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Thorne et al.

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(54) **CLEANING APPARATUS WITH COMBING UNIT FOR REMOVING DEBRIS FROM CLEANING ROLLER**

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(58) **Field of Classification Search**
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(57) **ABSTRACT**

A cleaning apparatus includes a combing unit including a series of spaced protrusions or teeth extending into a cleaning roller for preventing build up and removing debris (such as hair, string, and the like). The protrusions extend along a substantial portion of the cleaning roller and extend partially into the cleaning roller to intercept the debris as it passes around the roller. The protrusions have angled leading edges that are not aligned with a rotation center of the cleaning
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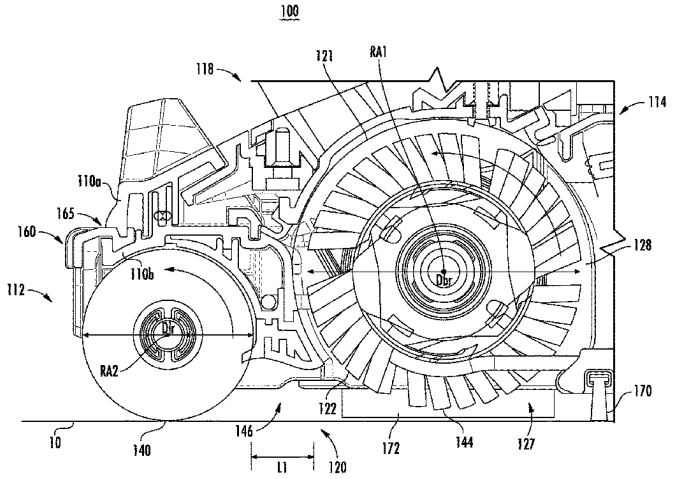

roller and are directed into or against a direction of rotation of the cleaning roller. The combing unit and protrusions have a shape and configuration designed to facilitate debris removal from the cleaning roller with minimal impact on the operation of the cleaning apparatus. The cleaning apparatus may include a surface cleaning head of an upright vacuum cleaner or sweeper or a robotic vacuum cleaner.

13 Claims, 14 Drawing Sheets

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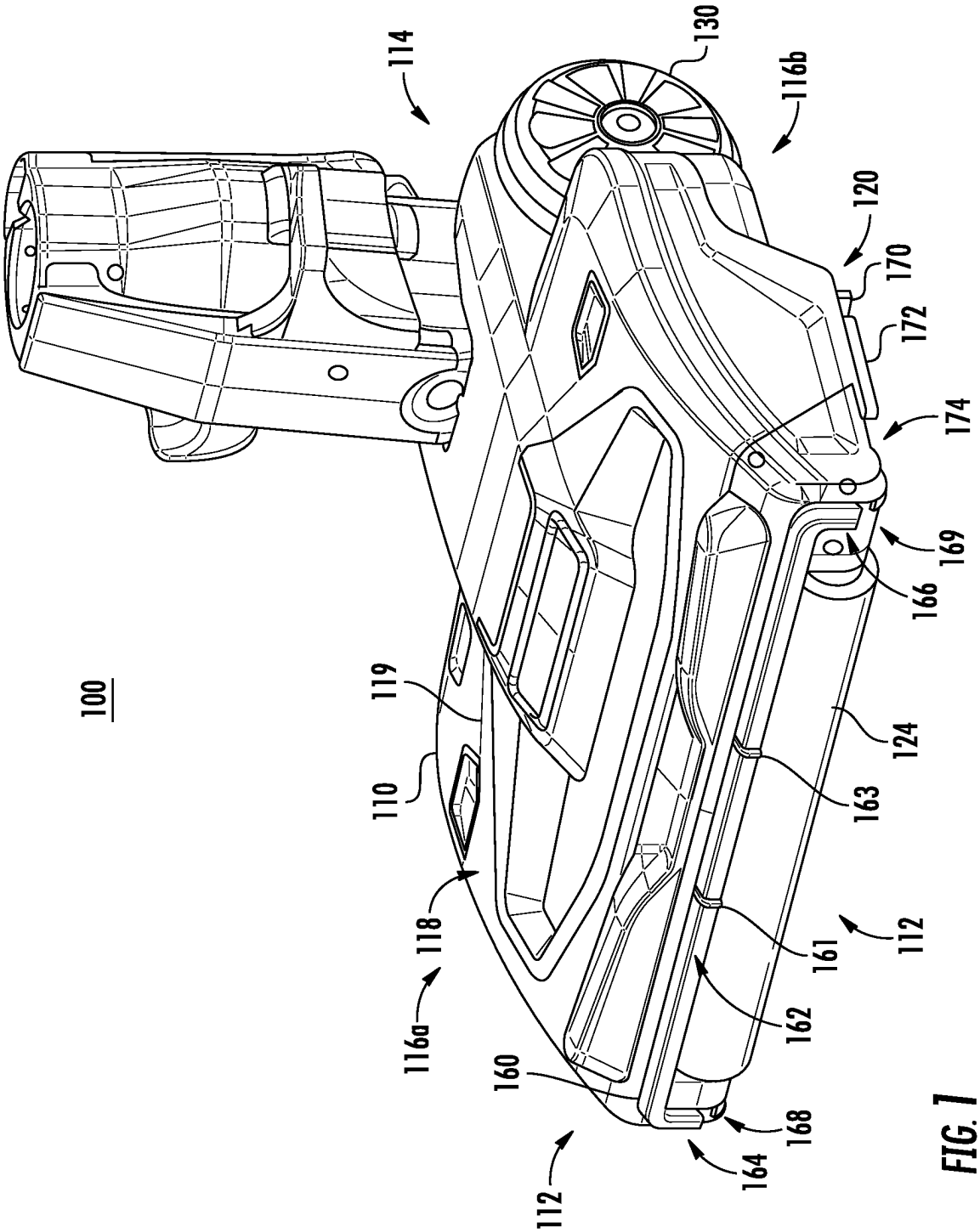
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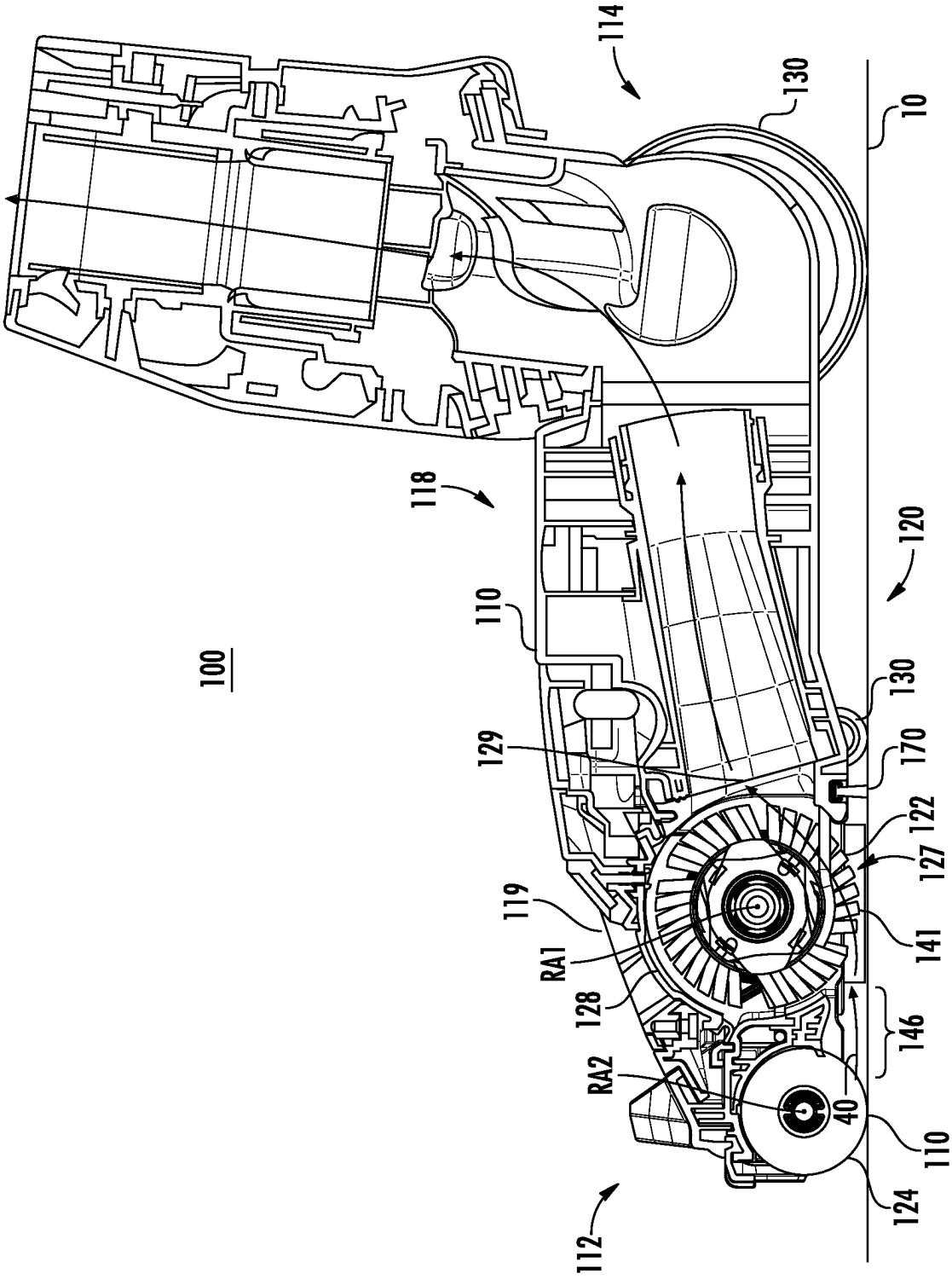
FIG. 1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122
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RA1
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FIG. 2

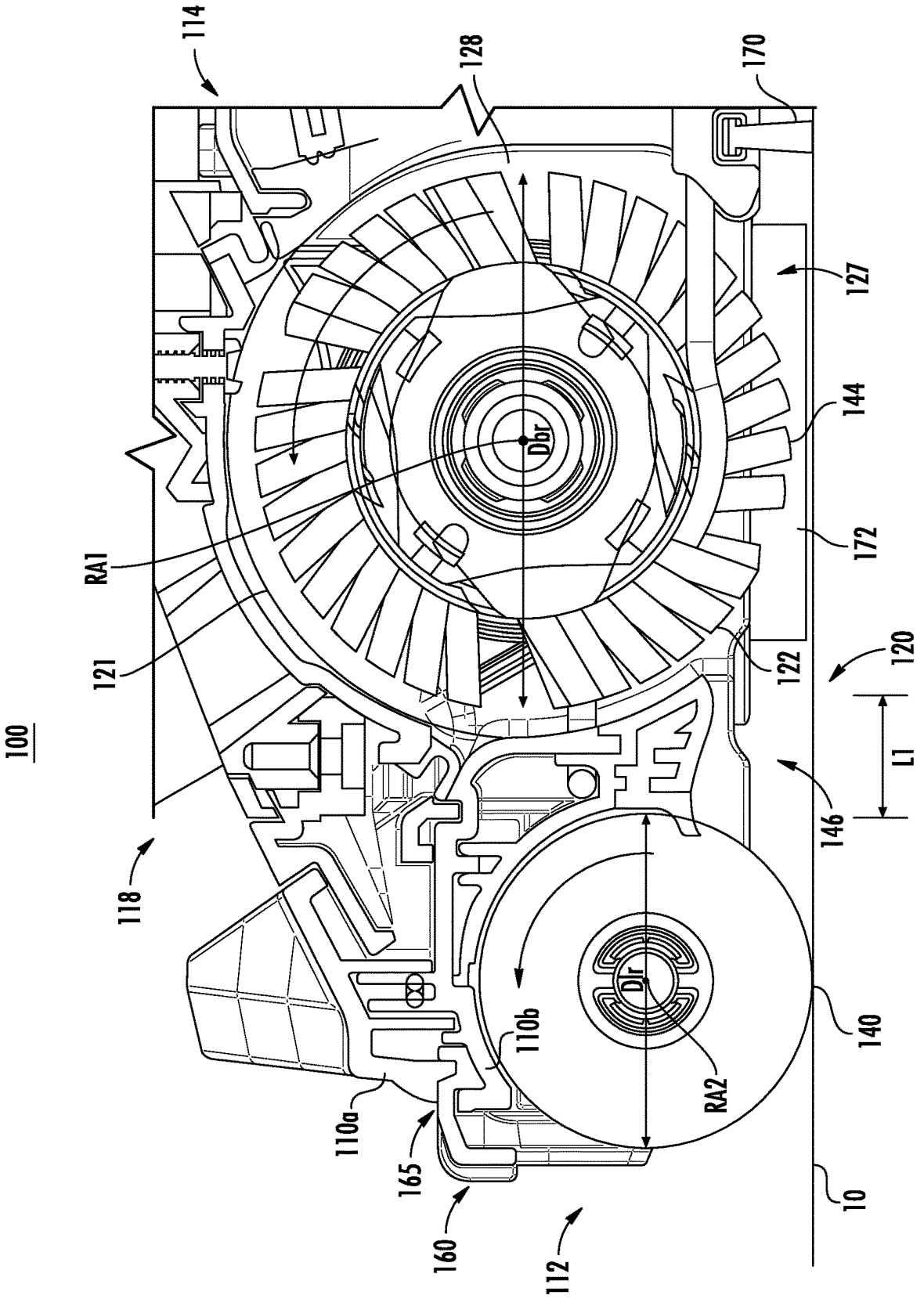
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FIG. 3

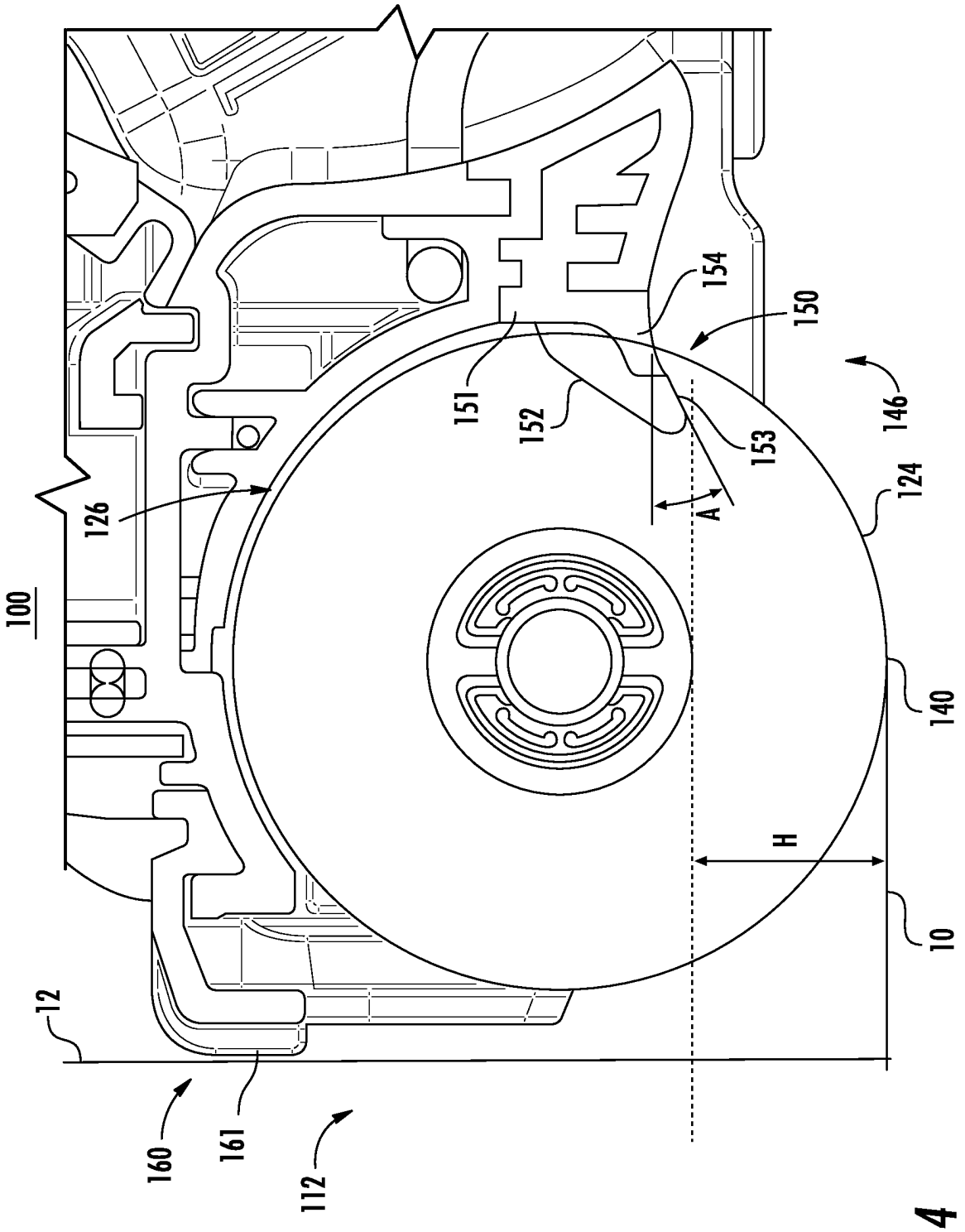

FIG. 4

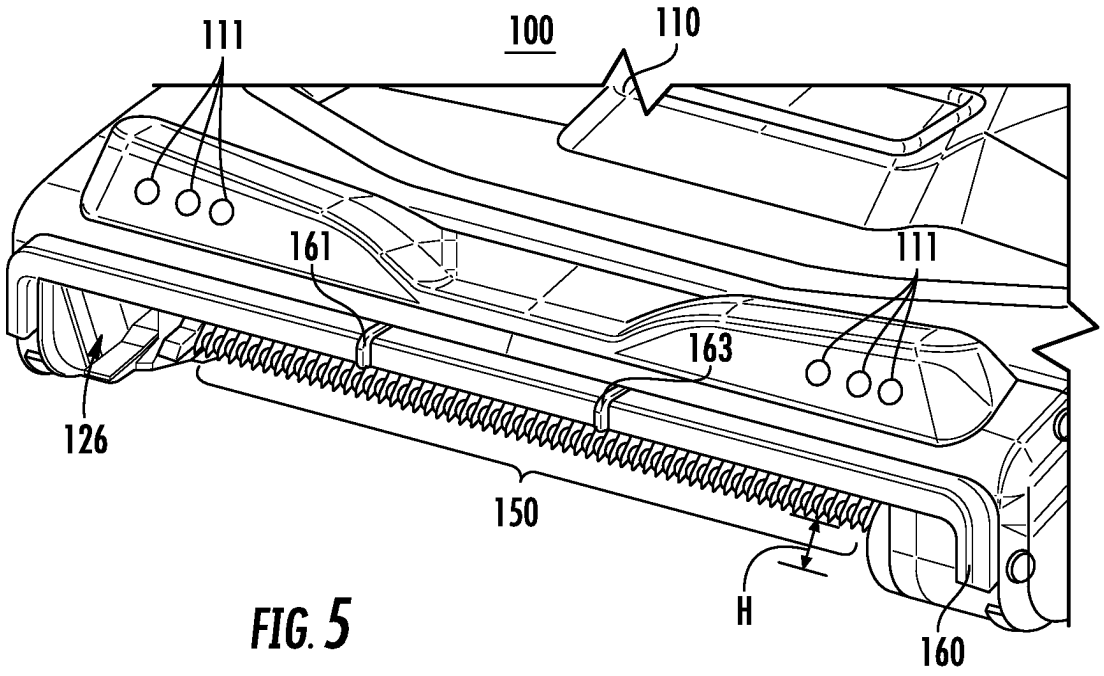

FIG. 5

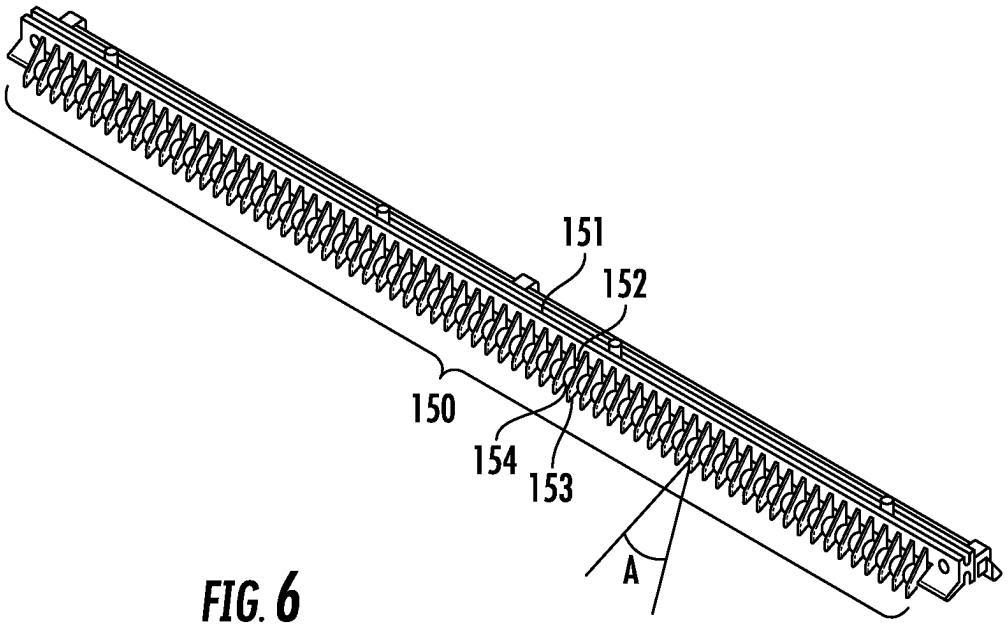

FIG. 6

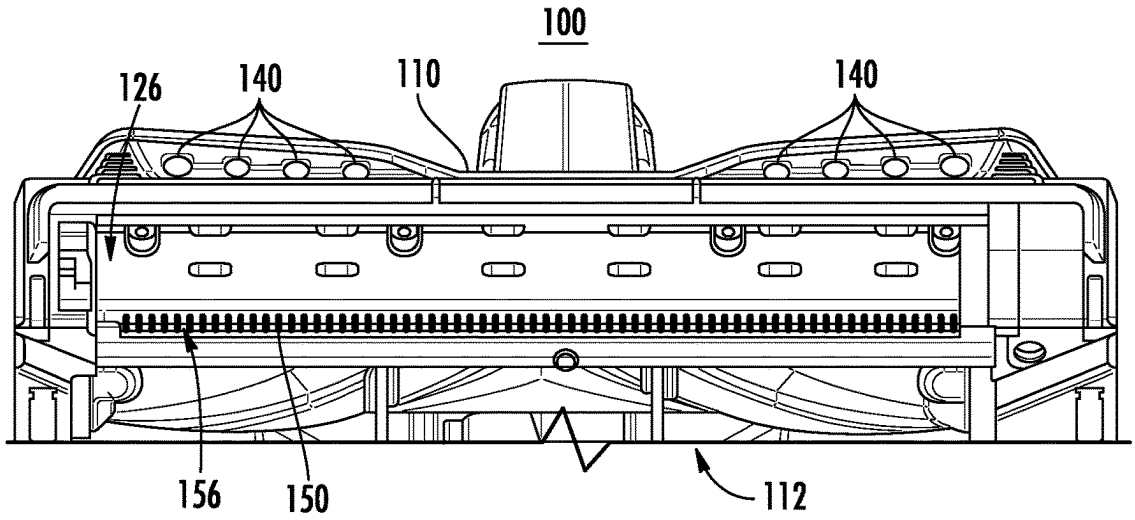
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FIG. 7

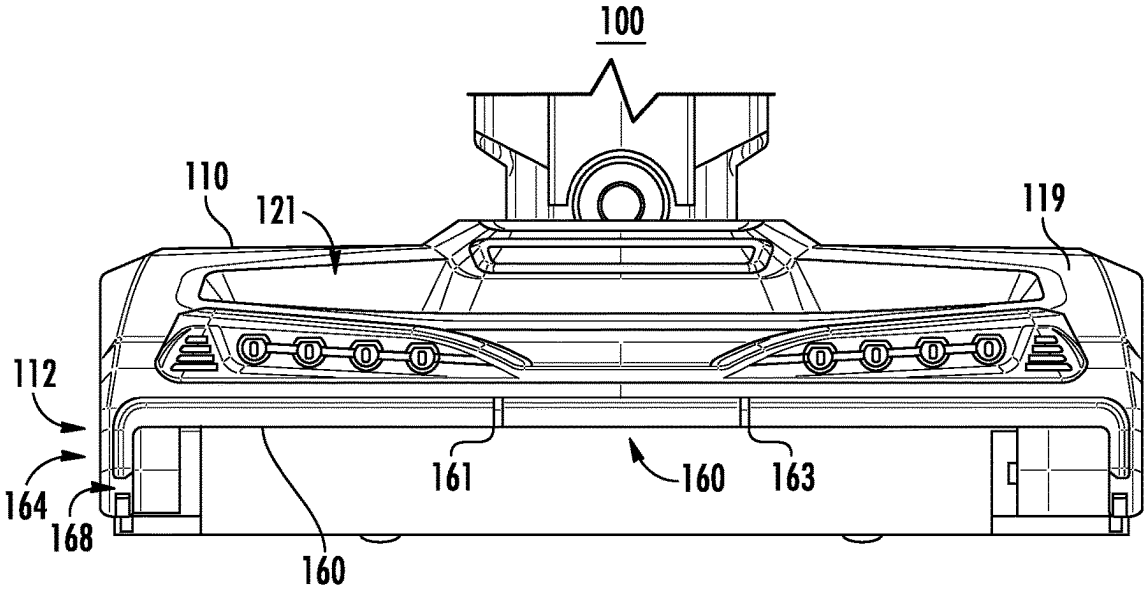
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FIG. 8

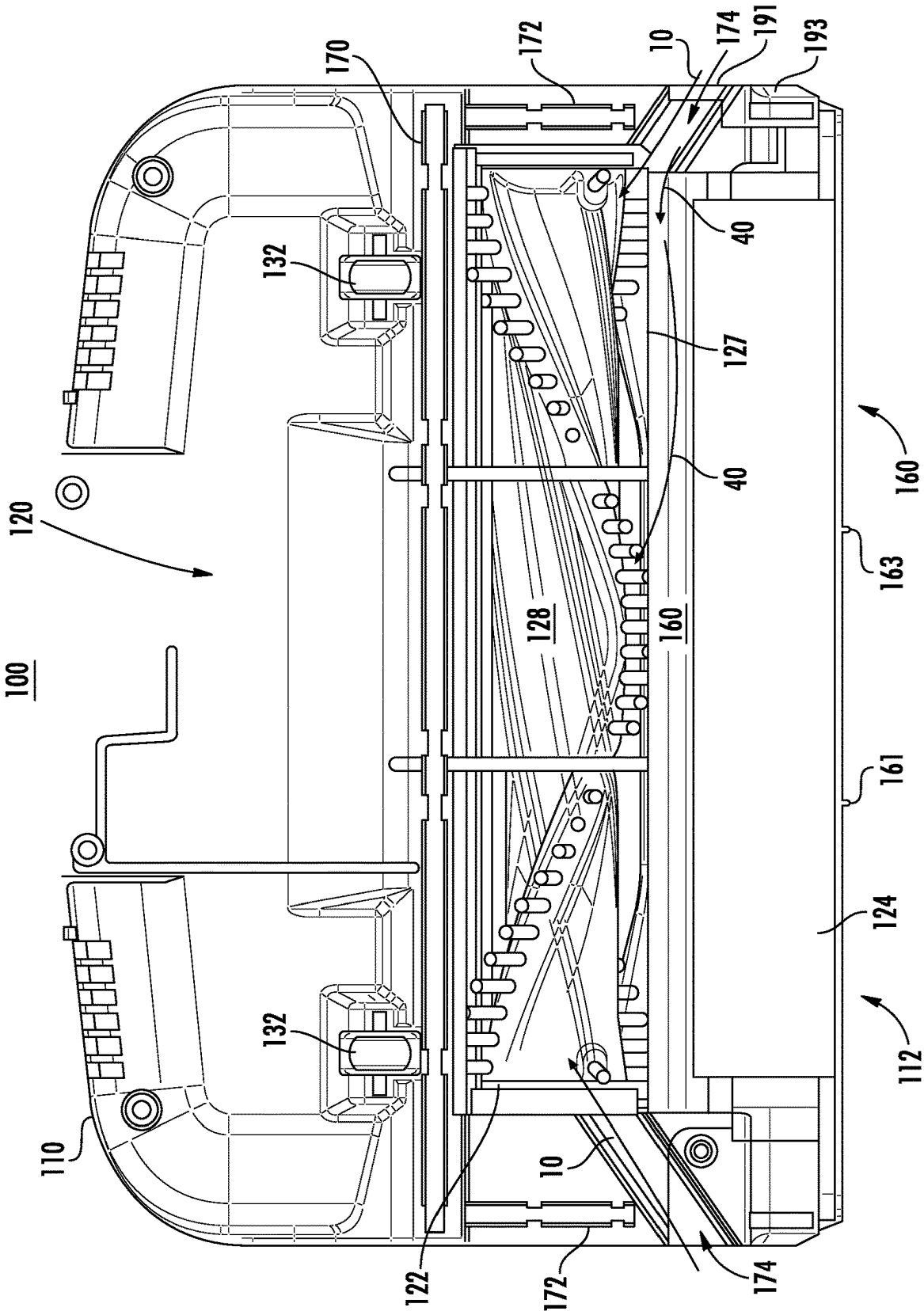
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FIG. 9

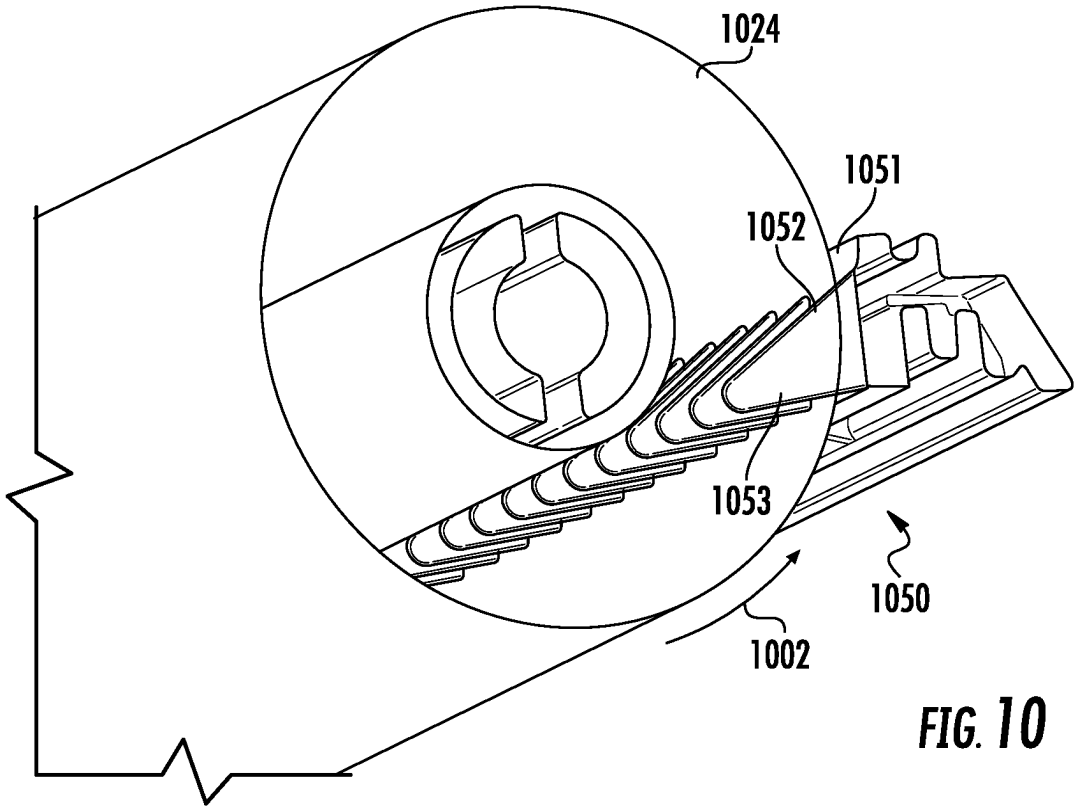
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FIG. 10

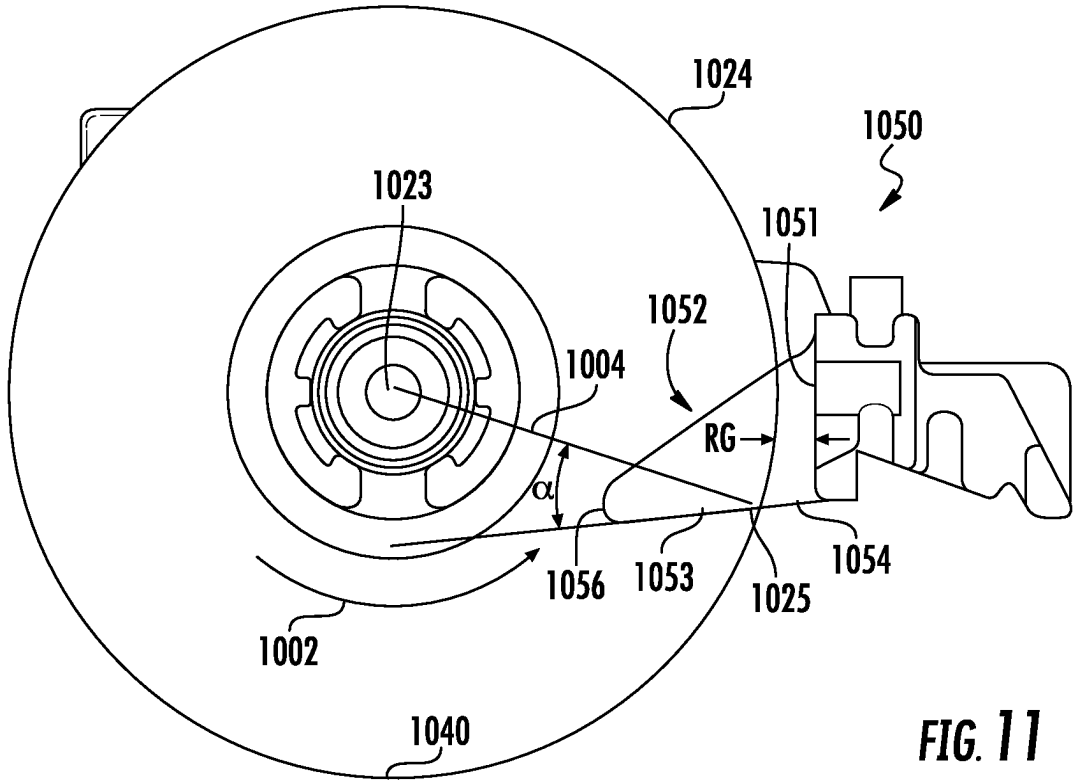
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FIG. 11

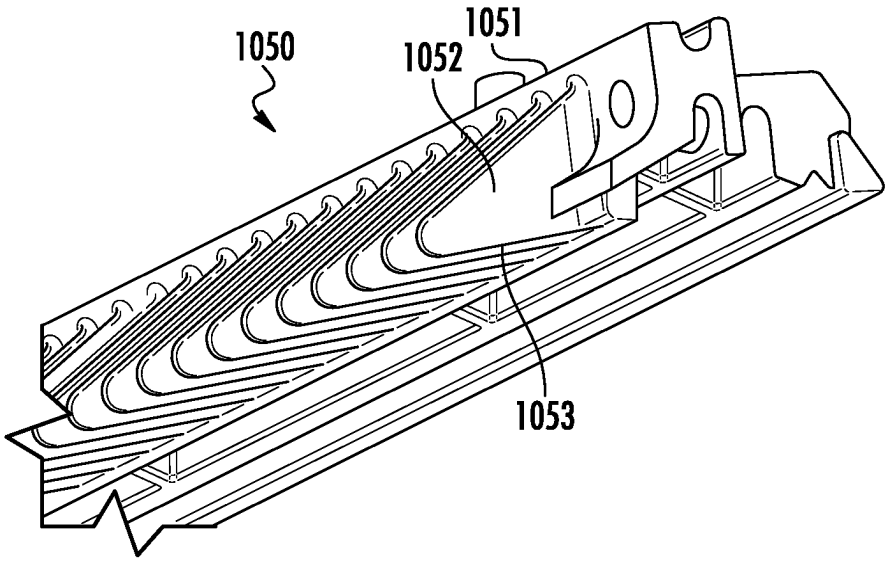

FIG. 12

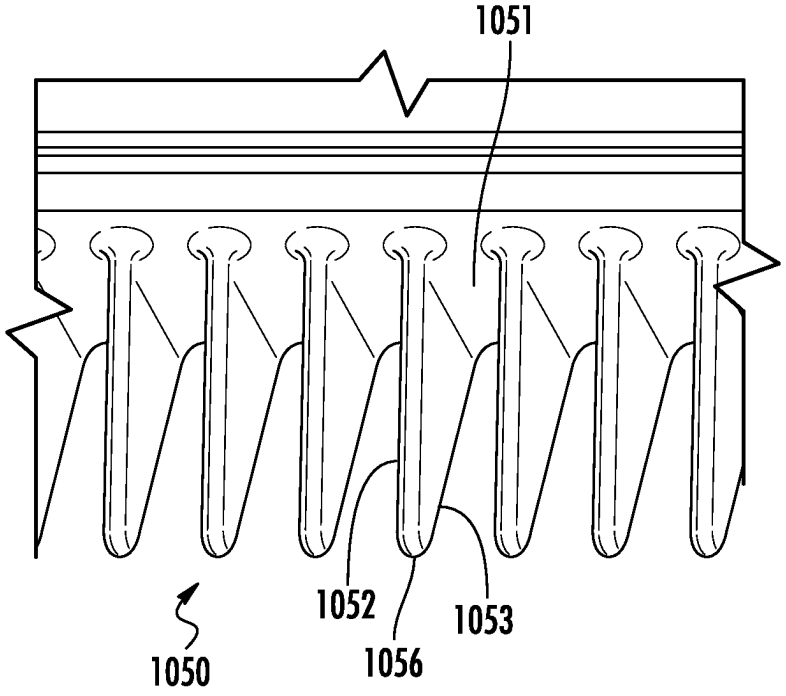

FIG. 13

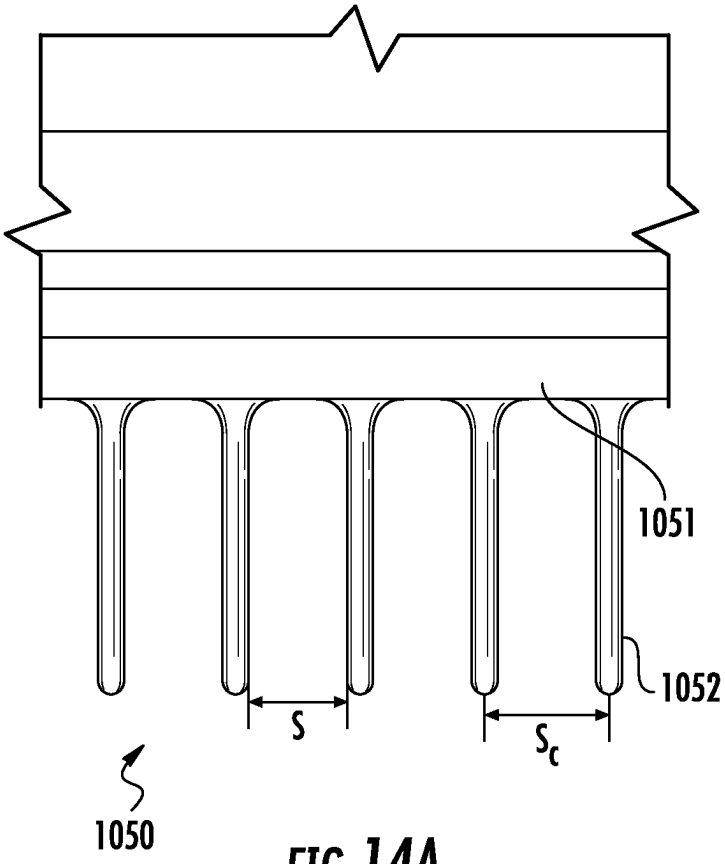

FIG. 14A

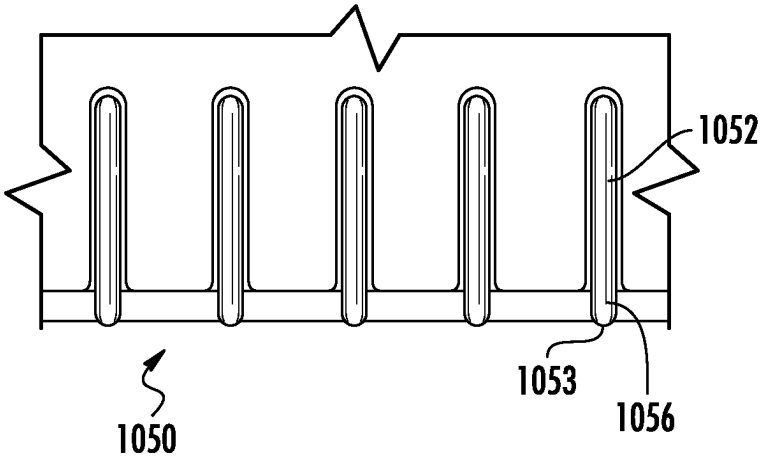

FIG. 14B

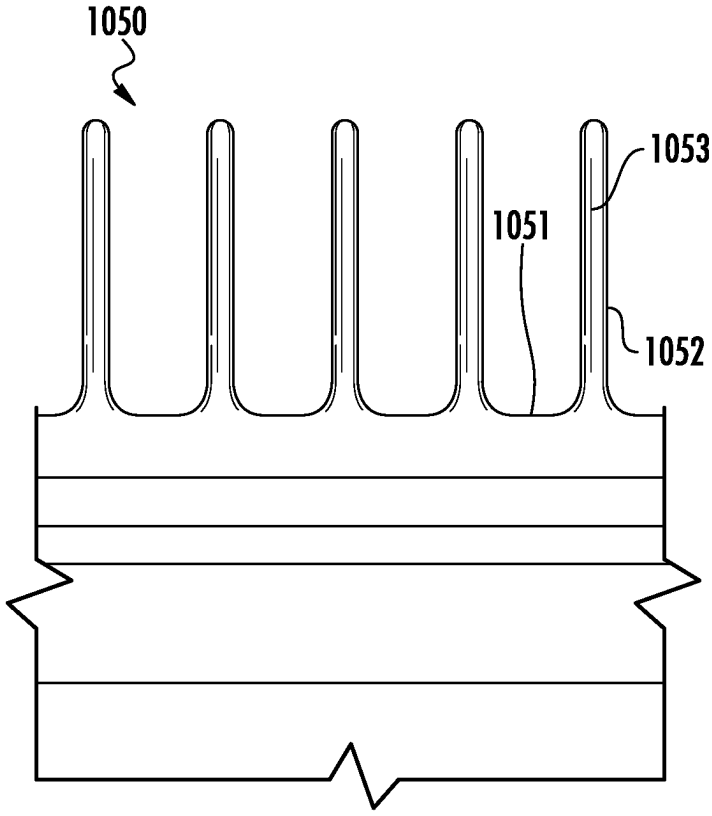

FIG. 14C

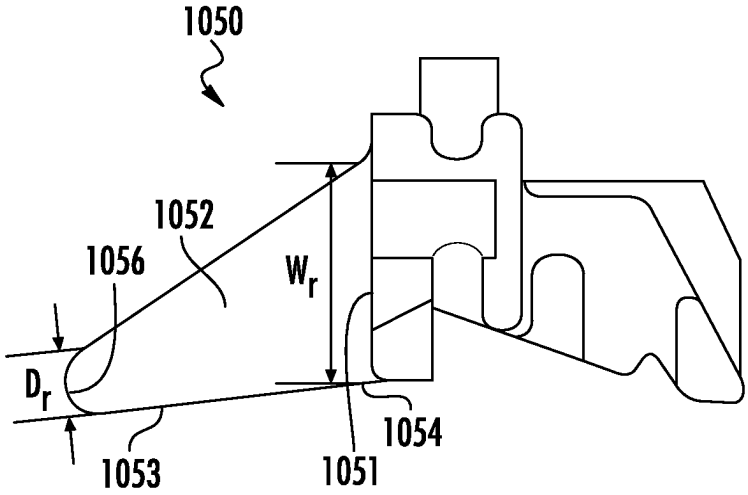

FIG. 14D

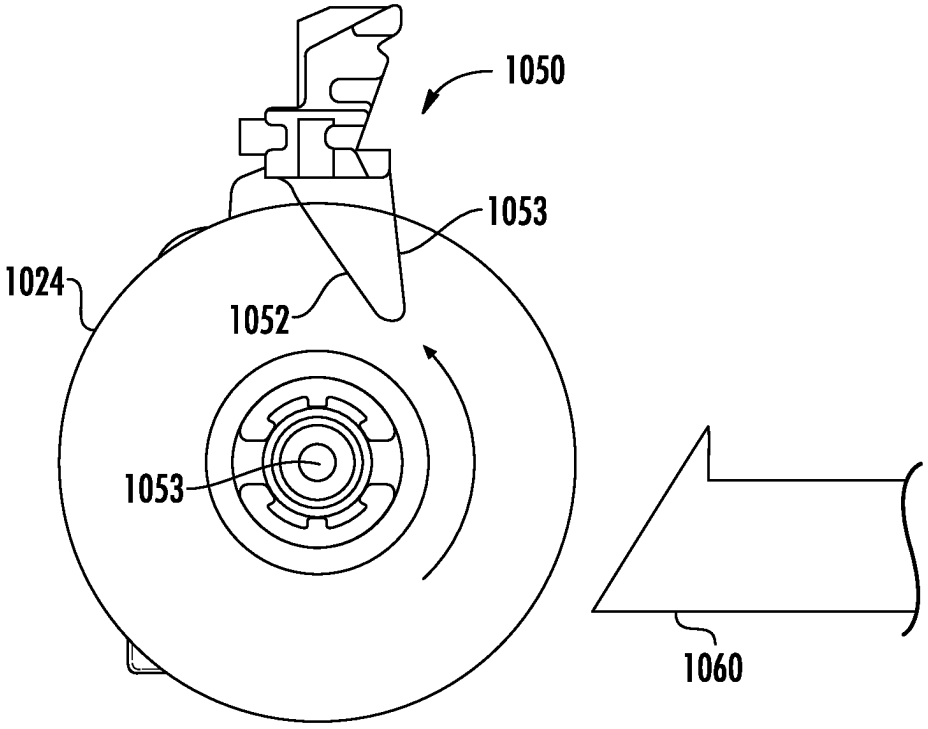

FIG. 15A

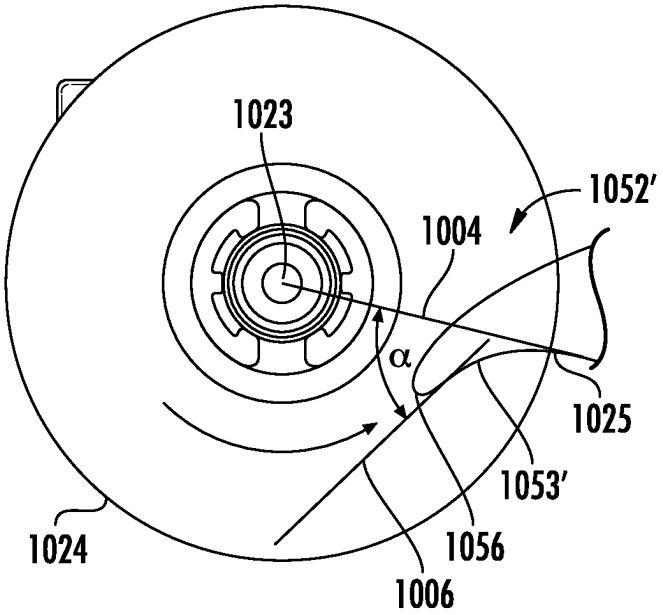

FIG. 15B

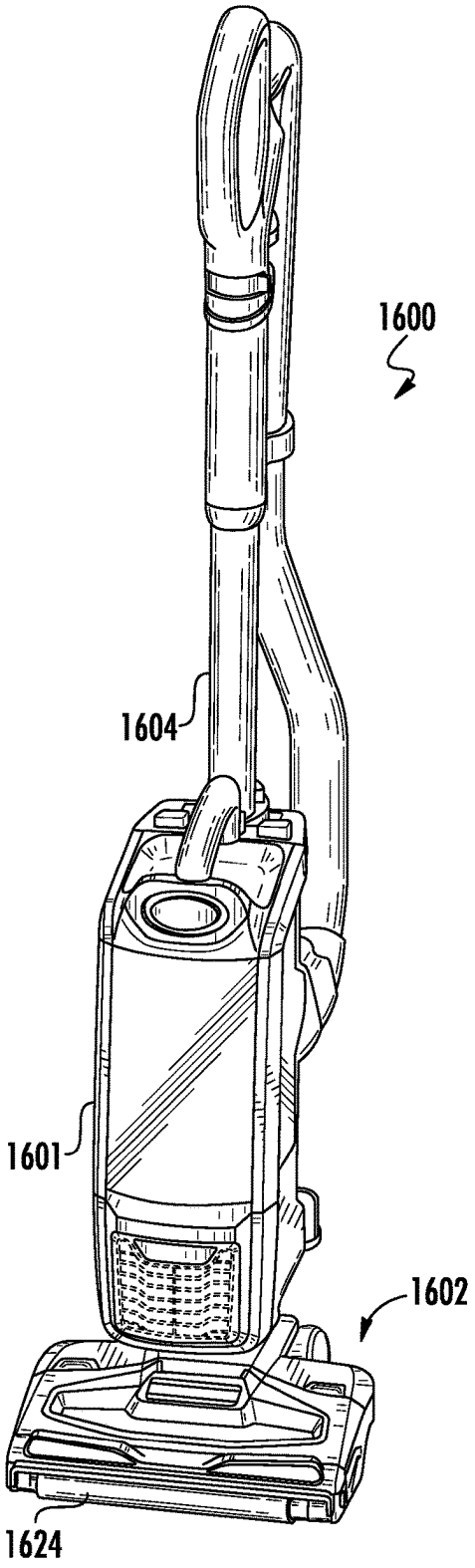

FIG. 16

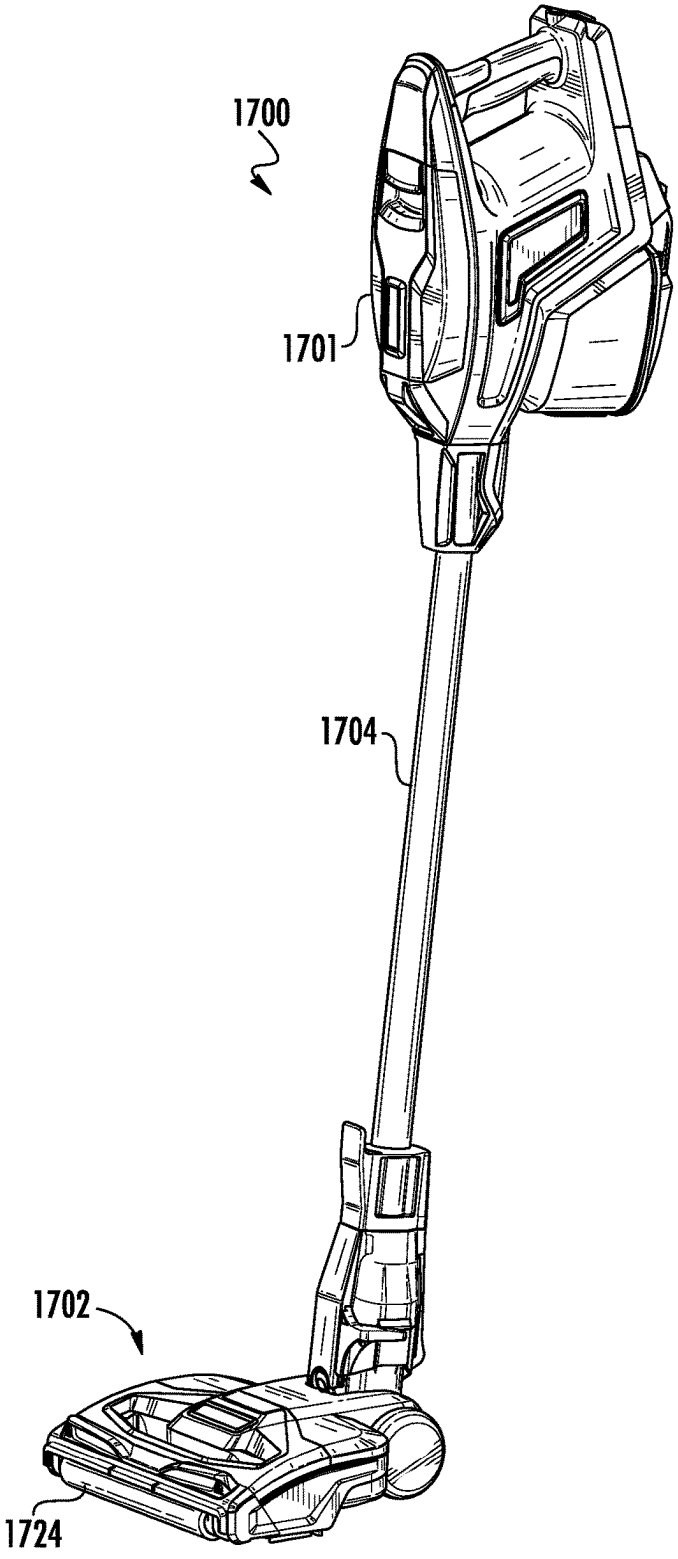

FIG. 17

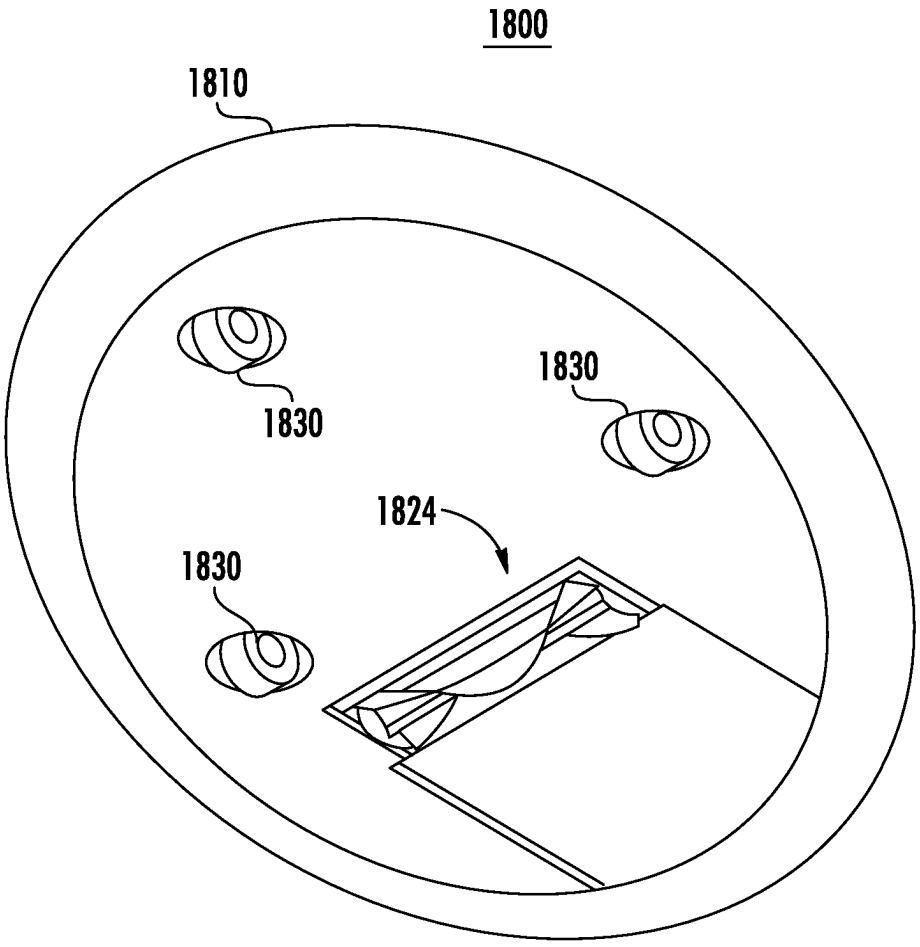

FIG. 18

CLEANING APPARATUS WITH COMBING UNIT FOR REMOVING DEBRIS FROM CLEANING ROLLER

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Application No. 62/469,853, filed Mar. 10, 2017 and is a continuation-in-part of U.S. patent application Ser. No. 15/331,045, filed Oct. 21, 2016, which claims the benefit of U.S. Provisional Patent Application Ser. No. 62/244,331 filed Oct. 21, 2015, U.S. Provisional Patent Application Ser. No. 62/248,813 filed Oct. 30, 2015, and U.S. Provisional Patent Application Ser. No. 62/313,394 filed Mar. 25, 2016, all of which are fully incorporated herein by reference. The present application is also a continuation-in-part of International Application No. PCT/US2016/058148, filed on Oct. 21, 2016, which is fully incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to cleaners with cleaning rollers and more particularly, to a cleaning apparatus, such as a surface cleaning head for a vacuum cleaner, with a combing unit for removing debris from a cleaning roller such as a leading roller.

BACKGROUND INFORMATION

Vacuum cleaners generally include a suction conduit with an opening on the underside of a surface cleaning head for drawing air (and debris) into and through the surface cleaning head. One of the challenges with vacuum cleaner design is to control engagement of the suction conduit with a surface being cleaned to provide the desired amount of suction. If the suction conduit is spaced too far from a surface, the suction may be less because the air is flowing into the suction conduit through a greater surface area. If the suction conduit is directly engaged with the surface and thus scaled on all sides, air will stop flowing into the suction conduit and the suction motor may be damaged as a result.

Vacuum cleaners also generally use agitation to loosen debris and facilitate capturing the debris in the flow of air into the suction conduit. Agitators are often used in the suction conduit of a surface cleaning head proximate a dirty air inlet to cause the agitated debris to flow into the dirty air inlet. If the agitator in the suction conduit is unable to loosen the debris or if the debris is too small, the suction conduit may pass over the debris without removing the debris from the surface. In other cases, the surface cleaning head may push larger debris forward without ever allowing the debris to be captured in the flow into the suction conduit (sometimes referred to as snowplowing).

One example of an agitator is a cleaning roller such as a brush roll. A cleaning roller may be located within a suction conduit and/or may be located at a leading side of a suction conduit (e.g., a leading roller). One challenge with a leading roller in particular is the debris (e.g., hair) that becomes entangled around the roller. Projections may be used to engage the roller to facilitate removal of debris, but existing structures are often not effective and/or interfere with the operation of the surface cleaning head.

SUMMARY

Consistent with an embodiment, a cleaning apparatus includes a housing defining an opening on an underside of the housing for receiving debris, a cleaning roller mounted in the housing for directing debris into the opening, and a combing unit extending a substantial length of a cleaning surface of the cleaning roller and in contact with the cleaning roller. The combing unit includes a series of spaced combing protrusions extending partially into the cleaning roller and having angled leading edges that are not aligned with a center of rotation of the cleaning roller. The angled leading edges are directed into a direction of rotation of the cleaning roller.

Consistent with another embodiment, a surface cleaning head includes a housing having a front side and back side. The housing defines a suction conduit with an opening on an underside of the housing between the front side and the back side. A brush roll is rotatably mounted to the housing within the suction conduit and at least a portion of the brush roll is proximate the opening of the suction conduit. A leading roller is mounted to the housing in front of the brush roll and adjacent the opening of the suction conduit. A front portion of the leading roller is at least partially exposed at the front side of the housing. The surface cleaning head also includes a combing unit extending a substantial length of a cleaning surface of the leading roller and in contact with the leading roller. The combing unit includes a series of spaced combing protrusions extending partially into the leading roller and having angled leading edges that are not aligned with a center of rotation of the leading roller. The angled leading edges are directed toward a direction of rotation of the leading roller.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages will be better understood by reading the following detailed description, taken together with the drawings wherein:

FIG. **1** is a perspective view of a surface cleaning head including dual agitators and combing protrusions, consistent with an embodiment of the present disclosure.

FIG. **2** is a side cross-sectional view of the surface cleaning head shown in FIG. **1** showing a flow path through a suction conduit.

FIG. **3** is an enlarged side cross-sectional view illustrating the leading roller and brush roll of the surface cleaning head shown in FIG. **1**.

FIG. **4** is an enlarged side cross-sectional view illustrating a leading roller and combing protrusions in the surface cleaning head shown in FIG. **1**.

FIG. **5** is a front perspective view of the front region of the surface cleaning head of FIG. **1** without the leading roller and illustrating the combing protrusions.

FIG. **6** is an enlarged perspective view of one embodiment of a plurality of combing protrusions.

FIG. **7** is a front bottom view of the front region of the surface cleaning head of FIG. **1** without the leading roller.

FIG. **8** is a front view the surface cleaning head of FIG. **1**.

FIG. **9** is a bottom view the surface cleaning head of FIG. **1**.

FIG. **10** is a perspective cross sectional view of combing protrusions engaging a cleaning roller, consistent with an embodiment of the present disclosure.

FIG. **11** is a side cross-sectional view of the combing protrusions engaging the cleaning roller.

FIG. **12** is a side perspective view of the combing protrusions shown in FIG. **10**.

FIG. **13** is a top perspective view of a section of the combing protrusions shown in FIG. **10**.

FIGS. **14**A-**14**D are top, front, bottom and side views of the section of combing protrusions shown in FIG. **13**.

FIG. **15**A is a side cross-sectional view of the combing protrusions engaging a cleaning roller above an axis of rotation, consistent with another embodiment.

FIG. **15**B is a side cross-sectional view of a combing protrusion having a curved leading edge engaging a cleaning roller, consistent with a further embodiment.

FIG. **16** is a perspective view of an upright vacuum cleaner including a surface cleaning head with dual rotating agitators and combing protrusions, consistent with embodiments of the present disclosure.

FIG. **17** is a perspective view of a stick type vacuum cleaner including a surface cleaning head with dual rotating agitators and combing protrusions, consistent with embodiments of the present disclosure.

FIG. **18** is a bottom perspective view of a robotic vacuum cleaner including a cleaning roller and combing protrusions, consistent with yet another embodiment of the present disclosure.

DETAILED DESCRIPTION

A cleaning apparatus, consistent with embodiments of the present disclosure, includes a combing unit (also referred to as a debriding unit or rib) including a series of spaced protrusions or teeth extending into a cleaning roller for preventing build up and removing debris (such as hair, string, and the like). The protrusions extend along a substantial portion of the cleaning roller and extend partially into the cleaning roller to intercept the debris as it passes around the roller. The protrusions have angled leading edges that are not aligned with a rotation center of the cleaning roller and are directed into or against a direction of rotation of the cleaning roller. The combing unit and protrusions have a shape and configuration designed to facilitate debris removal from the cleaning roller with minimal impact on the operation of the cleaning apparatus. The cleaning apparatus may include a surface cleaning head of an upright vacuum cleaner or sweeper or a robotic vacuum cleaner.

An embodiment of a surface cleaning head may include dual rotating agitators (e.g., a leading roller and a brush roll) and may be used to facilitate capturing of debris in the air flow into a suction conduit on the underside of the surface cleaning head. In this embodiment, the leading roller is generally positioned adjacent to and in advance of the opening of the suction conduit such that the leading roller engages debris and moves the debris toward the opening. At least a top half of the leading roller may be substantially outside of the flow path to the suction conduit and a bottom portion of the leading roller may be exposed to the flow path to the suction conduit. The rotating brush roll may be located in the suction conduit with the leading roller located in front of and spaced from the brush roll, forming an inter-roller air passageway between lower portions of the leading roller and the brush roll. In some embodiments, combing protrusions may contact the leading roller above the inter-roller air passageway to facilitate debris removal into the flow path. The surface cleaning head may also include a leading bumper that extends in front of the leading roller to protect a front portion of the leading roller and facilitate front edge cleaning.

Although specific embodiments of a surface cleaning head with a leading roller are shown, other embodiments of a cleaning apparatus with a combing unit are within the scope of the present disclosure. The cleaning apparatus with the combing unit may be used in different types of vacuum cleaners including, without limitation, an "all in the head" type vacuum, upright vacuum cleaners, canister vacuum cleaners, stick vacuum cleaners, robotic vacuum cleaners and central vacuum systems, and may be used in sweepers (e.g., low or no suction). The surface cleaning head with a leading roller may also include removable agitators (e.g., brush rolls) in openable agitator chambers, such as the type described in greater detail in U.S. Pat. No. 9,456,723 and U.S. Patent Application Pub. No. 2016/0220082, which are commonly-owned and fully incorporated herein by reference. The leading roller may be similarly removable.

As used herein, a "surface cleaning head" refers to a device configured to contact a surface for cleaning the surface by use of suction air flow, agitation, or a combination thereof. A surface cleaning head may be pivotably or steeringly coupled by a swivel connection to a wand for controlling the surface cleaning head and may include motorized attachments as well as fixed surface cleaning heads. A surface cleaning head may also be operable without a wand or handle. As used herein, "seal" or "sealing" refers to preventing a substantial amount of air from passing through to the suction conduit but does not require an air tight seal. As used herein, "agitator" refers to any element, member or structure capable of agitating a surface to facilitate movement of debris into a suction air flow in a surface cleaning head. As used herein, "soft" and "softer" refer to the characteristics of a cleaning element being more compliant or pliable than another cleaning element. As used herein, the term "flow path" refers to the path taken by air as it flows into a suction conduit when drawn in by suction. As used herein, the terms "above" and "below" are used relative to an orientation of the surface cleaning head on a surface to be cleaned and the terms "front" and "back" are used relative to a direction that a user pushes the surface cleaning head on a surface being cleaned (i.e., back to front). As used herein, the term "leading" refers to a position in front of at least another component but does not necessarily mean in front of all other components.

Referring to FIGS. **1**-**9**, an embodiment of a surface cleaning head **100** with dual agitators and a combing unit is shown and described. The surface cleaning head **100** includes a housing **110** with a front side **112**, and a back side **114**, left and right sides **116***a*, **116***b*, an upper side **118**, and a lower or under side **120**. The housing **110** defines a suction conduit **128** having an opening **127** on the underside **120** of the housing (shown in FIGS. **2** and **3**). The suction conduit **128** is fluidly coupled to a dirty air inlet **129**, which leads to a suction motor (not shown) either in the surface cleaning head **100** or another location in the vacuum. The suction conduit **128** is the interior space defined by interior walls in the housing **110**, which receives and directs air drawn in by suction, and the opening **127** is where the suction conduit **128** meets the underside **120** of the housing **110**.

The surface cleaning head **100** includes dual rotating agitators **122**, **124**, for example, a brush roll **122** and a leading roller **124**. The brush roll **122** and leading roller **124** may be configured to rotate about first and second rotating axes (RA**1**, RA**2**). The rotating brush roll **122** is at least partially disposed within the suction conduit **128** (shown in FIGS. **2** and **3**). The leading roller **124** is positioned in front of and spaced from the brush roll **122** and at least substantially outside the suction conduit **128**. In some embodiments, at least an inside upper portion (e.g., upper half) of the leading roller **124** is not exposed to the primary air flow path (e.g., arrow **40**) into the opening **127** of the suction conduit **128** while at least an inside of the bottom portion of the

leading roller **124** is exposed to the primary flow path into the opening **127** of the suction conduit **128**.

Other variations are possible where different portions of the leading roller **124** may be exposed or not exposed to the flow path into the suction conduit **128**. In other embodiments, for example, a flow path may allow air to flow over the upper portion of the leading roller **124**. The leading roller **124** may rotate about the second rotation axis RA**2** located within a leading roller chamber **126**. The leading roller chamber **126** may have a size and shape slightly larger than the cylindrical projection of the leading roller **124** when the leading roller **124** is rotating therein, for example, to form the flow path over the upper portion.

The surface cleaning head **100** may include one or more wheels **130** for supporting the housing on the surface **10** to be cleaned. The brush roll **122** may be disposed in front of one or more wheels **130**, **132** (see FIGS. **1** and **9**) for supporting the housing **110** on the surface **10** to be cleaned. For example, one or more larger wheels **130** may be disposed along the back side **114** and/or one or more smaller middle wheels **132** may be provided at a middle section on the underside **116** of the housing **110** and/or along the left and right sides **116***a*, **116***b*. Other wheel configurations may also be used. The wheels **130**, **132** facilitate moving the surface cleaning head **100** along the surface **10** to be cleaned, and may also allow the user to easily tilt or pivot the surface cleaning head **100** (e.g., brush roll **122** and/or the leading roller **124**) off of the surface **10** to be cleaned. The rear wheel(s) **130** and the middle wheel(s) **132** may provide the primary contact with the surface being cleaned and thus primarily support the surface cleaning head **100**. When the surface cleaning head **100** is positioned on the surface **10** being cleaned, the leading roller **124** may also rest on the surface **10** being cleaned. In other embodiments, the leading roller **124** may be positioned such that the leading roller **124** sits just above the surface being cleaned.

The rotating brush roll **122** may have bristles, fabric, or other cleaning elements, or any combination thereof around the outside of the brush roll **122**. Examples of brush rolls and other agitators are shown and described in greater detail in U.S. Pat. No. 9,456,723 and U.S. Patent Application Pub. No. 2016/0220082, which are fully incorporated herein by reference.

The leading roller **124** may include a relatively soft material (e.g., soft bristles, fabric, felt, nap or pile) arranged in a pattern (e.g., a spiral pattern) to facilitate capturing debris, as will be described in greater detail below. The leading roller **124** may be selected to be substantially softer than that of the brush roll **122**. The softness, length, diameter, arrangement, and resiliency of the bristles and/or pile of the leading roller **124** may be selected to form a seal with a hard surface (e.g., but not limited to, a hard wood floor, tile floor, laminate floor, or the like), whereas the bristles of the brush roll **122** may selected to agitate carpet fibers or the like. For example, the leading roller **124** may be at least 25% softer than the brush roll **122**, alternatively the leading roller **124** may be at least 30% softer than the brush roll **122**, alternatively the leading roller **124** may be at least 35% softer than the brush roll **122**, alternatively the leading roller **124** may be at least 40% softer than the brush roll **122**, alternatively the leading roller **124** may be at least 50% softer than the brush roll **122**, alternatively the leading roller **124** may be at least 60% softer than the brush roll **122**. Softness may be determined, for example, based on the pliability of the bristles or pile being used.

The size and shape of the bristles and/or pile may be selected based on the intended application. For example, the leading roller **124** may include bristles and/or pile having a length of between 5 to 15 mm (e.g., 7 to 12 mm) and may have a diameter of 0.01 to 0.04 mm (e.g., 0.01-0.03 mm). According to one embodiment, the bristles and/or pile may have a length of 9 mm and a diameter of 0.02 mm. The bristles and/or pile may have any shape. For example, the bristles and/or pile may be linear, arcuate, and/or may have a compound shape. According to one embodiment, the bristles and/or pile may have a generally U and/or Y shape. The U and/or Y shaped bristles and/or pile may increase the number of points contacting the floor surface **10**, thereby enhancing sweeping function of leading roller **124**. The bristles and/or pile may be made on any material such as, but not limited to, Nylon 6 or Nylon 6/6.

Optionally, the bristles and/or pile of leading roller **124** may be heat treated, for example, using a post weave heat treatment. The heat treatment may increase the lifespan of the bristles and/or pile of the leading roller **124**. For example, after weaving the fibers and cutting the velvet into rolls, the velvet may be rolled up and then run through a steam rich autoclave making the fibers/bristles more resilient fibers.

The leading roller **124** may have an outside diameter Dlr that is smaller than the outside diameter Dbr of the brush roll **122**. For example, the diameter Dlr may be greater than zero and less than or equal to 0.8Dbr, greater than zero and less than or equal to 0.7Dbr, or greater than zero and less than or equal to 0.6Dbr. According to example embodiments, the diameter Dlr may be in the range of 0.3Dbr to 0.8Dbr, in the range of 0.4Dbr to 0.8Dbr, in the range of 0.3Dbr to 0.7Dbr, or in the range of 0.4Dbr to 0.7Dbr. As an illustrative example, the brush roll **122** may have an outside diameter of 48 mm and the leading roller **124** may have an outside diameter of 30 mm. While the leading roller **124** may have an outside diameter Dlr that is smaller than the outside diameter Dbr of the brush roll **122**, the brush roll **122** may have bristles that are longer than the bristle and/or pile of the leading roller **122**.

Positioning a leading roller **124** (having a diameter Dlr that is smaller than the diameter Dbr of the brush roll **122**) in front of the brush roll **122** provides numerous benefits. For example, this arrangement decreases the height of the front side **112** of the surface cleaning head **100** (e.g., the housing **110**) from the surface **10** to be cleaned. The decreased height of the front of the surface cleaning head **100** provides a lower profile that allows the surface cleaning head **100** to fit under objects (e.g., furniture and/or cabinets). Moreover, the lower height allows for the addition of one or more light sources **111** (such as, but not limited to, LEDs), while still allowing the surface cleaning head **100** to fit under objects.

Additionally, the smaller diameter Dlr of the leading roller **124** allows the rotating axis of the leading roller **124** to be placed closer to the front side **112** of the surface cleaning head **100**. When rotating, the leading roller **124** forms a generally cylindrical projection having a radius that is based on the overall diameter of the leading roller **124**. As the diameter of the leading roller **124** decreases, the bottom contact surface **140** (FIG. **3**) of the leading roller **124** moves forward towards the front side **112** of the surface cleaning head **100**. In addition, when the surface cleaning head **100** contacts a vertical surface **12** (e.g., but not limited to, a wall, trim, and/or cabinet), the bottom contact surface **140** of the leading roller **124** is also closer to the vertical surface **12**, thereby enhancing the front edge cleaning of the surface cleaning head **100** compared to a larger diameter leading roller. Moreover, the smaller diameter Dlr of the leading

roller **124** also reduces the load/drag on the motor driving the leading roller **124**, thereby enhancing the lifespan of the motor and/or allowing a smaller motor to be used to rotate both the brush roll **122** and leading roller **124**.

The rotating brush roll **122** may be coupled to an electrical motor (either AC or DC) to cause the rotating brush roll **122** to rotate about the first rotating axis. The rotating brush roll may be coupled to the electrical motor by way of a gears and/or drive belts. The leading roller **124** may be driven from the same drive mechanism used to drive the rotating brush roll **122** or a separate drive mechanism. An example of the drive mechanism is described in U.S. patent application Ser. No. 15/331,045, filed Oct. 21, 2016, which is incorporated herein by reference. Other drive mechanisms are possible and within the scope of the present disclosure.

In at least one embodiment, the brush roll **122** and the leading roller **124** rotate in the same direction directing debris toward the suction conduit **128**, for example, counter clockwise as shown in FIG. **3**. This arrangement may reduce the number of parts (e.g., no clutch or additional gear train may be necessary), thereby making the surface cleaning head **100** lighter, reducing drivetrain loss (thereby allowing for smaller/less expensive motors), and less expensive to manufacture. Optionally, the brush roll **122** and the leading roller **124** may rotate at same speed, thereby reducing the number of parts (e.g., no additional gear train necessary) and reducing drivetrain loss (thus, smaller/less expensive motor) and making the surface cleaning head **100** lighter and less expensive to manufacture.

As shown in FIG. **3**, the leading roller **124** may be positioned within the housing **110** such that the bottom contact surface **140** is disposed closer to the surface **10** to be cleaned compared to the bottom contact surface **144** of the brush roll **122**. This arrangement allows the leading roller **124** to contact a surface **10** (e.g., a hard surface) without the brush roll **122** contacting the hard surface **10**. As may be appreciated, the leading roller **124** is intended to pick up debris from a hard surface **10** while the brush roll **122** is intended to primarily contact a carpet surface. This arrangement is therefore beneficial since it allows the leading roller **124** to form a seal between the front **112** of the surface cleaning head **100** with the hard surface **10**, thereby enhancing airflow and suction with the hard surface **10**. Additionally, this arrangement reduces the drag/torque on the drive motor(s) since the brush roll **122** (in some embodiments) does not have to contact the hard surface **10**. The reduced drag/torque may allow for a smaller, less expensive motor and/or may increase the lifespan of the motor.

According to some embodiments, as shown in FIG. **3**, the leading roller **124** is spaced apart a distance L**1** (which is greater than 0 mm) from the brush roll **122** such that the leading roller **124** does not contact the brush roll **122**. The distance L**1** allows for an inter-roller vacuum passageway **146** between lower portions of the brush roll **122** and the leading roller **124**, which provides at least a portion of the flow path into the opening **127** of the suction conduit **128**. The inter-roller vacuum passageway **146** allows for debris that is either picked up by (and/or removed from) the leading roller **124** to be entrained in the vacuum flow generated by the surface cleaning head **100** and/or to be picked up by the brush roll **122**, thereby enhancing the cleaning efficiency of the surface cleaning head **100**. Additionally, the distance L**1** reduces the load/drag on the motor(s), thereby enhancing the lifespan of the motor(s) and/or allowing smaller motors to be used to rotate both the brush roll **122** and the leading roller **124**.

One or both of the leading roller **124** and the brush roll **122** may be removable. The leading roller **124** may be removably coupled to the housing **110** of the surface cleaning head **100**. For example, a portion of the housing **110** (such as, but not limited to, a portion of the left and/or right side **116***a*, **116***b*) may be removably/hingedly coupled thereto. To remove the leading roller **124**, the removable portion may be unsecured/uncoupled from the rest of the housing **110**, thereby allowing the leading roller **124** to disengage from a drive wheel and allowing the leading roller **124** to be removed from the leading roller chamber **126**. Other ways of removably coupling the leading roller **124** within the housing **110** are also possible and within the scope of the present disclosure.

In some embodiments, the housing **110** of the surface cleaning head **100** may include a removable and/or hinged panel that allows the brush roll **122** to be removed. A shown in FIGS. **1** and **8**, for example, the surface cleaning head **100** includes a panel **119** that may be removably and/or hingedly coupled to the housing **110**. To remove the brush roll **122**, the panel **119** may be disengaged from the housing **110** (e.g., removed) to allow the user to have access to a brush roll chamber **121**. Examples of removable panels or covers and removable brush rolls are described in greater detail in U.S. Pat. No. 9,456,723 and U.S. patent application Pub. No. 2016/0220082, which are fully incorporated herein by reference. Alternatively or additionally, the leading roller **124** may be removable in the same way. Another example of a removable leading roller is described in U.S. patent application Ser. No. 15/331,045, filed Oct. 21, 2016, which is incorporated herein by reference.

The ability to remove the brush roll **122** and/or the leading roller **124** from the surface cleaning head **100** allows the brush roll **122** and/or the leading roller **124** to be cleaned more easily and may allow the user to change the size of the brush roll **122** and/or the leading roller **124**, change type of bristles on the brush roll **122** and/or the leading roller **124**, and/or remove the brush roll **122** and/or the leading roller **124** entirely depending on the intended application.

In some embodiments, the surface cleaning head **100** may also include a series of combing protrusions **150** (also referred to as debriding protrusions) in contact with the leading roller **124**, as shown in greater detail in FIGS. **4-7**. The combing protrusions **150** may be configured to remove debris (such as, but not limited to, hair, string, and the like) that may be wrapped around and/or entrapped/entrained in/on the leading roller **124** as the surface cleaning head **100** is being used (e.g., without the user having to manually remove the debris from the leading roller **124**). According to one embodiment, the combing protrusions **150** may contact only the leading roller **124** (e.g., the combing protrusions **150** may not contact the brush roll **122**). Some of the benefits of the combing protrusions **150** only contacting the leading roller **124** include increasing the lifespan of the leading roller **124**. Additionally, the combing protrusions **150** that only contact the leading roller **124** may reduce the load/drag on the motor, thereby allowing a smaller/less expensive motor to be used and making the surface cleaning head **100** lighter and less expensive to manufacture.

In this embodiment, the combing protrusions **150** may include a plurality of spaced ribs **152** with angled edges **153** extending into contact with a surface of the leading roller **124**. The spaced ribs **152** extend from a back support **151** with base portions **154** located therebetween to reinforce the spaced ribs **152**. The back support **151** may be mounted within the leading roller chamber **126**. The angled edges **153** of the spaced ribs **152** may be arranged at an angle A (see

FIGS. **4** and **6**) that is in the range of 15-20 degrees, for example, 20-25 degrees, such as 23.5 degrees. This example structure of the combing protrusions **150** may allow for increased strength and reduced frictional loses since less points may contact the leading roller **124**. Other shapes and configurations for the combing protrusions are also within the scope of the present disclosure.

As shown in FIGS. **4** and **5**, the combing protrusions **150** may be disposed at a height H above the bottom contacting surface **140** of the leading roller **124** and on a side or lower half of the leading roller **124**. The placement of the combing protrusions **150** may help to prevent the combing protrusions **150** from contacting a carpet, thereby reducing drag on the surface cleaning head **100** and reducing the likelihood of the combing protrusions **150** damaging the carpet. This arrangement also allows the combing protrusions **150** to be exposed to the inter-roller vacuum passageway **146**, thereby enhancing the removal of debris from the leading roller **124** by the combing protrusions **150**. The combing protrusion **150** may also substantially prevent air from flowing through the combing protrusions **150** to the inside upper portion (e.g., upper half) of the leading roller **124**. In other embodiments, a space may be formed between the outer surface of the leading roller **124** and the back support **151** such that air flows downward through the combing protrusions **150** to force debris into the air flow through the inter-roller vacuum passageway **146**.

As shown in FIG. **7**, an embodiment of the surface cleaning head **100** optionally includes an electrostatic discharge element (ESD) **156**. The ESD **156** may reduce and/or prevent the buildup of electrostatic charge on the surface cleaning head **100**. The ESD **156** may include any known device for discharging electrostatic charge. According to one embodiment, the ESD **156** may include Barnet fibers woven between the openings in the back of the leading roller chamber **126**. The Barnet fibers may be arranged in close proximity to the combing protrusions **150** and/or leading roller **124** for discharging. For example, the ESD **156** may be connected to a printed circuit board assembly (PCBA) that dumps charge out to the neutral AC line.

In some embodiments, the housing **110** may further include a bumper **160** forming a top part of the front side **112** of the housing **110**, as shown in FIGS. **1**, **3**, **5**, and **8**. The bumper **160** may reduce potential damage to either the surface cleaning head **100** and/or other objects in the environment. A front portion of the leading roller **124** is exposed at the front side **112** of the housing **110**, and the bumper **160** may extend around at least a top of the leading roller **124**. In the example embodiment, the bumper **160** includes a lateral portion **162** extending laterally along the front side **112** of the housing **110** and side portions **164**, **168** extending downwardly along left and right sides of the front side **112** of the housing **110**. The side portions **164**, **168** may extend to a point at or below the second rotation axis RA**2** of the leading roller **124**.

The bumper **160** may optionally define one or more front edge vacuum passageways **168**, **169** providing at least a portion of the air flow path. As shown in FIG. **4**, the bumper **160** may therefore generally form a seal with a vertical surface **12** (e.g., wall or the like) to improve front edge cleaning. The front edge vacuum passageways **168**, **169** may allow for increased airspeed of the air being sucked into the surface cleaning head **100**, thereby enhancing front edge cleaning. The bumper **160** may also include one or more lateral air passageways disposed in the lateral portion **162**, which also allow for increased airflow along the front side **112**.

The bumper **160** may also include one or more compression elements **161**, **163** (e.g., ribs) disposed on the lateral edge/section **162**. The compression elements **161**, **163** allow for increased resiliency and cushioning of the bumper **160**. When the bumper **160** is pushed against the vertical surface **12** (FIG. **4**), the compression elements **161**, **163** contact the surface **12** first and push the bumper **160** locally farther back than the rest of the bumper **160**, thereby forming a gap on either side of the compression elements **161**, **163**. The gaps on either side of the compression elements **161**, **163** form air paths allowing air to be drawn down in front of the leading roller **124**, which may disturb dust and debris so that it can be directed into the air flow path toward the suction conduit.

The bumper **160** may be formed as one piece with the housing **110** or may be formed as a separate piece secured within a groove and/or notch **165** formed between two or more pieces (e.g., an upper and lower portion **110***a*, **110***b*) of the housing **110**, as shown in FIG. **3**. The groove and/or notch **165** may facilitate assembly of the housing **110** and the bumper **160** (e.g., between a headlight portion **110***a* and main portion **110***b* of the housing **110**).

In some embodiments, the surface cleaning head **100** may further include one or more floor sealing strips **170**, **172** and side edge vacuum passageways **174** on an underside of the housing **110**, as shown in FIGS. **1** and **9**. The floor scaling strip(s) **170**, **172** may include one or more sections extending outwardly from the housing **110** and having a length sufficient to at least partially contact the surface **10** to be cleaned. The floor seals strip(s) **170**, **172** may include soft bristles, fabric material, rubber material, or other material capable of contacting the surface being cleaned to substantially prevent air flow into the opening **127** of the suction conduit **128** from the rear side. The sealing strips **170**, **172** may also include a combination of elements or materials, such as bristles with a rubber strip extending along the strip between the bristles (e.g., with the bristles being longer than the rubber strip).

In the example embodiment, a lateral floor sealing strip **170** extends along a rear lateral portion (e.g., behind the opening **127** of the suction conduit **128**) and side sealing strips **172** extend partially along the left and right sides **116***a*, **116***b*. The side sealing strips **172** extend, for example, along a substantial portion of the opening **127** of the suction conduit **128** and are spaced from the leading roller **124** to define one or more side edge vacuum passageways **174** extending back towards the opening **127** of the suction conduit **128**. Because the leading roller **124** itself forms a seal with the surface **10** being cleaned, additional sealing strips are unnecessary along the front side **112**. Although separate strips **170**, **172** are shown, one continuous sealing strip may be used. The floor sealing strips **170**, **172** may enhance scaling between the surface cleaning head **100** and the floor **10**, thereby enhancing the vacuum efficiency.

The side edge vacuum passageways **174** may enhance the side edge cleaning efficiency of the surface cleaning head **100**. Side edge vacuum passageways **174** draw in air from the front **112** and the corner/sides **116***a*, **116***b* towards the suction conduit **128**, thereby enhancing edge cleaning as well as front cleaning. At least one of the side edge vacuum passageways **474** may also direct air into the inter-roller air passageway **146** between the leading roller **124** and the brush roll **122** to facilitate removal of debris from the leading roller **124**. As such, the side edge vacuum passageways **174** and the inter-roller air passageway **146** together provide at least a portion of the primary air flow path (e.g., as indicated by arrows **40**) into the suction conduit **128**.

The side edge vacuum passageways **174** may be arranged at an approximately 45 degree angle with respect the longitudinal axis of the housing **110**. In other embodiments, the angle of the side edge vacuum passageways **174** may be within 30 to 60 degrees with respect the longitudinal axis of the housing **110**. Although the side edge passageways are shown as angled straight passageways, other shapes and configurations (e.g., S shaped or curved) are also possible and within the scope of the present disclosure.

Referring to FIGS. **10-14**D, a combing unit **1050** used for cleaning a cleaning roller **1024** in a cleaning apparatus is described in greater detail. The cleaning roller **1024** may be rotatably mounted in a housing, such as the surface cleaning head housing described above, with the combing unit **1050** engaging the cleaning roller **1024**. The combing unit **1050** includes a series of spaced combing protrusions or teeth **1052** extending from a back support **1051** and extending partially into the cleaning roller **1024**. Although the illustrated embodiment shows the combing unit **1050** with teeth **1052** extending from a single back support **1051**, the combing unit **1050** may also include teeth extending from multiple back supports.

The combing unit **1050** may extend along a substantial portion of a length of the cleaning roller **1024** (i.e., more than half) such that the combing teeth **1052** remove debris from a substantial portion of the cleaning surface of the cleaning roller **1024**. In an embodiment, the combing teeth **1052** may engage the cleaning surface of the cleaning roller **1024** along, for example, greater than 90% of a length of the cleaning surface of the cleaning roller **1024**. The combing unit **1050** works particularly well with cleaning rollers that are designed to move hair and other similar debris away from a center of the roller **1024**.

The combing teeth **1052** have angled leading edges **1053** that are not aligned with a rotation center **1023** of the cleaning roller **1024**. The angled leading edges **1053** are the edges that an incoming portion of the rotating cleaning roller **1024** hits first and are directed toward or into a direction of rotation (i.e., into arrow **1002**) of the cleaning roller **1020**. More specifically, the leading edge **1053** of a combing tooth **1052** forms an acute angle α relative to a line **1004** extending from an intersection point **1025** where the leading edge **1053** intersects with an outer surface of the cleaning roller **1024** to the rotation center **1023**. In some embodiments, the angle α is in a range of 5° to 50° and more specifically in a range of 20° to 30° and even more specifically about 24° to 25°.

In some embodiments, the combing teeth **1052** are positioned as close as possible to the bottom contact point **1040** of the cleaning roller **1024** but high enough to prevent being caught on a surface being cleaned (e.g., a carpet). The combing teeth **1052**, for example, may be positioned just above the lowest structure on the housing of a cleaning apparatus. Positioning the combing teeth **1052** closer to the bottom contact point **1040** of the cleaning roller **1024** allows debris to be intercepted and removed as soon as possible, thereby improving debris removal.

In another embodiment, shown in FIG. **15**A, the combing unit **1050** may have other orientations and positions relative to the cleaning roller **1024** (e.g., above the rotation center **1023**). In a robotic vacuum cleaner, for example, the combing unit **1050** may be positioned higher to prevent the combing teeth **1052** from interfering with the debris being deposited into a dust bin **1060**.

The combing teeth **1052** may extend into the cleaning roller **1024** to a depth in a range of 0% to 50% of the cleaning roller radius for a soft roller and 0% to 30% of the cleaning roller radius for a tufted brush roll. In one embodiment, the cleaning roller **1024** is a soft roller (e.g., nylon bristles with a diameter less than or equal to 0.15 mm and a length greater than 3 mm) and the combing teeth **1052** extend into the soft cleaning roller **1024** in a range of 15% to 35%. The combing protrusions **1052** may be positioned to provide a root gap or spacing between the back support **1051** and the outer surface of the cleaning roller **1024** such that air may flow between the cleaning roller **1024** and the back support **1051** and through the roots of the combing teeth **1052**. The air flow through the roots of the combing teeth **1052** may help to dislodge debris that has been removed from the cleaning roller **1024** and to direct the debris into an air flow passageway toward a suction conduit of a cleaning apparatus. The root gap may have a width RG in a range of 1 to 3 mm and more specifically a range of 2 to 3 mm. The root gap RG may extend across an entire length of the combing unit **1050**, or a root gap RG may be formed only in one or more sections along the length of the combing unit **1050** to form air channels only at those sections. In other embodiments, the back support **1051** of the combing unit **1050** may contact the outer surface of the cleaning roller **1024** to provide sealing and force air to flow under the cleaning roller **1024**.

In the illustrated embodiment (FIGS. **11** and **14**D), the combing teeth **1052** have a triangular-shaped "tooth" profile with a wider base or root **1054** having a root width W_r and a tip **1056** having a diameter D_r. In general, the base or root **1054** may be wide enough to prevent the tooth **1052** from bending upward when contacted by the rotating cleaning roller **1024** and the tip **1056** may be sharp enough to catch the debris. In some embodiments, the tip **1056** may be rounded with a diameter in the range of less than 3 mm and more specifically in the range of 1 to 2 mm and even more specifically about 1.6 mm. The root width W_r may be in a range of 5 to 6 mm.

In another embodiment, shown in FIG. **15**B, combing teeth **1052'** have a curved profile with curved leading edges **1053'** forming a concave curve. In this embodiment, a line **1006** extending from the curved leading edge **1053'** at the tip **1056** forms an angle α with the line **1004** extending from the intersection point **1025** to the rotation center **1023**. The combing teeth **1052'** with curved edges may be positioned and spaced similar to the teeth **1052** with straight leading edges **1053** as described and shown herein.

In some embodiments, the combing unit **1050** includes combing teeth **1052** spaced 4 to 16 teeth per inch and more specifically 7 to 9 teeth per inch. The combing teeth **1052** may be made of plastic or metal and may have a thickness that provides a desired rigidity to prevent bending when engaged with the rotating cleaning roller **1024**. In some embodiments, the combing teeth **1052** may have a thickness in a range of 0.5 to 2 mm depending upon the material. In one example, the combing teeth **1052** are made of plastic and have a thickness of 0.8 mm, a spacing S of about 2.4 mm, and a center-to-center spacing Se of about 3.3 mm.

Although the combing unit **1050** is shown with combing teeth **1052** having an equal spacing, a combing unit **1050** may also include teeth **1052** with different spacings including, for example, groups of equally spaced teeth. The combing unit **1050** may include a section at the center of the cleaning roller **1024** with no teeth and groups of combing teeth **1052** proximate ends of the cleaning roller **1024** where the hair and similar debris migrates during rotation. Although the combing unit **1050** is shown with teeth **1052** having the same shape or tooth profile and dimensions, the combing unit **1050** may include teeth of different shapes,

profiles dimensions and configurations at different locations along the combing unit **1050**.

FIGS. **16** and **17** illustrate examples of two different types of vacuum cleaners **1600**, **1700** that may include a surface cleaning head **1602**, **1702** with dual agitators including a leading roller **1624**, **1724** and a combing unit (not shown), consistent with the embodiments described herein. The surface cleaning head **1602** with the leading roller **1624** may be used on an upright vacuum cleaner **1600** with a removable canister **1601** coupled to a wand **1604**, such as the type described in U.S. Patent Application Pub. No. 2015/0351596, which is commonly owned and fully incorporated herein by reference. The surface cleaning head **1702** with the leading roller **1724** may be used on a stick type vacuum cleaner **1700** with a removable handheld vacuum **1701** coupled at one end of a wand **1704**, such as the type described in U.S. Patent Application Pub. No. 2015/0135474, which is commonly owned and fully incorporated herein by reference.

FIG. **18** illustrates a robotic vacuum cleaner **1800** that includes a housing **1810** and a cleaning roller **1824** with a combing unit (not shown) as disclosed herein. The robotic vacuum cleaner **1800** may also include one or more wheels **1830** for moving about a surface to be cleaned. An example of the combing unit used in a robotic vacuum cleaner is disclosed in greater detail in U.S. Provisional Application No. 62/469,853, filed Mar. 10, 2017, which is incorporated herein by reference.

While the principles of the invention have been described herein, it is to be understood by those skilled in the art that this description is made only by way of example and not as a limitation as to the scope of the invention. Other embodiments are contemplated within the scope of the present invention in addition to the exemplary embodiments shown and described herein. Modifications and substitutions by one of ordinary skill in the art are considered to be within the scope of the present invention, which is not to be limited except by the following claims.

What is claimed is:

1. A cleaning apparatus comprising:

a housing having a front side and back side, the housing including a suction conduit fluidly coupled to an opening on an underside of the housing between the front side and the back side, the suction conduit fluidly coupled to a suction motor;

a brush roller rotatably mounted to the housing;

a leading roller mounted in the housing in front of the brush roller and spaced from the brush roller such that a position of the leading roller relative to the housing is fixed and the leading roller and brush roller do not contact each other;

one or more drive mechanisms coupled to the brush roller and the leading roller configured to simultaneously drive the brush roller and the leading roller;

a wall defining a portion of the suction conduit, the wall separating at least an inside upper portion of the leading roller from the suction conduit such that at least the inside upper portion of the leading roller is substantially outside of a flow path to the suction conduit; and

a series of spaced combing protrusions extending from the wall, the combing protrusions configured to contact an outer surface of the lower portion of the leading roller between the rotation center of the leading roller and the bottom contact surface of the leading roller.

2. The cleaning apparatus of claim **1**, wherein the combing protrusions have roots at the back support and the tips at an opposite end from the roots, the combing protrusions being wider at the roots than at the tips.

3. The cleaning apparatus of claim **1**, wherein the combing protrusions include leading edges that form an acute angle relative to a line extending from an intersection point of the leading edge and the leading roller to a rotation center of the leading roller.

4. The cleaning apparatus of claim **1**, wherein at least some of the combing protrusions have a curved profile with at least the leading edge forming a concave curve.

5. The cleaning apparatus of claim **1**, wherein at least some of the combing protrusions have a triangular-shaped profile.

6. The cleaning apparatus of claim **1**, wherein the combing unit is spaced across at least 90% of a length of the cleaning roller.

7. The cleaning apparatus of claim **1**, wherein the housing defines an inter-roller air passageway between lower portions of the brush roller and the leading roller and below the combing protrusions, the inter-roller air passageway being in fluid communication with the suction conduit of the housing.

8. The cleaning apparatus of claim **7**, wherein the debriding protrusions configured to contact the outer surface of the lower portion of the leading roller to remove debris from the leading roller, the debriding protrusions exposed to the inter-roller passageway such that the removed debris falls into the inter-roller passageway and into the flow path to the opening of the suction conduit.

9. The cleaning apparatus of claim **1**, wherein an upper portion of the leading roller above the combing protrusions is outside of the suction conduit.

10. The cleaning apparatus of claim **1**, wherein the cleaning apparatus is a robotic cleaner.

11. The cleaning apparatus of claim **1**, wherein the apparatus is a sweeper and further comprises a wand coupled at one end to the cleaning apparatus.

12. The cleaning apparatus of claim **1**, wherein the apparatus is a stick vacuum and further comprises a wand coupled at one end to the cleaning apparatus and a hand vacuum removably coupled to an opposite end of the wand.

13. The cleaning apparatus of claim **1**, wherein the apparatus is a upright canister vacuum and further comprises a wand coupled at one end to the cleaning apparatus and a removable canister coupled to the wand.

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