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(54) ELECTROSTATIC DUST COLLECTION WAND

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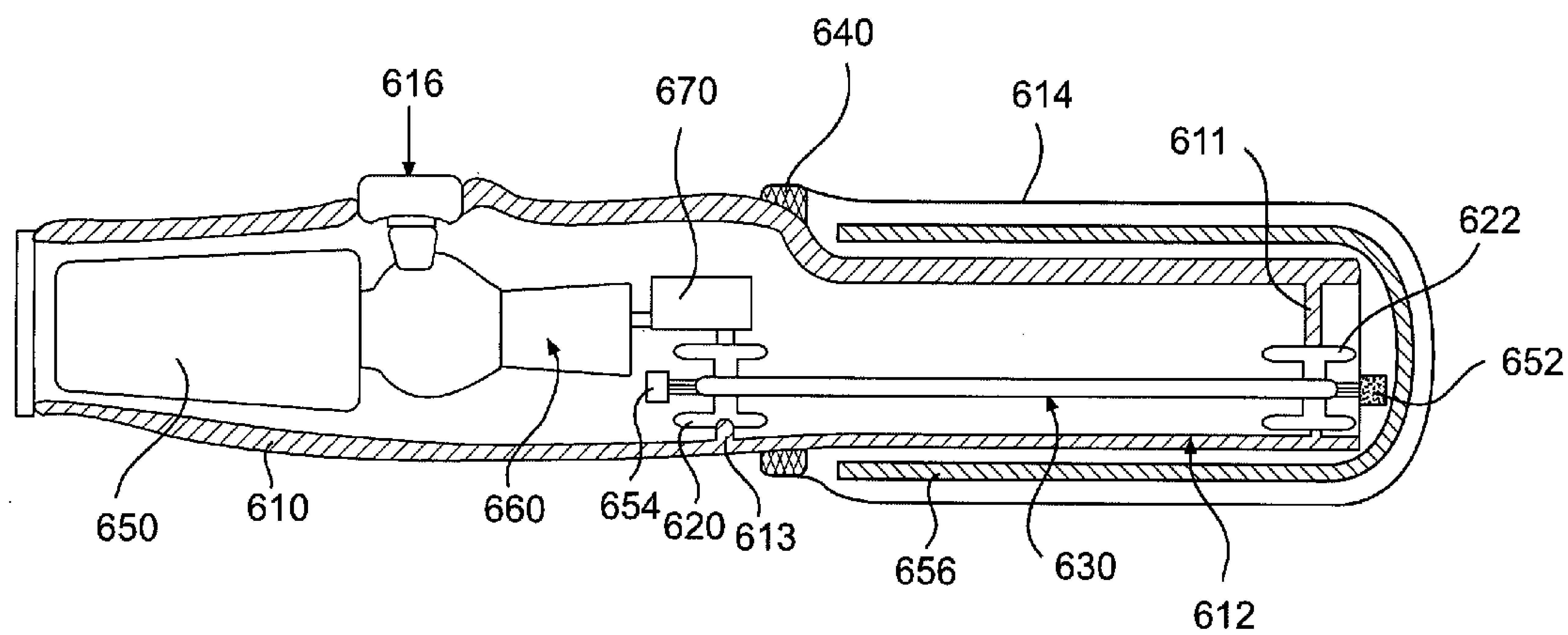
(57) ABSTRACT

An electrostatic dust wand has a handle, a triboelectric charge generator, and a fibrous material. The triboelectric charge generator is coupled to the handle, and generates an electrostatic charge to attract dust particles to the cleaning implement. The fibrous material at least partially covers the triboelectric charge generator, to collect and to retain dust particles. The triboelectric charge generator has at least one movable member having a first triboelectric property, and an actuator for driving the at least one movable member. The electrostatic charge may be generated by movement of he at least one movable member against the fibrous material. Alternatively, or in addition, the electrostatic charge may be generated by relative movement of two members of the triboelectric charge generator against one another.



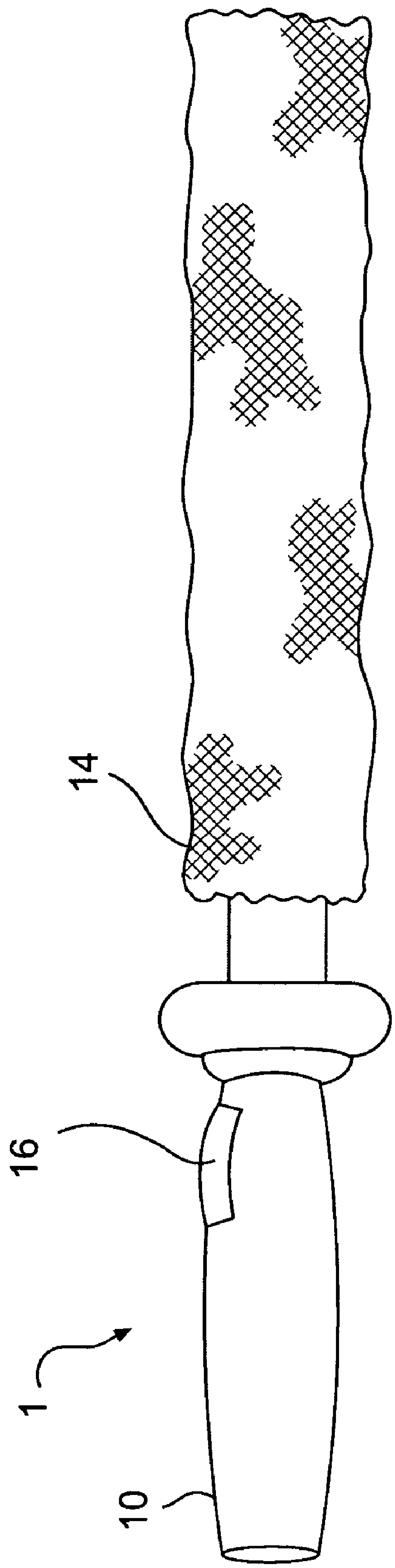


FIG. 1

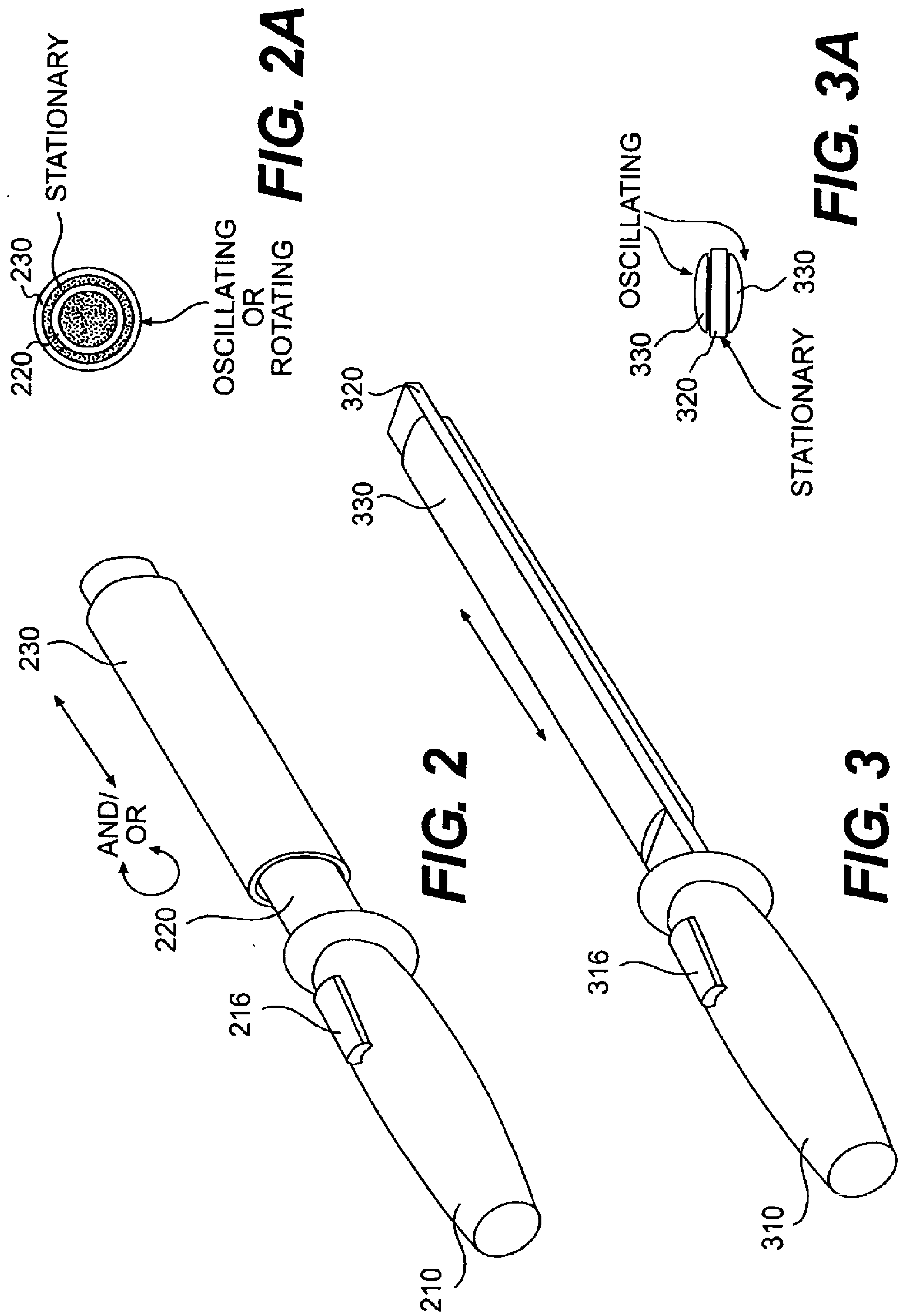


FIG. 2A

FIG. 2

FIG. 3A

FIG. 3

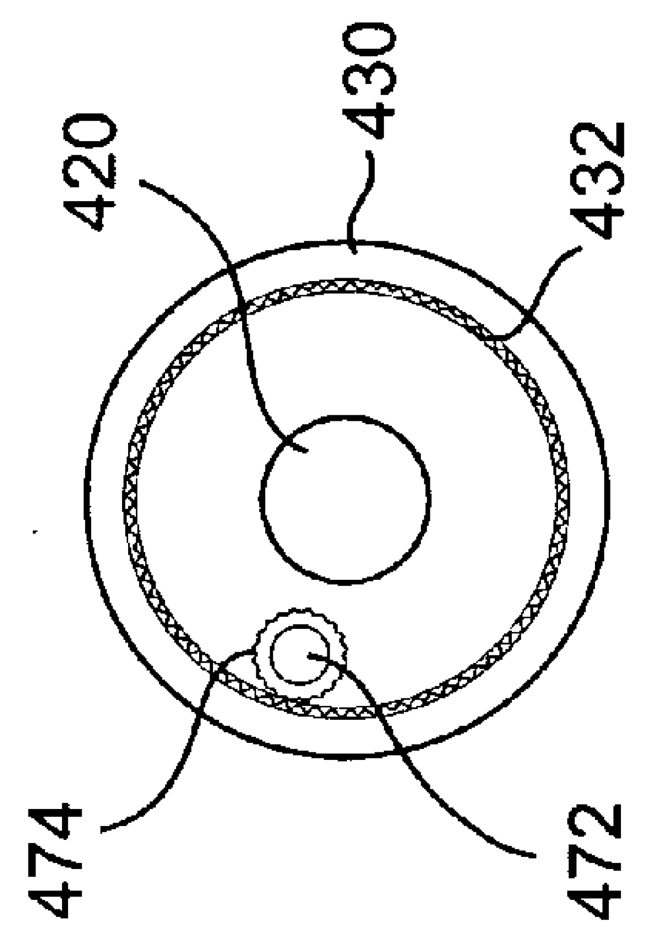

420
430
432
474
472

FIG. 4A

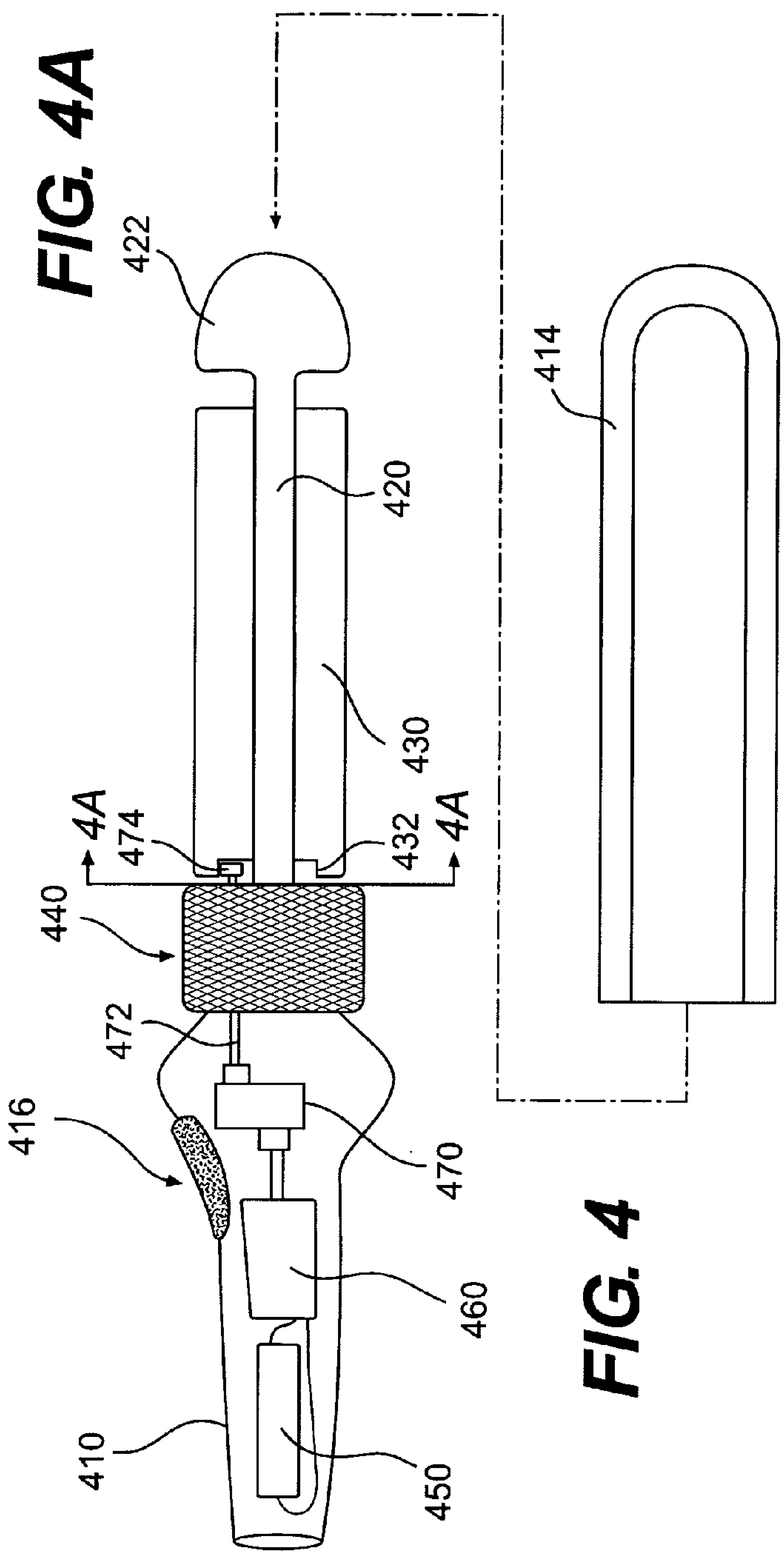

422
420
430
414
4A
474
432
4A
440
472
416
470
460
410
450

FIG. 4

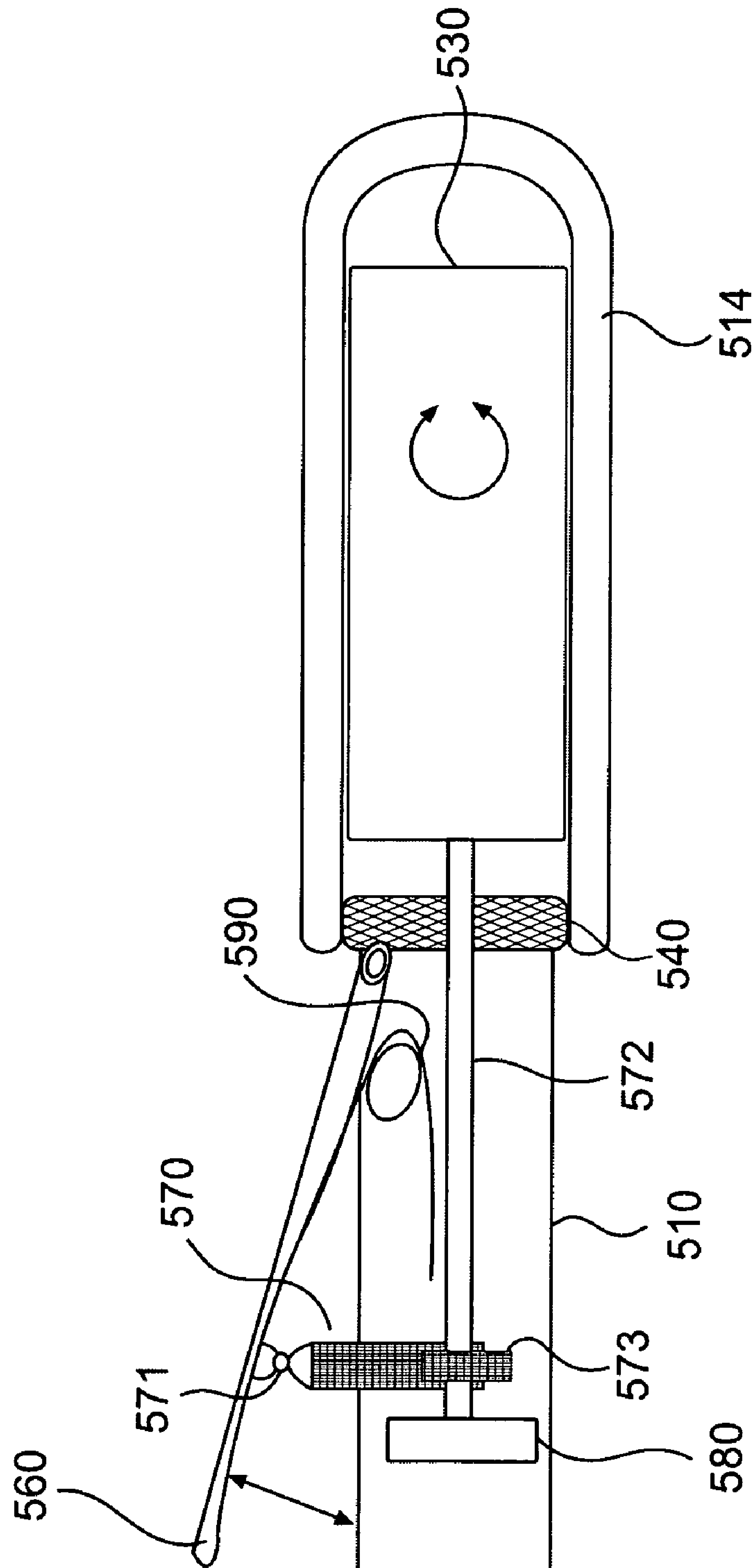


FIG. 5

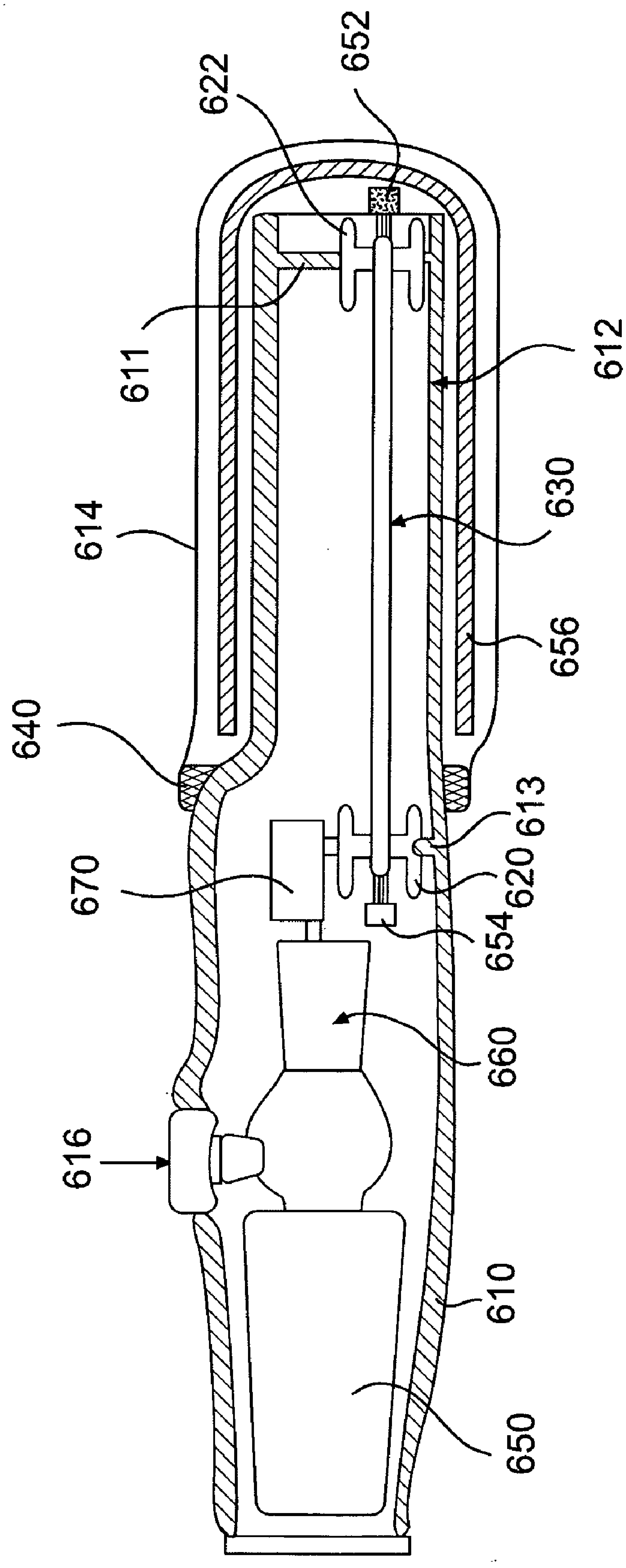


FIG. 6

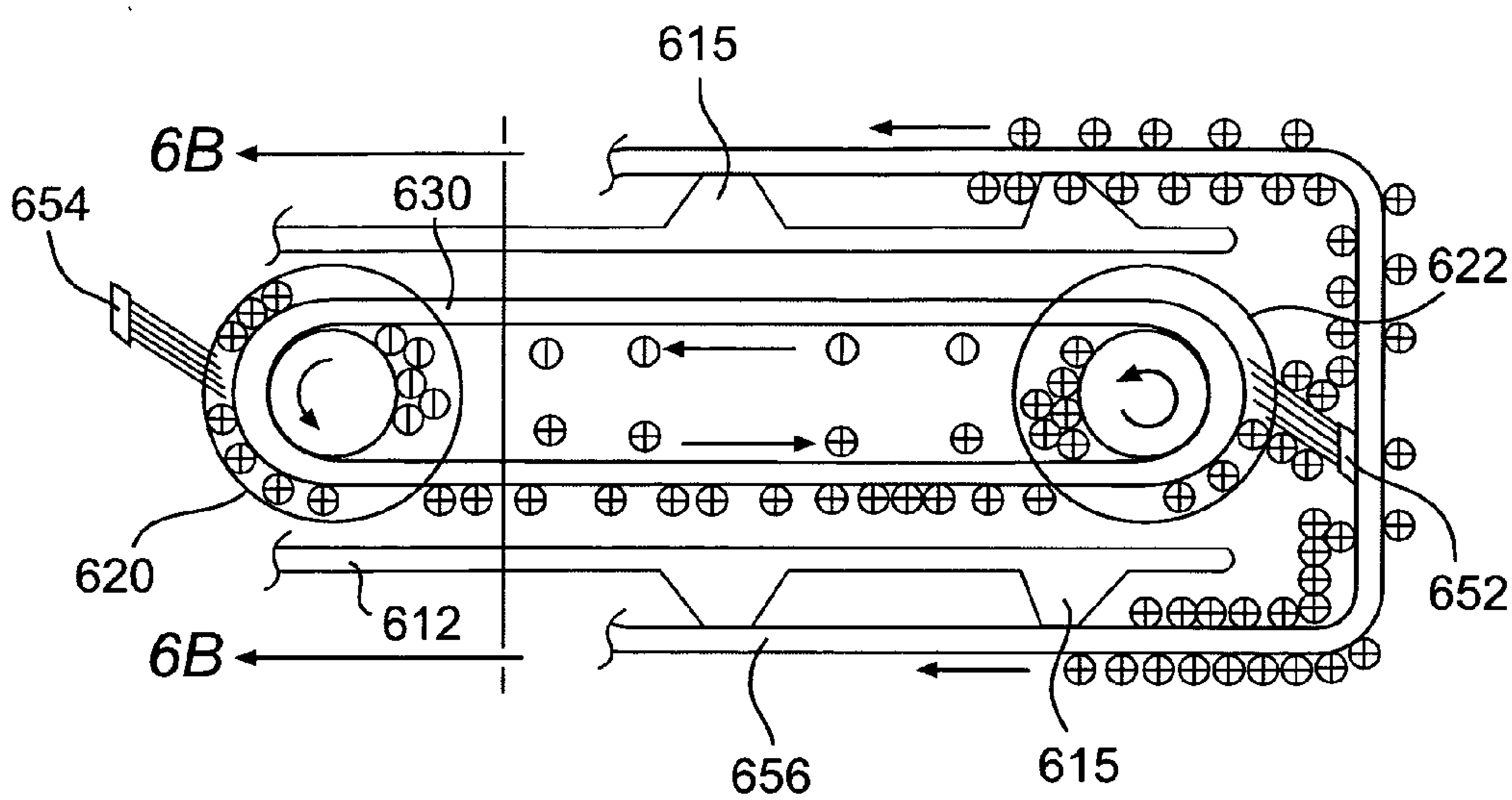

615
6B
654
630
622
620
612
6B
656
615
652

FIG. 6A

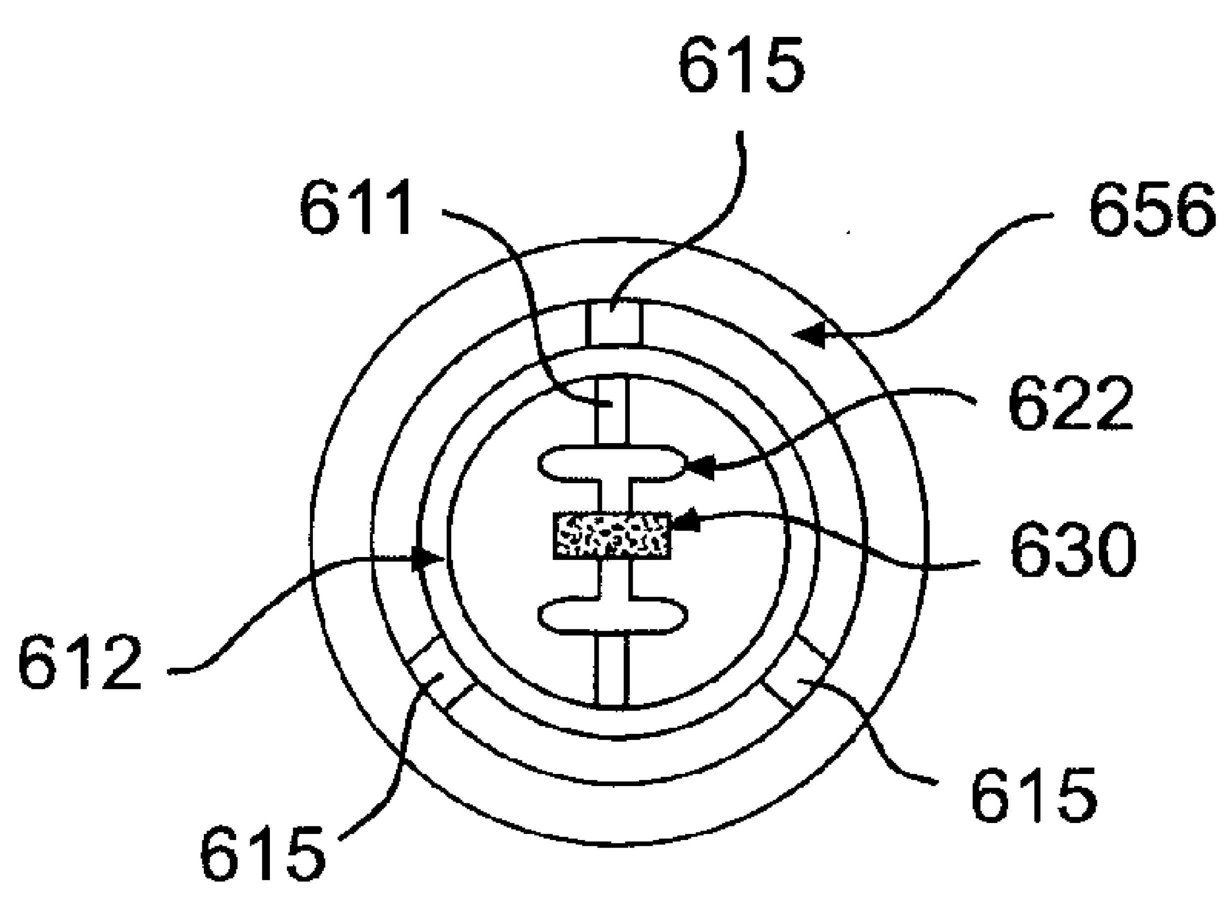

615
611
656
622
630
612
615
615

FIG. 6B

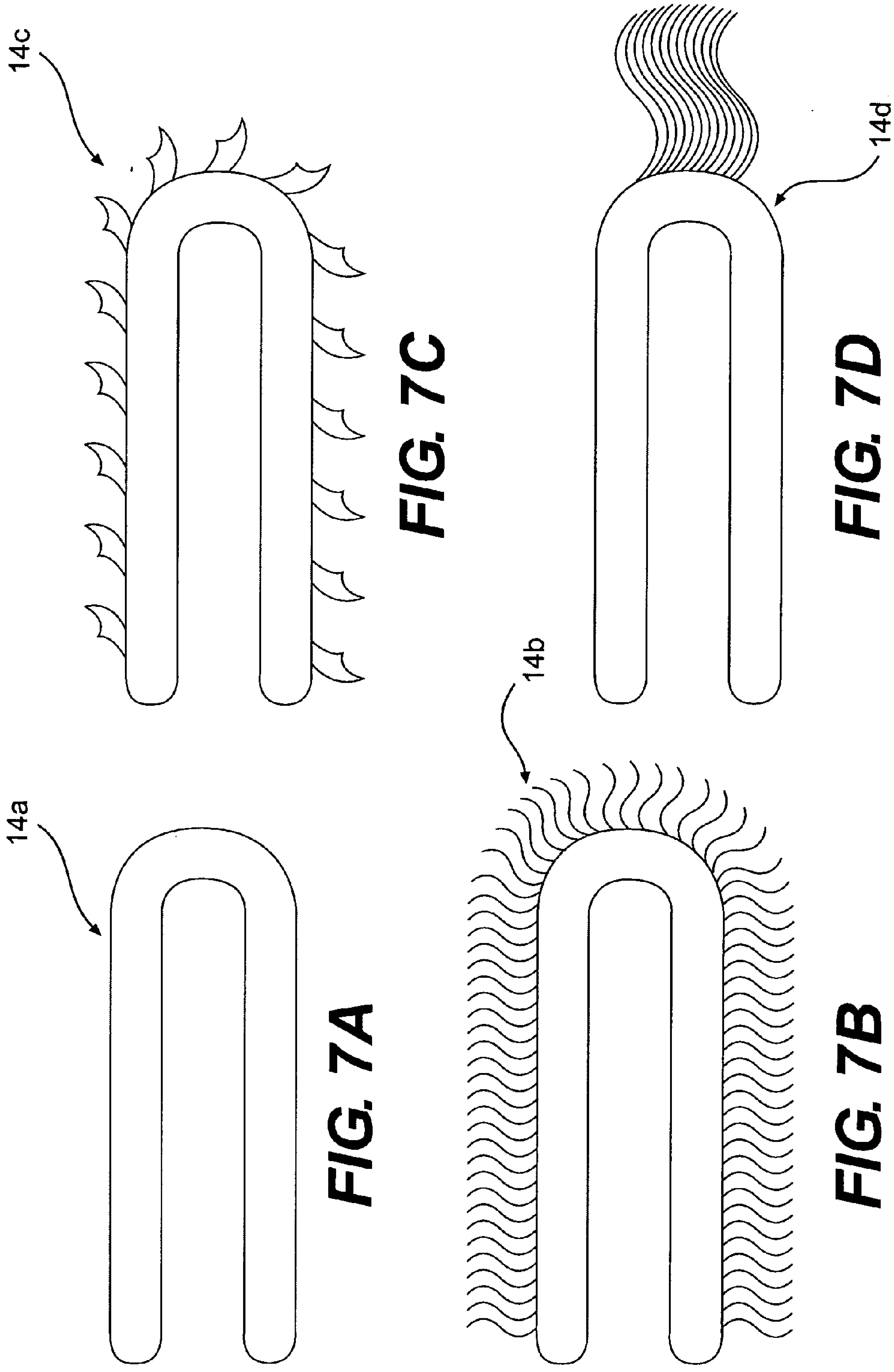


FIG. 7C

FIG. 7D

FIG. 7A

FIG. 7B

ELECTROSTATIC DUST COLLECTION WAND

FIELD OF THE INVENTION

[0001] The invention relates generally to cleaning implements for removing dust and other contaminants from a surface. In particular, the invention relates to cleaning implements having a triboelectric charge generator for generating an electrostatic charge to attract the dust and contaminants to the cleaning implement.

BACKGROUND OF THE INVENTION

[0002] Many techniques are known for cleaning dust and other contaminants from a surface. The most common method for removing dust from a surface is to use a cloth, with or without a cleaning or polishing solution, to wipe the dust from the surface. It is also known, as disclosed in U.S. Pat. No. 6,047,435 to Suzuki et al., to use a cleaning cloth attached to a handle in order to clean hard-to-reach areas. However, cleaning cloths may not pick up all of the dust on a surface, especially once the cloth starts to get dirty. Also, cleaning cloths cannot adequately remove dust from rough or uneven surfaces, where the dust is trapped in recesses, grooves, cracks, or the like.

[0003] An electrostatic brush has been proposed in U.S. Pat. No. 3,355,755 to Brooks. The brush includes an elongated handle having a brush head with a plurality of bristles surrounding a central dust passage, opposite to which is a piezo-electric ceramic crystal. When a hand lever is operated, a plunger is reciprocated to energize the piezo-electric crystal to generate an electrostatic charge. However, such a brush does not effectively trap and hold the dust. Thus, once the piezo-electric crystal is deactivated, the dust may fall back onto the surface to be cleaned. Also, once the brush becomes dirty, there is no provision to remove the bristles to clean or to replace them. Moreover, a brush having the foregoing construction would be complicated and costly to manufacture. Accordingly, there remains a need in the art for a cleaning implement that can adequately clean a wide variety of surfaces, and is inexpensive to manufacture.

SUMMARY OF THE INVENTION

[0004] My invention relates to a cleaning implement that remedies the foregoing and other deficiencies in the prior art. Generally, a cleaning implement according to my invention includes a triboelectric charge generator for generating and maintaining an electrostatic charge to attract dust and contaminants to the cleaning implement, and a fibrous material that collects and retains dust that comes into contact with the cleaning implement. The electrostatic charge is generated by contact and separation of two or more elements that have different triboelectric properties. Preferably, the electrostatic charge is generated by movement of a member of the triboelectric charge generator against the fibrous material. Alternatively, or in addition, the electrostatic charge may be generated by relative movement of two members of the triboelectric charge generator against one another.

[0005] As used herein, the terms "dust" and "dust particles" should be interpreted broadly to include any substance comprising a plurality of small particles, including (without limitation) dust, clay, pollen, dust mites, dead skin, inorganic matter, hair, sawdust, and the like.

[0006] As used herein, the term "triboelectric property" refers to the relative propensity of a material to gain or to lose electrons due to contact with and separation from another material. For the purposes of this application, two materials will be said to have "different" triboelectric properties if, when those materials are brought into contact and then separated, at least one of the materials has a gain or loss of electrons. Repeated contact and separation of the materials results in a build up of a measurable electrostatic charge. One way to measure static charge is through the use of an electrostatic field meter. Such meters have various ranges of measurement. One such meter is a portable field meter Model 257D available from Monroe Electronics, Inc. in Lyndonville, N.Y. Other conventional devices for measuring static charge are known in the art. A wide range of electrostatic charges may be used to attract dust particles. The greater the charge, the greater the attractive force will be. By way of example only, an electrostatic charge in the range of about 250 to about 20,000 volts is typical of the charge generated by a cleaning implement according to my invention to collect dust.

[0007] Briefly, when two surfaces of different materials are brought into contact, the atoms at the interface of the two surfaces tend to share their valence electrons. When the materials are separated, the atoms near the surface of one material have a tendency to keep some of the shared electrons, while atoms of the other surface have a tendency to give the shared electrons away. The result is a net charge imbalance, or triboelectric charge, between the two surfaces. While only contact is necessary to generate the triboelectric charge, rubbing the materials together enhances the effect.

[0008] Materials are often ranked in order of their propensity to lose or to gain electrons when brought into contact with another object. This ranking is known as the "triboelectric series."

[0009] The following is a representative triboelectric series, listing materials from most positive (i.e., greatest propensity to lose electrons) to most negative (i.e., greatest propensity to gain electrons):

[0010] Dry human skin (high positive charge)

[0011] Asbestos

[0012] Leather

[0013] Rabbit's fur

[0014] Glass

[0015] Mica

[0016] Human hair

[0017] Nylon

[0018] Wool

[0019] Lead

[0020] Cat's fur

[0021] Silk

[0022] Aluminum

[0023] Paper (small positive charge)

[0024] Cotton (no charge)

[0025] Steel (no charge)

[0026] Wood (small negative charge)

[0027] Lucite

[0028] Amber

[0029] Sealing wax

[0030] Acrylic

[0031] Polystyrene

[0032] Resins

[0033] Hard rubber

[0034] Nickel, Copper

[0035] Sulphur

[0036] Brass, Silver

[0037] Gold, Platinum

[0038] Acetate, Rayon

[0039] Synthetic rubber

[0040] Polyester

[0041] Styrene (Styrofoam)

[0042] Orlon

[0043] Saran

[0044] Polyurethane

[0045] Polyethylene

[0046] Polypropylene

[0047] Vinyl (PVC)

[0048] Silicon

[0049] Teflon® (high negative charge)

[0050] A material towards the bottom of the series, when touched to a material near the top of the series, will attain a more negative charge, and vice versa. The further away two materials are from each other on the series, the greater the charge transferred.

[0051] In one aspect, my invention relates to a cleaning implement comprising a handle, a triboelectric charge generator, and a fibrous material. The triboelectric charge generator is coupled to the handle, and generates an electrostatic charge to attract dust particles to the cleaning implement. The fibrous material at least partially covers the triboelectric charge generator, for collecting and retaining the dust particles.

[0052] Preferably, the triboelectric charge generator comprises at least one movable member having a first triboelectric property, and an actuator for driving the at least one movable member.

[0053] In one preferred arrangement, the fibrous material has a triboelectric property different than that of the at least one movable member and contacts at least a portion of the at least one movable member. Thus, motion of the at least one movable member relative to the fibrous material at least partially generates the electrostatic charge.

[0054] Additionally, or instead, the triboelectric charge generator may comprise at least one stationary member having a triboelectric property different than that of the at least one movable member and contacting at least a portion of the at least one movable member. Thus, motion of the at least one movable member relative to the at least one stationary member at least partially generates the electrostatic charge.

[0055] Alternatively, the triboelectric charge generator may comprise at least two movable members and an actuator. At least one movable member has a first triboelectric property and at least one movable member has a second triboelectric property different than the first triboelectric property. The actuator drives the at least two movable members, the at least two movable members being at least partially in contact with and movable relative to one another.

[0056] In another respect, my invention relates to a cleaning implement comprising a handle, a triboelectric charge generator, and a sleeve of fibrous sheet material. The triboelectric charge generator is coupled to the handle, and comprises an electric motor for driving at least one movable member, having a first triboelectric property, in motion relative to at least one other element having a second triboelectric property different than the first triboelectric property, thereby generating an electrostatic charge. The sleeve of fibrous sheet material at least partially covers the triboelectric charge generator, for collecting and retaining dust particles.

[0057] As used herein, the term "sleeve" should be understood to include any sleeve, sock, tube, sheath, or the like. A sleeve may be open at, one or both ends, and may have any suitable cross section (e.g., circular, rectangular, oval, square, etc.) so as to fit over at least a portion of a triboelectric charge generator.

[0058] A better understanding of these and other features and advantages of the invention may be had by reference to the drawings and to the accompanying description, in which preferred embodiments of the invention are illustrated and described.

BRIEF DESCRIPTION OF THE DRAWINGS

[0059] **FIG. 1** is a front view of a cleaning implement according to a preferred embodiment of my invention.

[0060] **FIG. 2** is a perspective view of a cleaning implement according to another preferred embodiment of my invention, with the fibrous material removed for clarity.

[0061] **FIG. 2A** is an end view of the cleaning implement of **FIG. 2**, taken from the end opposite to the handle.

[0062] **FIG. 3** is a perspective view of a cleaning implement according to another preferred embodiment of my invention.

[0063] **FIG. 3A** is an end view of the cleaning implement of **FIG. 3**, taken from the end opposite to the handle.

[0064] **FIG. 4** is a schematic side view of a cleaning implement according to another preferred embodiment of my invention.

[0065] **FIG. 4A** is an end view of the cleaning implement of **FIG. 4**, taken from the end opposite to the handle.

[0066] **FIG. 5** is a schematic side view of a cleaning implement according to another preferred embodiment of my invention.

[0067] **FIG. 6** is a schematic side view of a cleaning implement according to another preferred embodiment of my invention.

[0068] **FIG. 6A** is a detail view of the triboelectric charge generation portion of the cleaning implement of **FIG. 6**.

[0069] **FIG. 6B** is an end view of the cleaning implement of **FIG. 6**, taken from the end opposite to the handle.

[0070] **FIGS. 7A-7D** are cross-sectional views of four different embodiments of fibrous material that are usable with my invention.

[0071] Throughout the figures, like or corresponding reference numerals have been used for like or corresponding parts.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0072] Generally, as illustrated in **FIG. 1**, a cleaning implement **1** according to a preferred embodiment of my invention comprises a handle **10** having an on/off switch **16**, a triboelectric charge generator (as shown in **FIGS. 2-6**, and described in detail in the descriptions of those figures), and a fibrous material **14** at least partially covering the triboelectric charge generator. Preferably, a cleaning implement according to my invention is a hand held unit or "electrostatic dust collection wand."

[0073] The handle may be of any suitable shape and size, depending, for example, on the size, shape, and/or location of a surface that the cleaning implement is designed to clean. For example, the handle of the cleaning implement **1** shown in **FIG. 1** is relatively small to accommodate dusting surfaces that are within arms' reach, such as table tops, counters, window sills, electronic equipment, blinds, appliances, and the like. However, if the implement is to be used for cleaning floors, walls, ceilings, ceiling fans, or other more remote surfaces, the handle could be made longer and/or extendible to reach those surfaces. Likewise, if smaller surfaces are to be cleaned, a smaller handle could be provided to fit into tight spaces, crevices, under furniture, and the like, or to clean more fragile objects, such as pictures, vases, curios, and the like. The material of the handle is not critical. However, if the handle is formed integrally with the triboelectric charge generator, it should be made of a dielectric material so that the charge generated by the triboelectric charge generator is not dissipated to the user of the cleaning implement through the handle.

[0074] The triboelectric charge generator preferably comprises at least one movable member having a first triboelectric property, and an actuator for driving the at least one movable member to impart motion thereto. The movable member preferably is in contact with and moves relative to at least one other element having a second triboelectric property different than the first triboelectric property. The at least one other element may be the fibrous material, one or more stationary members, and/or one or more additional movable members. The relative motion between the at least one movable member and the at least one other element causes electrons to be transferred from one to the other, thereby creating a charge imbalance and generating an electrostatic charge.

[0075] The at least one movable member and the at least one other element can be made of any materials, as long as the materials have different triboelectric properties. Preferably, the at least one movable member comprises at least one of glass, nylon, wool, lead, silk, aluminum, paper, and cotton, and the at least one other element comprises at least one of wood, butyl rubber, nickel, copper, brass, silver, gold, platinum, polyester, styrene, polyurethane, polyethylene, polypropylene, vinyl, polyvinylchloride (PVC), silicon, polytetrafluoroethene, perfluoroalkoxy polymer resin (the foregoing two materials being commonly known as Teflon®), and rubber. More preferably, the at least one movable member comprises nylon and the at least one other element comprises polypropylene and/or PVC, and may preferably be coated with a layer of Teflon®, polyethylene, and/or silicon. Of course, these material constructions could be reversed, in which case the electron transfer would be in the opposite direction.

[0076] The fibrous material preferably comprises a sleeve of fibrous sheet material, as illustrated, for example, in **FIGS. 1**, **4**, **5**, and **6**. However, the fibrous material may advantageously take any other suitable form, such as a flat sheet (which may wrap partially or completely around the triboelectric charge generator), a geometric block, a sphere, an ovoid, or the like, depending, for example, on the surface to be cleaned, consumer preference, and the like. Moreover, as shown in FIGS. 7A-D, the fibrous material may take numerous different configurations. For example, **FIG. 7A** depicts a sleeve of fibrous material **14*a*** comprising a filter material, such as a spun-glass filter, a spun-lace filter, a cellulose fiber filter, composites thereof, and the like. **FIG. 7B** depicts a sleeve of fibrous material **14*b*** having a plurality of fibers extending from at least one surface thereof. **FIG. 7C** depicts a sleeve of fibrous material **14*c*** having a plurality of flaps of fibrous material-extending from at least one surface thereof. **FIG. 7D** depicts a sheet of fibrous material **14*d*** having a plurality of fibers extending from a distal end thereof.

[0077] The fibrous material is preferably made of a synthetic, nonwoven sheet material, such as Grab-its® cloths made by S.C. Johnson & Son, Inc. of Racine, Wis. However, the fibrous material may be made of any other suitable fibrous material, as long as it is capable of collecting and retaining dust and, when desired, generating at least a portion of the electrostatic charge. Examples of suitable materials include woven and/or nonwoven fibrous materials, sponge materials, foam materials, microfiber and/or nanofiber cloth materials, like materials, and composites thereof. Further, the fibrous material may include synthetic fibers, natural fibers, or a combination thereof. The fibrous material may itself be (or become) electrostatically charged and/or may be at least partially conductive so as to distribute a generated charge throughout the fibrous material.

[0078] Preferably, the fibrous material is releasably secured to the cleaning implement by a fastener. As used herein, the term "fastener" should be construed to include a hook and loop fastener (e.g., Velcro®), a snap, a clip, a clamp, a hook, or any other suitable retainer, such that the fibrous material can be removed and cleaned or replaced when it becomes soiled. However, other more permanent forms of attachment may also be acceptable. This arrangement also allows a user to change the type of fibrous material, depending on the surface to be cleaned, the type of dust or debris that is to be cleaned, the user's preference of shape and/or color of the fibrous material, or the like.

[0079] Moreover, it may be desirable, in each of the embodiments described herein, to select a fibrous material having a triboelectric property different than one or more members of the triboelectric charge generator, such that motion of the member(s) relative to the fibrous material generates a triboelectric charge in addition to, or instead of, the charge generated by the member(s) of the triboelectric charge generator alone. Along these lines, a further ring or sleeve (not shown) could be provided outside the fibrous material. By sliding the ring along the outside length of the cleaning implement, a charge would be generated by the contact of the ring with the fibrous material. In that case, the ring should be selected to be a material having a triboelectric property different than that of the fibrous material.

[0080] **FIG. 2** illustrates a preferred embodiment of a cleaning implement according to my invention. The cleaning implement of **FIG. 2** is shown with the fibrous material removed for clarity. The cleaning implement comprises a handle **210** having a switch **216** for activating the triboelectric charge generator to generate an electrostatic charge. In this embodiment, the triboelectric charge generator includes an elongated central member **220** extending axially from the handle **210**, and a cylindrical member **230** positioned circumjacent the central member **220**. For weight reasons, the central member **220** is preferably itself a hollow cylinder, as shown in **FIG. 2A**. Alternatively, the central member **220** could comprise a solid rod. Preferably the central member **220** is stationary, while the cylindrical member **230** is driven for reciprocating axial (i.e., oscillating) and/or rotational motion relative to the central member **220** by an actuator (not shown) of the triboelectric charge generator via a conventional gear train (also not shown). Alternatively, however, the central member **220** could be driven for oscillating and/or rotational motion while the cylindrical member **230** is held stationary. Preferably, the actuator comprises an electric motor powered by a power source, such as one or more batteries, a rechargeable or replaceable battery pack, a wall socket, or any other conventional power source.

[0081] A triboelectric charge can be generated by the motion of the cylindrical member **230** relative to the central member **220**, through interaction between the moving cylindrical member **230** and the fibrous sleeve of material (not shown in this figure), or both. In the first case, the cylindrical member **230** and the central member **220** are respectively made of materials having different triboelectric properties, as described in detail above. In the second case, the moving cylindrical member **230** and the sleeve of fibrous material are respectively made of materials having different triboelectric properties.

[0082] **FIG. 3** illustrates a cleaning implement according to another embodiment of my invention. The cleaning implement of **FIG. 3** is shown with the fibrous material removed for clarity. The cleaning implement of **FIG. 3** is similar to that pictured in **FIG. 2**, to the extent that it has a handle **310** and a switch **316** to activate a triboelectric charge generator. In the embodiment of **FIG. 3**, however, the triboelectric charge generator comprises a plurality of generally flat plates **320**, **330**, so that the cleaning implement can fit in narrow spaces, such as between blinds, under doors, and the like. **FIG. 3** illustrates a triboelectric charge generator comprising three plates, a central plate **320**, which is stationary relative to the handle **310**, and a pair of side plates **330** positioned substantially parallel and adjacent to the stationary plate **320** and oscillating axially relative to the stationary plate **320**. Preferably, the stationary plate **320** is made of a material near one end of the triboelectric series (e.g., nylon), while the side plates **330** are chosen to be a material near the other end of the triboelectric series (e.g., polypropylene and/or PVC). In this manner, the stationary member **320** would become positively charged and the side members **330** would both become negatively charged. Because the materials are further apart in the triboelectric series, this arrangement would generate a greater electrostatic charge.

[0083] Also, the sleeve of fibrous material (not shown in this figure) could be made of a material having a triboelectric property different from that of the side plates **330**, such that the interaction between the side plates **330** and the fibrous material generates an electrostatic charge in addition to, or instead of, the charge generated between the stationary and movable members **320**, **330**.

[0084] Alternatively, the stationary plate **320** could be chosen to be a material (e.g., steel or cotton) near the center of the triboelectric series, while one side plate **330** is chosen to be a material (e.g., nylon) near the positive end of the triboelectric series and the other side plate **330** is chosen to be a material (e.g., polypropylene and/or PVC) near the negative end of the triboelectric series. Because the stationary member **320** in this alternative variation is made of a material near the center of the triboelectric series, it accepts electrons from the nylon side member **330** and donates electrons to the polypropylene and/or PVC side member **330**. Accordingly, the charge on the stationary member **320** will remain substantially neutral, which allows a triboelectric charge to be generated quickly. In this manner, one side plate **330** would become positively charged and the other side plate **330** would become negatively charged. This arrangement has the additional benefit that the cleaning implement can attract particles having either a positive charge or a negative charge.

[0085] In practice, my invention is not limited to three plates, and any number of two or more plates can be used, as long as each successive plate has a different triboelectric property than the last. Moreover, rather than some plates being stationary and some being moving, all of the plates could be made to move relative to one another. Also, as previously mentioned, the members **320**, **330** of the triboelectric charge generator and the fibrous material can be so selected as to generate an electrostatic charge.

[0086] **FIG. 4** illustrates a cleaning implement according to another embodiment of my invention. The embodiment of **FIG. 4** is similar to that of **FIG. 2**, in that it includes a handle **410** including a switch **416** for activating a triboelectric charge generator, and fibrous sleeve of material **414**. The sleeve of fibrous material **414** is shown removed from the cleaning implement for clarity. In use, however, the sleeve of fibrous material **414** is slid over the triboelectric charge generator and held in place by a suitable fastener. Also, like the embodiment of **FIG. 2**, the triboelectric charge generator comprises a stationary central member **420** extending axially from the handle **410**, and a cylindrical member **430** positioned circumjacent the central member **420**. In this embodiment, the central member **420** comprises a solid rod having an enlarged end **422**, which retains and stabilizes the cylindrical member **430**. As shown, the cylindrical member **430** is driven for rotation by an electric motor **460**, which is powered by one or more batteries **450**, via a gearbox **470** and a drive axle **472**. The drive axle **472** extends from the gearbox **470** and engages a gear surface **432** formed on the interior of the cylindrical member **430**, as shown, for example, in **FIG. 4A**. Alternatively, the motor **460** could be directly coupled to the gear surface **432** by the drive axle **472**, but without the provision of a gearbox.

[0087] The cylindrical member **430** has a triboelectric property different than at least one, and preferably both, of the fibrous sleeve **414** and the central member **420**. Thus, as the cylindrical member **430** is rotated, an electrostatic charge is generated at the interface(s) of the cylindrical member **430** with the fibrous sleeve **414** and/or the central member **420**.

[0088] **FIG. 5** shows a manually powered cleaning implement according to another embodiment of my invention. The concept of the cleaning implement shown in **FIG. 5** is similar to that shown in **FIG. 4**, to the extent that it includes a handle **510**, a triboelectric charge generator, and a fibrous sleeve **514**. However, instead of an electric motor as the actuator for the triboelectric generator, this embodiment uses work input by an operator squeezing the handle **510** of the implement to power the triboelectric charge generator. In this embodiment, the triboelectric charge generator comprises a rotating member **530** having a triboelectric property different than that of the fibrous sleeve **514**, and an actuator.

[0089] The actuator in this embodiment comprises a lever **560** which, when depressed by an operator, translates a linear gear **570**, which rides against and engages a drive gear **573** mounted on a drive shaft **572** to rotate the inner member **530**. A hinge **571** allows the linear gear to pivot so as to constantly align with and engage the drive gear **573** on the drive shaft **572**. A flywheel **580** provides additional inertia to the drive shaft **572** to keep the member **530** rotating. When a user releases the lever **560**, a torsion spring **590** biases the lever back toward a raised position (shown in **FIG. 5**). With each subsequent depression of the lever **560**, the member **530**, and hence the flywheel, gain additional speed and momentum. Thus, a suitable triboelectric charge can be built up and maintained by a user at the interface of the rotating member **530** and the fibrous sleeve **514**. In **FIG. 5**, the fibrous sleeve of material **514** is shown affixed to the cleaning implement by a suitable fastener **540**.

[0090] A cleaning implement according to yet another embodiment of my invention is shown in **FIGS. 6, 6A**, and 6B. The cleaning implement of **FIG. 6** is similar to that shown in **FIG. 4**, except for the configuration of the triboelectric charge generator. In the embodiment of **FIG. 6**, the triboelectric charge generator functions similarly to a conventional Van de Graff generator. The details of charge generation in a Van de Graff generator are known in the art, as described for example in Electrostatics: Exploring, Controlling and Using Static Electricity, by A. D. Moore et al., Laplacian Press, 2nd edition, December 1997, which is incorporated herein by reference. Accordingly, only a general discussion of this charge generation process is described below. However, a Van de Graff generator has not previously been used to generate an electrostatic charge in a cleaning implement to collect dust. Nor has the technology been used in connection with a fibrous material to collect and retain dust that is attracted to the cleaning implement by the electrostatic charge.

[0091] As illustrated in **FIG. 6**, the triboelectric charge generator comprises a pair of rollers **620**, **622**, and a band of flexible material **630** extending around and riding on the rollers **620**, **622**. One of the rollers **620** ("the driven roller") is coupled to and driven by an electric motor **660** via a gearbox **670**, the motor **660** being powered by a suitable power source **610**. Alternatively, the gearbox may be dispensed with and the motor **660** coupled to drive the roller **620** directly. The other roller **622** ("the free roller") is freely rotatable. The rollers **620**, **622** are spaced apart from one another within a housing **612** of the cleaning implement, and are at least partially supported by roller supports **613**, **611**, respectively, formed on the interior of the housing **612**.

[0092] A pair of conductive brushes **654**, **652**, preferably made of steel or brass, is positioned adjacent to or in contact with the flexible band **630**, with one brush located near each roller **620**, **622**. However, the brushes could be made of any suitable conductive material, metals being particularly suitable for this purpose. Brush **652** is electrically connected to a conductive sleeve **656**, which at least partially surrounds the housing **612**. Preferably, the conductive sleeve **656** is made with smooth or rounded contours to minimize charge concentrations and, hence, arcing. The conductive sleeve **656** can also be made of any suitable conductive material, with metals again being particularly suitable. Brush **654** is connected to a ground. As best seen in **FIGS. 6A and 6B**, the conductive sleeve **656** is spaced from the housing **612** by a plurality of raised support ribs **615**.

[0093] A sleeve of fibrous material **614** is positioned over the triboelectric charge generator and held in place by a suitable fastener **640**.

[0094] In operation, when a user manipulates a switch **616** to activate the triboelectric charge generator, the electric motor **660** drives the gearbox **670**, which in turn rotates the driven roller **620**. Because the flexible band **630** passes around the rollers **620**, **622**, it is rotated around the exterior of the rollers **620**, **622**. As the flexible band **630** travels around the rollers **620**, **622**, the band **630** is continuously brought into contact with and then separated from both of the rollers **620**, **622**. This contact with and subsequent separation of the band **630** from the rollers **620**, **622**, causes a transfer of electrons between the band **630** and the rollers **620**, **622**. The direction of the electron transfer between the band **630** and the rollers **620**, **630**, depends on the materials each of these components is made of. In one configuration, shown in **FIG. 6A**, the band **630** is made of synthetic rubber or natural rubber, preferably without any conductive fillers. The rollers **620**, **622**, are made of nylon, the driven roller **620** being covered with a material that is closer to the negative end of the triboelectric series than rubber, such as silicon.

[0095] As the band **630** passes around the driven roller **620**, electrons are transferred to the driven roller **620**, from the band **630**. Thus, the inner surface of the band **630** becomes positively charged and the driven roller **620** becomes negatively charged, as generally shown in **FIG. 6A**. The negative charge at the driven roller **620** is much more concentrated than the positive charge on the band **630**. The concentrated negative charge of the driven roller **620** repels the electrons from the brush **654**, causing it to become positively charged. The concentrated negative charge of driven roller **620** also causes nearby air molecules to break down into plasma and free electrons. The positively charged plasma particles are attracted by the negatively charged driven roller **620**, but are blocked by, and adhere to, the outer surface of the band **630** and are carried away from the driven roller **620**. The free electrons are attracted to the positively charged brush **654**. Thus, a continuous stream of positively charged particles is carried on the band **630** away from the driven roller toward the free roller **622**.

[**0096**] The free roller **622**, being made of nylon, looses electrons to the band **630**. Thus, the free roller **622** develops a concentrated positive charge, while the inner surface of the band **630** develops a negative charge (top inside in **FIG. 6A**), as shown in **FIG. 6A**. The concentrated positive charge of roller **622** attracts electrons to the tip of brush **652**. Thus, as the positively charged particles carried up on the outside of the band **630** (bottom inside in **FIG. 6A**) approach the brush **652**, they are attracted to the negatively charged brush **652**. This positive charge is transferred from the brush **652** to the conductive sleeve **656**, where the charge distributes evenly over the surface of the conductive sleeve **656**. In this manner the sleeve **656** becomes electrostatically (positively) charged.

[**0097**] Alternatively, the rollers could be reversed (i.e., the free roller could be coated with silicon while the driven roller is not), in which case the polarity of the charge on the conductive sleeve **656** would be reversed.

[**0098**] Throughout the drawings, conventional mounting features within the handle of the cleaning implement (e.g., flanges, bushings, bearings, bosses, guides, supports, connectors, and the like) have been omitted for clarity, the arrangement of such features being within the skill of one of ordinary skill in the art and not forming a part of my invention.

[**0099**] The embodiments discussed above are representative of preferred embodiments of my invention and are provided for illustrative purposes only. They are not intended to limit the scope of the invention. Although specific structures, dimensions, components, etc., have been shown and described, such are not limiting. Modifications and variations are contemplated within the scope of my invention, which is intended to be limited only by the scope of the accompanying claims. For example, the various different handles, triboelectric charge generation components, and fibrous materials described herein can be interchanged and combined in various different combinations.

[**0100**] Also, preferred materials for each of the components are discussed herein; however, any of the various materials described as being suitable for a component of one embodiment may be applied to similar or analogous components of the other embodiments.

[**0101**] Moreover, where two components are described as being made of materials at opposite ends of the triboelectric series, or one material being at the positive end of the triboelectric series and the other being at the negative end of the triboelectric series, the materials need not be at the extreme ends of the series (although the further the materials are separated on the triboelectric series, the greater their ability to transfer electrons and, consequently, the greater the charge generated). Rather, any two materials having different triboelectric properties than each other can be used in each of the embodiments described herein. This is because the triboelectric series is only a ranking of the materials relative to one another. For example, steel will take electrons when brought into contact with nylon, but will donate electrons when brought into contact with silicon.

INDUSTRIAL APPLICABILITY

[**0102**] My invention provides an effective cleaning implement that is usable for cleaning dust from surfaces. The cleaning implement is effective to clean dust from uneven and porous surfaces, as well as flat, smooth surfaces, due to the electrostatic charge generated by the implement. The cleaning implement is particularly cost effective due to the relatively inexpensive materials and simple construction.

I claim:

1. A cleaning implement comprising:

a handle;

a triboelectric charge generator coupled to said handle, said triboelectric charge generator generating an electrostatic charge to attract dust particles to the cleaning implement; and

a fibrous material, at least partially covering said triboelectric charge generator, for collecting and retaining the dust particles.

2. A cleaning implement according to claim 1, said triboelectric charge generator comprising at least one movable member having a first triboelectric property, and an actuator for driving said at least one movable member.

3. A cleaning implement according to claim 2, said fibrous material having a triboelectric property different than that of said at least one movable member and contacting at least a portion of said at least one movable member, motion of said at least one movable member relative to said fibrous material at least partially generating the electrostatic charge.

4. A cleaning implement according to claim 2, said triboelectric charge generator further comprising at least one stationary member having a triboelectric property different than that of said movable member and contacting at least a portion of said at least one movable member, motion of said at least one movable member relative to said at least one stationary member at least partially generating the electrostatic charge.

5. A cleaning implement according to claim 4, said fibrous material having a triboelectric property different than that of said movable member and contacting at least a portion of said at least one movable member, motion of said at least one movable member relative to said fibrous material at least partially generating the electrostatic charge.

6. A cleaning implement according to claim 4, wherein one of said at least one movable member and said at least one stationary member is disposed circumjacent to the other of said at least one movable member and said at least one stationary member.

7. A cleaning implement according to claim 4, said at least one movable member and said at least one stationary member being disposed substantially parallel to and adjacent to one another.

8. A cleaning implement according to claim 1, said triboelectric charge generator comprising at least two movable members, at least one movable member having a first triboelectric property and at least one movable member having a second triboelectric property different than the first triboelectric property, and an actuator for driving said at least two movable members, said at least two movable members being at least partially in contact with and movable relative to one another.

9. A cleaning implement according to claim 1, said fibrous material comprising a sleeve, which fits over said triboelectric charge generator.

10. A cleaning implement according to claim 9, said fibrous material being removably attached to the cleaning implement by a fastener.

11. A cleaning implement according to claim 9, said fibrous material comprising at least one of loose fibers and loose flaps of material protruding from an exterior surface of said sleeve of fibrous material.

12. A cleaning implement according to claim 2, said actuator comprising an electric motor powered by a power source, said electric motor driving said at least one movable member to impart motion thereto.

13. A cleaning implement according to claim 2, said actuator comprising a manual actuator, said manual actuator configured to convert work input by a user to mechanical energy to drive said at least one movable member to impart motion thereto.

14. A cleaning implement according to claim 2, said actuator driving said at least one movable member for substantially axial, reciprocating motion relative to said handle.

15. A cleaning implement according to claim 2, said actuator driving said at least one movable member for substantially rotational motion relative to said handle.

16. A cleaning implement according to claim 2, said at least one movable member comprising a first roller, said triboelectric charge generator further comprising a band of flexible material, said band extending around and riding on said roller.

17. A cleaning implement according to claim 16, said triboelectric charge generator further comprising a second roller, said band of flexible material extending around and riding on both said first and second rollers.

18. A cleaning implement according to claim 17, further comprising a conductive sleeve at least partially surrounding said triboelectric charge generator, and at least one conductive brush in electrical communication with said conductive sleeve, one end of said at least one brush being adjacent to, or in contact with, said band of flexible material.

19. A cleaning implement according to claim 18, at least one of said conductive sleeve and said conductive brushes comprising a metal.

20. A cleaning implement according to claim 18, at least one of said conductive sleeve and said conductive brushes comprising a conductive polymer.

21. A cleaning implement according to claim 1, said cleaning implement comprising an electrostatic dust collection wand.

22. A cleaning implement comprising:

a handle;

a triboelectric charge generator coupled to said handle, said triboelectric charge generator comprising an electric motor for driving at least one movable member, having a first triboelectric property, in motion relative to at least one other element having a second triboelectric property different than the first triboelectric property, thereby generating an electrostatic charge; and

a sleeve of fibrous sheet material at least partially covering said triboelectric charge generator, for collecting and retaining dust particles.

23. A cleaning implement according to claim 22, said fibrous material being removably attached to the cleaning implement by a fastener.

24. A cleaning implement according to claim 22, said fibrous material comprising at least one of loose fibers and loose flaps of material protruding from an exterior surface of said sleeve of fibrous sheet material.

25. A cleaning implement according to claim 22, further comprising a power source for powering said electric motor.

26. A cleaning implement according to claim 22, said electric motor driving said at least one movable member for substantially axial, reciprocating motion relative to said handle.

27. A cleaning implement according to claim 22, said electric motor driving said at least one movable member for substantially rotational motion relative to said handle.

28. A cleaning implement according to claim 22, said at least one other element comprising said sleeve of fibrous sheet material, motion of said at least one movable member relative to said sleeve of fibrous sheet material at least partially generating the electrostatic charge.

29. A cleaning implement according to claim 22, said at least one other element comprising at least one stationary member having a triboelectric property different than that of said movable member and contacting at least a portion of said at least one movable member, motion of said at least one movable member relative to said at least one stationary member at least partially generating the electrostatic charge.

30. A cleaning implement according to claim 29, wherein one of said at least one movable member and said at least one stationary member is disposed circumjacent to the other of said at least one movable member and said at least one stationary member.

31. A cleaning implement according to claim 29, said at least one movable member and said at least one stationary member being disposed substantially parallel to and adjacent to one another.

32. A cleaning implement according to claim 22, said at least one movable member comprising a first roller, said triboelectric charge generator further comprising a band of flexible material, said band extending around and riding on said roller.

33. A cleaning implement according to claim 32, said triboelectric charge generator further comprising a second roller, said band of flexible material extending around and riding on both said first and second rollers.

34. A cleaning implement according to claim 33, further comprising a conductive sleeve at least partially surrounding said triboelectric charge generator, and at least one conductive brush in electrical communication with said conductive sleeve, one end of said at least one brush being adjacent to, or in contact with, said band of flexible material.

35. A cleaning implement according to claim 34, at least one of said conductive sleeve and said conductive brushes comprising a metal.

36. A cleaning implement according to claim 34, at least one of said conductive sleeve and said conductive brushes comprising a conductive polymer.

37. A cleaning implement according to claim 22, said cleaning implement comprising an electrostatic dust collection wand.

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