,9
A	1-3	13-16

X	JP 2006 061486 A (FUKAI KOGYO KK) 9 March 2006 (2006-03-09)	1-6, 8-14, 17-20
Y	paragraph [0008] - paragraph [0023];	7,9
A	figure 1	15,16

X	DE 199 35 067 A1 (MOSER ELEKTROGERAETE GMBH [DE]) 8 February 2001 (2001-02-08)	1-6, 8-12,15, 17-20
Y	column 1, line 66 - column 3, line 37;	7,9
A	figures 1-3	13,14,16

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[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
30 January 2015	09/02/2015

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	Kunz, Lukas

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/065703

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y A	column 6, line 21 - column 7, line 23; figures 3a,3b	7,9 15

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Y	US 2006/078844 A1 (GOLDMAN PAUL D [US] ET AL) 13 April 2006 (2006-04-13) paragraph [0062]	9

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2014/065703

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		WO 2006041920 A1	20-04-2006