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(54) **REMOVABLE ROTATABLE AGITATOR WITH A TAB CONFIGURED TO BE GRIPPED BY A USER**

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Description

TECHNICAL FIELD

[0001] The present invention relates to vacuum cleaners and more particularly, to a vacuum cleaner surface cleaning head including an openable agitator chamber and removable agitators for use therein.

BACKGROUND INFORMATION

[0002] The following is not an admission that anything discussed below is part of the prior art or part of the common general knowledge of a person skilled in the art.

[0003] A surface cleaning apparatus, more commonly known as a vacuum cleaner, may be used to clean a variety of surfaces using at least suction. Various types of vacuum cleaners are known including, without limitation, upright vacuum cleaners, canister vacuum cleaners, stick vacuum cleaners and central vacuum systems. A surface cleaning apparatus typically includes a surface cleaning head with an inlet. Some vacuum cleaners include some or all of the operating components (e.g., the suction motor and the air treatment members) at a location other than the surface cleaning head to enable the surface cleaning head to be lighter or smaller. An upright vacuum cleaner, for example, may include an upright section containing at least an air treatment member that is mounted to a surface cleaning head. A canister vacuum cleaner may include a canister body containing at least an air treatment member and a suction motor that is connected to a surface cleaning head by a flexible hose and a handle. Another type of vacuum cleaner includes the suction motor and the air treatment members (*e.g.*, one or more cyclones) positioned in the surface cleaning head.

[0004] A surface cleaning apparatus, such as any of the vacuum cleaners mentioned above, may also include one or more mechanical agitators, such as a rotating brush roll, in the surface cleaning head to facilitate cleaning a surface. One problem with mechanical agitators, particularly rotating brush rolls, is the difficulty removing debris (e.g., hair) that becomes entangled. The surface cleaning head often must be turned upside down to determine if the agitator is entangled or clogged and to remove the debris. Removing the debris from the mechanical agitator located inside the surface cleaning head may also be difficult, especially through the limited opening in the bottom of the surface cleaning head. An inability to remove the debris adequately may result in a decrease in performance and even damage to the mechanical agitator and/or vacuum cleaner.

[0005] In some conventional vacuum cleaners, the agitator also may not be suitable for all surfaces and/or conditions. A rotating brush roll, for example, may be desirable to provide agitation on a carpet but not on a hard wood floor. This may further limit the performance as well as the versatility of the vacuum cleaner.

[0006] WO 2011/158596 A1 describes a floor surface suction tool used in an electric vacuum cleaner comprising a case forming an outer shell, a rotary brush provided so as to be freely rotatable in an interior portion of the case, a drive unit provided in the case for driving the rotation of the rotary brush, and a drive unit side mounting guide to which a driving force is conveyed from the drive unit and which connects to the rotary brush; wherein the rotary brush and the drive unit side mounting guide are connected in a universal joint structure.

SUMMARY

[0007] According to a first aspect of the invention, there is provided a removable rotatable agitator for use in a surface cleaning head according to claim 1.

[0008] According to a second aspect of the invention, there is provided a surface cleaning head according to claim 11 comprising the rotatable agitator of the first aspect.

[0009] Optional and/or preferable features are laid out in the dependent claims.

[0010] Consistent with an embodiment, a surface cleaning head is provided for a vacuum. The surface cleaning head includes a cleaning head housing having a front end portion, a rear end portion, laterally disposed sides, an upper portion and a bottom portion. An agitator chamber is located in the front end portion of the cleaning head housing. The agitator chamber has a top opening through the upper portion of the cleaning head housing and a bottom opening through the bottom portion of the cleaning head housing. An external cover is pivotably mounted to the cleaning head housing for covering the top opening of the agitator chamber. The external cover is pivotable between a closed position and an open position, and the agitator chamber is covered when the external cover is in the closed position and accessible through the top opening when the external cover is in the open position. A rotatable driven agitator is removably mounted within the agitator chamber such that the agitator is configured to contact a surface through the bottom opening and configured to be removed through the top opening. The rotatable driven agitator includes a driven end and a non-driven end. The external cover engages the non-driven end of the agitator in the closed position to hold the agitator in the agitator chamber and the external cover disengages from the non-driven end of the agitator when moved to the open position. The agitator is accessible and removable through the top opening when the external cover is in the open position.

[0011] Consistent with another embodiment, a surface cleaning head is provided for a vacuum. The surface cleaning head includes a cleaning head housing including a front end portion, a rear end portion, laterally disposed sides, an upper portion and a bottom portion. An agitator chamber is located in the front end portion of the cleaning head housing. The agitator chamber has a top opening through the upper portion of the cleaning head

housing and a bottom opening through the bottom portion of the cleaning head housing. An external cover is pivotably mounted to the cleaning head housing for covering the top opening of the agitator chamber and is movable between a closed position and an open position. The agitator chamber is covered when the external cover is in the closed position and accessible through the top opening when the external cover is in the open position. A sealing member is located around a perimeter of at least one of an inside portion of the external cover and the cleaning head housing around the agitator chamber for sealing an interface between the cleaning head housing and the external cover around the agitator chamber. A latching mechanism is configured to provide multiple points of engagement around the perimeter between the external cover and the cleaning head housing for holding the external cover in the closed position. A rotatable driven agitator is mounted within the agitator chamber such that the agitator is configured to contact a surface through the bottom opening. The rotatable driven agitator includes a driven end and a non-driven end and is accessible through the top opening when the external cover is in the open position

[0012] Consistent with an embodiment, a surface cleaning head is provided for a vacuum. The surface cleaning head includes a cleaning head housing having a front end portion, a rear end portion, laterally disposed sides, an upper portion and a bottom portion. An agitator chamber is located in the front end portion of the cleaning head housing and has a top opening through the upper portion of the cleaning head housing and a bottom opening through the bottom portion of the cleaning head housing. The agitator chamber includes a non-driven side and a driven side. The surface cleaning head also includes an agitator drive mechanism including a drive member at the driven side of the agitator chamber and an agitator drive motor drivingly coupled to the drive member. An external cover is mounted to the cleaning head housing for covering the top opening of the agitator chamber and is movable between a closed position and an open position such that the agitator chamber is covered when the external cover is in the closed position and accessible through the top opening when the external cover is in the open position. A rotatable driven agitator is removably mounted within the agitator chamber such that the agitator is configured to contact a surface through the bottom opening and is accessible and removable through the top opening when the external cover is in the open position. The rotatable driven agitator includes a non-driven end mounted at the non-driven side of the agitator chamber such that the agitator spins freely at the non-driven end and a driven end including a driven member. The driven member mates axially and engages with the drive member of the drive mechanism such that the drive member transmits torque and rotation to the driven member and the rotatable driven agitator.

[0013] Consistent with another embodiment, a surface cleaning head is provided for a vacuum. The surface cleaning head includes a cleaning head housing having a front end portion, a rear end portion, laterally disposed sides, an upper portion and a bottom portion. An agitator chamber is located in the front end portion of the cleaning head housing and has a top opening through the upper portion of the cleaning head housing and a bottom opening through the bottom portion of the cleaning head housing. An external cover is mounted to the cleaning head housing for covering the top opening of the agitator chamber. The external cover is movable between a closed position and an open position such that the agitator chamber is covered when the external cover is in the closed position and accessible through the top opening when the external cover is in the open position. At least first and second rotatable driven agitators are configured to be removably mounted within the agitator chamber and removable through the top opening when the external cover is in the open position such that the rotatable driven agitators are interchangeable. The first rotatable driven agitator has different agitating characteristics than the second rotatable driven agitator.

[0014] Consistent with a further embodiment, a surface cleaning head is provided for a vacuum. The surface cleaning head includes a cleaning head housing having a front end portion, a rear end portion, laterally disposed sides, an upper portion and a bottom portion. An agitator chamber is located in the front end portion of the cleaning head housing and has a top opening through the upper portion of the cleaning head housing and a bottom opening through the bottom portion of the cleaning head housing. The agitator chamber is configured to receive a rotatable driven agitator such that the agitator contacts a surface through the bottom opening and is removable through the top opening. The agitator chamber includes a non-driven side for receiving a non-driven end of the rotatable driven agitator and a driven side for receiving a driven end of the rotatable driven agitator. The surface cleaning head also includes an agitator drive mechanism including a drive member at a driven side of the agitator chamber and an agitator drive motor drivingly coupled to the drive member. The drive member is configured to mate axially and engage with the driven member on the rotatable driven agitator such that the drive member transmits torque and rotation to the driven member and the rotatable driven agitator. An external cover is mounted to the cleaning head housing for covering the top opening of the agitator chamber. The external cover is movable between a closed position and an open position such that the agitator chamber is covered when the external cover is in the closed position and accessible through the top opening when the external cover is in the open position.

[0015] Consistent with an embodiment, a removable rotatable agitator assembly is provided for use in a surface cleaning head of a vacuum. The removable rotatable agitator assembly includes an agitator body having a driven end and a non-driven end and at least one agitating element located on at least a portion of the agitator body

between the driven end and the non-driven end. The removable rotatable agitator assembly further includes a driven member located at the driven end of the agitator body. The driven member is configured to mate axially and engage with a drive member on a drive mechanism in the surface cleaning head. The removable rotatable agitator assembly further includes an axle extending from the non-driven end of the agitator body, a bushing rotatably mounted on the axle, and an end cap mounted on the bushing and configured to be mounted without rotation in an agitator chamber of the surface cleaning head.

[0016] Consistent with another embodiment, a removable rotatable agitator assembly includes an agitator body having a driven end and a non-driven end, at least one agitating element located on at least a portion of the agitator body between the driven end and the non-driven end, and a splined driven member located at the driven end of the agitator body. The splined driven member is configured to mate axially and engage with a splined drive member on a drive mechanism in the surface cleaning head.

[0017] Consistent with an embodiment, a surface cleaning head is provided for a vacuum. The surface cleaning head includes a cleaning head housing having a front end portion, a rear end portion, laterally disposed sides, an upper portion and a bottom portion. An agitator chamber is located in the front end portion of the cleaning head housing. The agitator chamber has a top opening through the upper portion of the cleaning head housing and a bottom opening through the bottom portion of the cleaning head housing and includes at least one driven side. The surface cleaning head also includes an agitator drive mechanism including a drive member at the driven side of the agitator chamber and an agitator drive motor drivingly coupled to the drive member. The drive member is configured to engage and drive a rotatable driven agitator when received in the agitator chamber. An external cover is mounted to the cleaning head housing for covering the top opening of the agitator chamber. The external cover is movable between a closed position and an open position. The agitator chamber is covered when the external cover is in the closed position and accessible through the top opening when the external cover is in the open position. The surface cleaning head further includes a non-driven agitator removably mounted within the agitator chamber without engaging the drive member such that the non-driven agitator is configured to contact a surface through the bottom opening. The non-driven agitator is accessible and removable through the top opening when the external cover is in the open position.

[0018] Consistent with another embodiment, a surface cleaning head is provided for a vacuum. The surface cleaning head includes a cleaning head housing having a front end portion, a rear end portion, laterally disposed sides, an upper portion and a bottom portion. An agitator chamber is located in the front end portion of the cleaning head housing. The agitator chamber has a top opening through the upper portion of the cleaning head housing and a bottom opening through the bottom portion of the cleaning head housing and includes at least one driven side. The surface cleaning head also includes an agitator drive mechanism including a drive member at the driven side of the agitator chamber and an agitator drive motor drivingly coupled to the drive member. At least one rotatable driven agitator is configured to be removably mounted within the agitator chamber and configured to engage the drive member of the agitator drive mechanism such that the drive member causes the rotatable driven agitator to rotate. At least one non-driven agitator is configured to be removably mounted within the agitator chamber without engaging the drive member and such that the non-driven agitator is configured to contact a surface through the bottom opening.

[0019] A removable non-driven agitator not forming part of the present invention is provided for use in an agitator chamber of a surface cleaning head. The removable non-driven agitator includes an agitator body defining first and second elongated air inlets, an air outlet, and an air path between the at least one air inlet and the air outlet. The elongated air inlets are located along at least a portion of a bottom portion of the agitator body, and the air outlet is located on the agitator body at a position to provide engagement with a dirty air inlet in the agitator chamber of the surface cleaning head. The bottom portion of the agitator body has a width corresponding to a width of a bottom opening of the agitator chamber. First and second ends of the agitator body are configured to engage the agitator chamber without engaging a drive member in the agitator chamber. The removable non-driven agitator also includes at least one cleaning pad supported on a pad support member on at least one side of the bottom portion of the agitator body and a seal around the air outlet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] 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 an openable agitator chamber covered by an external cover with a transparent region, consistent with an embodiment of the present disclosure.

FIG. 1A is a cross-sectional view of the surface cleaning head shown in FIG. 1 taken along line 1A-1A.

FIG. 2 is a perspective view of a vacuum cleaner with the surface cleaning head shown in FIG. 1 connected to a wand and handle.

FIG. 3 is a perspective view of the surface cleaning head shown in FIG. 1 with an external cover removed to show a top opening into the agitator chamber.

FIG. 3A is a bottom view of the surface cleaning head shown in FIG. 1 showing a bottom opening into the

agitator chamber.

FIGS. 4A and 4B are different perspective views of an embodiment of a brush roll agitator for use in the surface cleaning head shown in FIG. 1.

FIG. 4C is a cross-sectional view of the brush roll agitator shown in FIG. 4B taken along line 4C-4C.

FIGS. 5A and 5B are perspective and side views, respectively, of another embodiment of a brush roll agitator for use in the surface cleaning head shown in FIG. 1.

FIG. 5C is a cross-sectional view of the brush roll agitator shown in FIG. 5B taken along line 5C-5C.

FIG. 5D is a side view of a further embodiment of a rotatable agitator for use in the surface cleaning head shown in FIG. 1.

FIG. 6A is a perspective view of an embodiment of a non-driven agitator for use in a surface cleaning head, consistent with embodiments of the present disclosure.

FIG. 6B is an end view of the non-driven agitator shown in FIG. 6A.

FIG. 6C is a top view of the non-driven agitator shown in FIG. 6A.

FIG. 6D is bottom view of the non-driven agitator shown in FIG. 6A.

FIGS. 7A and 7B are different side perspective views of a surface cleaning head with an external cover in an open position and with an agitator removed from the agitator chamber, consistent with an embodiment of the present disclosure.

FIG. 8 is a top view of agitator chamber and external cover of the surface cleaning head shown in FIGS. 7A and 7B.

FIG. 9 is a side view of the surface cleaning head shown in FIGS. 7A and 7B.

FIG. 10 is a top view of the surface cleaning head shown in FIGS. 7A and 7B including a rotatable agitator and a drive mechanism, consistent with an embodiment of the present disclosure.

FIG. 11 is a top view of the surface cleaning head including a non-driven agitator received in the agitator chamber.

FIG. 12 is a bottom view of the surface cleaning head including the non-driven agitator shown in FIG. 11.

FIG. 13 is a top perspective view of an embodiment of a drive mechanism for use in the surface cleaning head shown in FIG. 10.

FIG. 14 is an exploded view of the drive mechanism shown in FIG. 13.

FIG. 15 is a close-up perspective view of a splined drive member and a splined driven member of the drive mechanism shown in FIG. 13.

FIG. 16 is a cross-sectional view of a spline coupling between the splined drive member and the splined driven member taken along line 16-16 in FIG. 13.

FIG. 17 is a side cross-section view of the splined driven member taken along line 17-17 in FIG. 15.

FIG. 18 is an exploded view of a non-driven end of an embodiment of a rotatable agitator for use in the surface cleaning head shown in FIG. 10.

FIGS. 19 and 20 are different side perspective views of an embodiment of an end cap for use on the rotatable agitator shown in FIG. 18.

FIG. 21 is a top perspective view of a non-driven side of the agitator chamber in the surface cleaning head of FIG. 10 without the rotatable agitator.

FIG. 22 is a top perspective view of the non-driven side of the agitator chamber in the surface cleaning head of FIG. 10 with the non-driven end of the rotatable agitator received therein.

FIG. 23 is a cross-sectional view of the end cap of the agitator seated in the agitator chamber in the surface cleaning head of FIG. 10 with the cover closed.

FIG. 24 is a perspective view of a stick vacuum cleaner including a cleaning head with an openable agitator chamber, consistent with a further embodiment of the present disclosure.

FIG. 25 is a perspective view of an upright vacuum cleaner including a cleaning head with an openable agitator chamber, consistent with yet another embodiment of the present disclosure.

FIG. 26 is a side view of a surface cleaning head including an external cover that pivots rearwardly, consistent with another embodiment of the present disclosure.

FIG. 27 is a side view of a surface cleaning head including a multiple piece external cover, consistent with a further embodiment of the present disclosure.

FIG. 28 is a top view of a surface cleaning head including an external cover that slides rearwardly or forwardly to open the agitator chamber, consistent with another embodiment of the present disclosure.

FIG. 29 is a top view of a surface cleaning head including an external cover that slides to a side to open the agitator chamber, consistent with another embodiment of the present disclosure.

[0021] The drawings included herewith are for illustrating various examples of articles, methods, and apparatuses of the teaching of the present specification and are not intended to limit the scope of what is taught in any way.

DETAILED DESCRIPTION

[0022] A surface cleaning head, consistent with embodiments of the present disclosure, may be configured to receive a removable rotatable driven agitator, such as a brush roll, or a non-driven agitator. Either of these agitators may be located in an openable agitator chamber for purposes of removing debris and/or removing the agitator. The openable agitator chamber may be covered by an external cover that is movable between an open position and a closed position. A sealing member may be located between the external cover and a surface

cleaning head housing and around a perimeter of the agitator chamber. A surface cleaning head, consistent with other embodiments of the present disclosure, includes a removable rotatable agitator, such as a brush roll, which is driven by a drive mechanism that axially engages the driven end. The removable agitator may be secured in the agitator chamber by the external cover. The surface cleaning head may also include one or more transparent regions (e.g., a window on the external cover) to allow visual inspection of the agitator during use.

[0023] The non-driven agitator may include an agitator body including a bottom portion supporting one or more cleaning pads. The non-driven agitator body may also define one or more air inlets, an air outlet and an air passageway extending therebetween to facilitate air passage through the surface cleaning head. Different removable agitators with different characteristics may be used interchangeably in the surface cleaning head.

[0024] In the illustrated embodiments, the openable agitator chamber, external cover, removable rotatable agitator and other features described herein are used in an "all in the head" type vacuum cleaner in which the functional or operational components for the transport and treatment of fluid (e.g., air) are substantially all contained within the surface cleaning head. The openable agitator chamber, external cover, removable rotatable agitator and other features described herein may also be implemented, within the scope of the present disclosure, in a surface cleaning head for any type of surface cleaning apparatus or vacuum including, without limitation, upright vacuum cleaners, canister vacuum cleaners, stick vacuum cleaners, robotic vacuum cleaners and central vacuum systems.

[0025] 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, "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, "transparent" means capable of allowing enough light to pass through so that objects on the other side can be seen.

[0026] Referring to FIGS. 1-3A, an embodiment of a surface cleaning head 100 is shown and described in greater detail. As shown in greater detail in FIG. 2, a wand 102 is steeringly coupled by a swivel connection to the surface cleaning head 100 and includes a handle 104 at one end to allow the user to control the surface cleaning head 100 during use. The wand 102 may have a telescoping configuration to provide length adjustment. The handle 104 may include controls 106 (e.g., a switch and/or speed control) for controlling operation of the surface cleaning head 100. In other embodiments, a surface cleaning head 100 may be provided without a wand and handle (e.g., in a robotic vacuum surface cleaning head or in a motorized attachment surface cleaning head).

[0027] The surface cleaning head 100 includes a cleaning head housing 110, an agitator chamber 120 located in the housing 110, and a rotatable agitator 130 located in the agitator chamber 120. The rotatable agitator 130 rotates about a rotation axis 2 (FIGS. 1A and 3) that may be generally orthogonal to the direction of travel 4 of the surface cleaning head 100. In the illustrated embodiment, the agitator chamber 120 is openable to provide access to the agitator 130. Providing access to the agitator 130 within the agitator chamber 120 may allow a user to inspect and/or clean the agitator 130 without having to remove the agitator and without having to touch a dirty agitator. The rotatable agitator 130 may also be removable from the agitator chamber 120 for inspection, cleaning and/or replacement. In other embodiments, the openable agitator chamber 120 may include a fixed agitator that is not removable, a non-rotatable or non-driven agitator or any type of cleaning member.

[0028] The cleaning head housing 110 may generally include one or more pieces that enclose or encompass components of the surface cleaning head 100. In the illustrated embodiment, the surface cleaning head 100 is used in an "all in the head" type vacuum cleaner. As such, the cleaning head housing 110 encloses or encompasses an air transportation and treatment system 140 (shown schematically in FIGS. 1 and 3). The air transportation and treatment system 140 includes, for example, a suction motor 142, a cyclone including a cyclone chamber 144 and a dirt collection chamber 146 external to the cyclone chamber 144, and one or more filters 148. An air flow path 141 extends from a dirty air inlet 143 located in the agitator chamber 120 to a clean air outlet 145. The suction motor 142 causes air to be drawn into the dirty air inlet 143, through the cyclone chamber 144, and out the clean air outlet 145. As the dirt passes through the cyclone chamber 144, dirt is collected in the dirt collection chamber 146. Smaller particles may also be collected in the filter(s) 148. The air transportation and treatment system 140 may be similar to those used in existing or known "all in the head" type vacuum cleaners, for example, as disclosed in U.S. Patent No. 7,329,294.

[0029] The cleaning head housing 110 includes a front end portion 112, a rear end portion 114, laterally disposed sides 113, 115, an upper portion 116, and a bottom portion 118. In the illustrated embodiment, the wand 102 is steeringly coupled to the rear end portion 114, and the agitator chamber 120 is located in the front end portion 112 and extends between a top opening 117 in the upper portion 116 and a bottom opening 119 in the bottom portion 118. The rotatable agitator 130 is located in the agitator chamber 120 and is configured to contact a surface to be cleaned through the bottom opening 119. The top opening 117 and the bottom opening 119 allow the rotatable agitator 130 to be accessed from either the top

or bottom or the top and bottom simultaneously, which may help facilitate inspection or servicing of the agitator. For example, a user may clean the agitator 130 via the top opening 117 while allowing debris separated from the agitator 130 to fall out of the chamber via the bottom opening 119. The rotatable agitator 130 may also be removable from the agitator chamber 120, for example, through the top opening 117, as will be described in greater detail below.

[0030] In the illustrated embodiment, the top opening 117 of the agitator chamber 120 has a width that is greater than a width of the agitator 130 to help provide access to the entire agitator 130 and/or to allow the rotatable agitator 130 to be removed. In other embodiments, the width of the top opening 117 of the agitator chamber 120 may be shorter. The bottom portion 118 includes one or more bottom guards or bars 111a, 111b extending across the bottom opening 119 (FIG. 3A).

[0031] In the illustrated embodiment, an external cover 122 is mounted to the upper portion 116 of the cleaning head housing 110 for covering the top opening 117 of the agitator chamber 120 (FIG. 1). The agitator chamber 120 may thus be opened while the surface cleaning head 100 is resting on the floor, thereby eliminating the need to pick up or reposition the surface cleaning head in order to access the agitator chamber 120. The external cover 122 is movable between a closed position (e.g., FIG. 1) and an open position (e.g., FIG. 3). In the closed position, the external cover 122 forms the top portion of the agitator chamber 120. The agitator chamber 120 and the agitator 130 may thus be easily accessed (e.g., without having to remove other walls or covers) simply by moving the external cover 122 to the open position. In the illustrated embodiment, the external cover 122 extends substantially the entire width of the surface cleaning head 100 but may also be shorter in other embodiments.

[0032] In the illustrated embodiment, the surface cleaning head 100 includes one or more transparent regions 124 that allow visual inspection of the agitator chamber 120. The transparent region 124 may be made out of a polycarbonate material. In this embodiment, the transparent region 124 is in the form of a window located on the external cover 122. Additionally or alternatively, one or more transparent regions may be located in other locations on the cleaning head housing 110 that allow visual inspection of the agitator 130 in the agitator chamber 120, for example, on the sides 113, 115. The transparent region 124 together with the movable external cover 122 thus facilitate a determination of debris in the agitator chamber 120 and/or agitator 130 and then removal of that debris.

[0033] The external cover 122 may be locked in the closed position using any suitable mechanism. In the illustrated embodiment, the external cover 122 includes one or more latch releases 126a, 126b for releasing respective latching mechanisms (not shown) that hold the external cover 122 into engagement with the cleaning head housing 110, as will be described in greater detail below. In the illustrated embodiment, the latch releases 126a, 126b are located proximate the respective sides 113, 115. Additionally or alternatively, one or more releasable latches may be provided in other locations on the external cover 122 and/or on the cleaning head housing 110. The external cover 122 may be pivotably or movably coupled to the cleaning head housing 110, as will be described in greater detail below, or may be completely removable from the cleaning head housing 110 (FIG. 3).

[0034] The surface cleaning head 100 may also include one or more lights, such as LEDs 129 on the external cover 122. In this embodiment, wiring (not shown) extends from the housing 110 to the external cover 122 and passes through the inside of the cover 122 to the LEDs 129. The lights may also be mounted on other locations on the cleaning head housing 110.

[0035] In the illustrated embodiment, as shown in FIG. 1A, the rotatable agitator 130 is engaged with an agitator drive mechanism 150 at a driven end 132 and rotates freely at a non-driven end 134 of the rotatable agitator 130. The agitator drive mechanism 150 thus drives the driven end 132 to cause the rotatable agitator 130 to rotate around the rotation axis 2 during use. The drive mechanism 150 may axially engage the driven end 132 of the rotatable agitator 130 without engaging the rotatable agitator 130 with a belt and in a manner that allows the agitator 130 to be easily removed and inserted, as will be described in greater detail below.

[0036] As shown in FIG. 2, an agitator caddy 160 may be mounted on the wand 102 for holding one or more spare agitators, such as a rotatable driven agitator or a non-driven agitator. The agitator caddy 160 may be removably mounted or fixed to the wand 102. In other embodiments, the agitator caddy 160 may be mounted in other locations on the surface cleaning head 100 or wand 102. The illustrated embodiment of the agitator caddy 160 includes a container 162 sized and configured to receive at least one agitator and a cover 164 pivotably coupled to the container 162 at a hinge 165. In other embodiments, the agitator caddy 160 may include a container without a cover or may include other structures configured to receive and hold an agitator.

[0037] The illustrated embodiment of the agitator caddy 160 further includes one or more mounting arms 166 extending from container 162. The mounting arms engage the wand 102 to mount the caddy 160 to the wand 102. The mounting arms 166 may be shaped similar to the contours of the wand 102 and may be dimensioned such that the arms 166 flex and apply pressure against the wand 102 to hold the agitator caddy 160 in place and prevent the caddy 160 from sliding. In other embodiments, the agitator caddy 160 may include other structures for engaging and mounting on the wand 102 and/or surface cleaning head 100.

[0038] In this embodiment, as shown in greater detail in FIGS. 4A-4C, the rotatable agitator 130 is a rotatable brush roll including brush agitator elements 136. The

brush agitator elements 136 may include brush bristles, such as nylon bristles, extending substantially radially from an agitator body 131. In this embodiment, the brush agitator elements 136 are arranged in one or more helical patterns 135a, 135b around the agitator body 131. The helical patterns 135a, 135b include, for example, opposite helical patterns 135a, 135b that meet at a location 137 on the agitator body 131, forming a chevron shaped pattern. The location 137 where the helical patterns of agitator elements 136 meet (i.e., the point of the chevron) may correspond to the location of the dirty air inlet 143 in the agitator chamber 120 when the agitator is inserted in the chamber. As shown in FIG. 4C, the agitator elements 136 may be angled relative to radial lines extending radially from an axis of rotation of the agitator 130. In the illustrated embodiment, the agitator elements 136 are angled toward a direction of rotation.

[0039] This embodiment of the rotatable agitator 130 also includes one or more cutting grooves 138 extending substantially axially along at least a portion of the agitator body 131. The cutting groove(s) 138 are recessed below a surface of the agitator body 131 and have a depth sufficient to accommodate a cutting tool (e.g., scissors or knife). The cutting tool may thus be inserted beneath strands of hair, string or other types of debris that can get wound around the rotatable agitator 130 during use. The cutting tool may then be translated along the length of the cutting groove 138 to cut hair or other debris entangled around the agitator 130. The rotatable agitator 130 may be manually rotated to allow the cutting groove 138 to be accessed through the top opening 117 or through the bottom opening 119 of the chamber 120. If the rotatable agitator 130 is removable, the agitator 130 may be removed for cutting away the hair and other entangled debris. This embodiment of the rotatable agitator 130 further includes spaces 139a, 139b to accommodate the bottom guards or bars 111a, 111b such that the rotatable agitator 130 extends partially through the bottom opening 119 (see FIG. 1A).

[0040] The agitator body 131 may be solid, hollow or partially solid/hollow. The agitator body 131 may also include wheel weights to balance the rotatable agitator 130 when driven. One example of the wheel weights (not shown) may include screws threaded into the body 131. A hollow agitator body may not need to be weighted.

[0041] A rotatable agitator or brush roll may also include other types of agitator patterns and/or agitator elements including, without limitation, fabric material (e.g., cloth, felt or polyester), a rubber material, and bristles of different thicknesses and/or materials. Rotatable agitators with different agitator patterns and/or agitator elements may be used for different surfaces, functions and/or applications. A rotatable agitator with stiffer bristles may be used, for example, for carpets and/or deep cleaning. A rotatable agitator with softer bristles or fabric may be used, for example, for hardwood floors and/or delicate quick cleaning. Thus, different brush rolls having different agitating characteristics may be easily interchangeable in a surface cleaning head with an openable agitator chamber, consistent with embodiments described herein, to increase the functionality and improve the performance of the vacuum cleaner.

[0042] As shown in FIGS. 5A-5C, another embodiment of a rotatable agitator 530 includes agitator elements 536 arranged in helical patterns 535 extending from one end to the other end of the agitator body 531. In this embodiment, the agitator elements 536 include bristles extending in a substantially continuous row with two breaks or spaces 539a, 539b to accommodate the bottom guards or bars 111a, 111b such that the rotatable agitator 530 extends partially through the bottom opening 119 when positioned in the agitator chamber 120 shown in FIG. 1A.

[0043] In this embodiment, the agitator elements 536 may also be different, for example, bristles of a different material, thickness and/or height as compared to the agitator elements 136 in the agitator 130. In one example, the agitator 130 shown in FIGS. 4A-4C may include stiffer nylon bristles for carpet surfaces or deep cleaning applications and the agitator 530 shown in FIGS. 5A-5C may include softer nylon bristles for hard surfaces or delicate applications. The stiffer nylon bristles of the brush roll agitator 130 for the carpet may be thicker (e.g., a diameter of 0.23 $\pm$ 0.02 mm) and shorter (e.g., a height from the brush roll agitator body 131 of 8.0 $\pm$ 0.6 mm). The softer nylon bristles of the brush roll agitator 530 for the hard surfaces may be thinner (e.g., a diameter of 0.04 $\pm$ 0.02 mm) and longer (e.g., a height from the brush roll agitator body 531 of 13 $\pm$ 0.2 mm). When the brush roll agitator 530 has longer bristles, the diameter of the brush roll agitator body 531 may be smaller such that the overall outer diameter can fit in the agitator chamber. In the example embodiment, the brush roll agitator 130 with the thicker and shorter bristles has an overall outer diameter of about 54 $\pm$ 0.3 mm and the brush roll agitator 530 with the thinner and longer bristles has an overall outer diameter of about 55 $\pm$ 0.4 mm.

[0044] According to a further embodiment, a rotatable agitator 530', shown in FIG. 5D, may include fabric material 536' wrapped around at least a portion of an agitator body 531'. The fabric material 536' may include, for example, a felt material. This embodiment of the rotatable agitator may also be suited for hard surfaces and/or delicate applications. The rotatable agitator includes a combination of agitator elements including a soft agitator element (e.g., a fabric material or soft bristles/brush) and a relatively stiff agitator element (e.g., a rubber blade or stiff bristles/brush).

[0045] In further embodiments, a surface cleaning head 100 with an openable agitator chamber 120 may be configured to receive non-rotatable, non-driven agitators in addition to rotatable driven agitators. A non-driven agitator is configured to engage each side of the agitator chamber 120 without engaging the drive mechanism 150 on the driven side of the chamber, as will be described in greater detail below. The non-driven agitator is also configured to engage the dirty air inlet 143 to allow

air flow through the non-driven agitator into the air transportation and treatment system 140. A non-driven agitator may be suited for flat, hard surfaces such as hardwood floors or other surfaces or conditions where a rotating agitator may be undesirable.

[0046] One example not forming part of the present invention of a non-driven agitator 630 is shown in greater detail in FIGS. 6A-6D. The non-driven agitator 630 includes an agitator body 631 including a bottom portion with a pad support member 633 that supports one or more cleaning pads 635a-635c. The agitator body 631 may be a single molded piece or may be assembled from two or more molded pieces that are attached together, such as by screws or other attachment methods. As shown, the cleaning pad(s) 635a-635c generally extend the length of the non-driven agitator 630 with breaks or spaces 639a, 639b to accommodate the bottom guards or bars across the bottom opening of the agitator chamber in the surface cleaning head. Although the illustrated example shows three cleaning pads 635a-635c, other numbers of cleaning pads may be used.

[0047] The cleaning pads 635a-635c may include textile or fabric pads, such as felt pads, or other sheets or pads having a nap or pile suitable for cleaning a surface. The cleaning pads 635a-635c may also include brush pads having bristles extending therefrom. Similar to the brush rolls described above, different non-driven agitators may have different types of cleaning pads for different cleaning applications, such as brush pads with stiff bristles and brush pads with soft bristles. In one example, a brush pad with soft bristles may have thinner nylon bristles (e.g., a diameter of 0.04 ± 0.02 mm).

[0048] The cleaning pad(s) 635a-635c may also be removably attached to the bottom support member 633, for example, using hook and loop fasteners such as VELCRO® or other attachment methods. Other attachment mechanisms may be used such as clips. Thus, different cleaning pads with different textures may be attached to the non-driven agitator 630 for use in different applications. Removable cleaning sheets or pads may also be attached to other locations of the agitator body 631, for example, the sheets or pads may be wrapped around the pad support member 633 and attached on a top portion of the agitator body 631. Combinations of different types of cleaning pads may also be used at the same time or different times to provide different cleaning characteristics. The cleaning pads may also be reusable or disposable. The non-driven agitator 630 may include permanent cleaning or abrasive material attached thereto to provide cleaning or scrubbing in addition to or instead of the removable cleaning sheets or pads.

[0049] The non-driven agitator 630, the agitator body 631 also defines one or more air inlets 636a, 636b, an air outlet 638 and an air path therebetween such that the inlet(s) 636a, 636b are in fluid communication with the outlet 638. The air inlets 636a, 636b are elongated and extend along at least a portion of the pad support member 633 adjacent to the cleaning pad(s) 635a-635c. Although the illustrated example shows the cleaning pad(s) 635a-635c on one side of the air inlets 636a, 636b, cleaning pads 635a-635c may be located on both sides of the air inlets 636a, 636b. The air is directed from the air inlets 636a, 636b along the air path (as indicated by the arrows) to the air outlet 638. When the non-driven agitator 630 is positioned in the agitator chamber 120 (FIG. 3), the air outlet 638 is engaged in fluid communication with the dirty air inlet 143 and the air inlets 636a, 636b are located at the bottom opening of the agitator chamber 120 such that the air transportation and treatment system 140 causes the air to be drawn through the air inlets 636a, 636b and the air outlet 638. The non-driven agitator 630 thus facilitates air flow through the surface cleaning head while also providing a non-rotating cleaning pad.

[0050] The air outlet 638 may include a seal 639 around a perimeter thereof to provide sealing between the air outlet 638 and the dirty air inlet. The seal 639 may be made of an elastomeric material or other suitable sealing material and may have any known configuration, such as a lip seal or a face seal, capable of forming a seal against a flat face. Alternatively, the air outlet 638 may be configured to engage a seal around the dirty air inlet in the agitator chamber.

[0051] The illustrated example of the non-driven agitator 630 also includes one or more projections 637 on the bottom portion of the agitator body 631. The projections 637 are configured to be received in associated slots in the agitator chamber, as will be described in greater detail below. These projections 637 are generally spaced along the bottom portion of the body 631 on the other side of the air inlets 636a, 636b. The non-driven agitator 630 may also include at least one wing 631a extending from at least one end of the agitator body 631 (FIG. 6A). The wing 631a is configured to be positioned beneath a drive member in the agitator chamber, as will be described in greater detail below.

[0052] Referring to FIGS. 7-9, an embodiment of a surface cleaning head 700 with a pivotable external cover 722 is described in greater detail. In this embodiment, the surface cleaning head 700 includes a cleaning head housing 710 including an agitator chamber 720 and the pivotable external cover 722 coupled with a hinge 723 to a front portion 712 of the cleaning head housing 710. The pivotable external cover 722 pivots at the hinge 723 between a closed position (not shown) and an open position (shown). If the pivotable external cover 722 includes lights, the wiring (not shown) for the lights may pass across the hinge 723. In this embodiment, the pivotable external cover 722 pivots forwardly relative to the housing 710 to open the agitator chamber 720 (FIG. 9). In the open position, the agitator chamber 720 is accessible and the agitator may be removed from the agitator chamber 720 as shown. This embodiment of the surface cleaning head 700 may also be used with a rotatable agitator that is not removable such that the pivotable external cover 722 is opened merely to remove the debris that has collected on the rotatable agitator. The pivotable ex-

ternal cover 722 may also include a transparent window 724 extending across a central region of (FIG. 8) for viewing the agitator chamber 720 when the cover is in the closed position.

[0053] A sealing member 725 may also be located between the pivotable external cover 722 and the cleaning head housing 710 and around the perimeter of the agitator chamber 720. A removable agitator (not shown) may thus be mounted in the agitator chamber 720 inside of the sealing member 725. In the illustrated embodiment, the pivotable external cover 722 includes the sealing member 725 extending around an inside perimeter of the cover 722. In the closed position, the sealing member 725 seals against the cleaning head housing 710 around the perimeter of the agitator chamber 720. The sealing member 725 is capable of forming a substantially air tight seal at the interface between the cover 722 and the cleaning head housing 710 with substantially equal pressure around the perimeter of the chamber 720 to prevent air and/or debris from passing through.

[0054] The sealing member 725 may be made of an elastomeric material or other suitable sealing material and may have any known configuration capable of forming a seal against a flat face or rib. A lip seal or face seal, for example, may be used on the pivotable external cover 722 to facilitate alignment and sealing when the cover pivots to the closed position. In other embodiments, the sealing member 725 may be provided on the cleaning head housing 710.

[0055] The surface cleaning head 700 may also include a latch mechanism to secure the pivotable external cover 720 in the closed position. The latch mechanism may provide multiple points of engagement around the perimeter between the external cover 720 and the cleaning head housing 710 such that the sealing member 725 is engaged with substantially equal pressure around the perimeter of the chamber 720.

[0056] In the illustrated embodiment, the pivotable external cover 722 includes latch mechanisms 770a, 770b on an opposite side from the hinge 723. The latch mechanisms 770a, 770b may include slidable actuators 772a, 772b with hooks 774a, 774b that releasably engage slots 776a, 776b on the cleaning head housing 710. Each of the latch mechanisms 770a, 770b include two hooks 774a, 774b to provide four spaced apart points of engagement between the cover 720 and the housing 710.

[0057] The slidable actuators 772a, 772b translate in a transverse direction between a latched position and an unlatched position. The slidable actuators 772a, 772b may be biased into the latched position, for example, by springs (not shown). The slidable actuators 772a, 772b are operably coupled to latch releases 726a, 726b for moving the slidable actuators 772a, 772b against the spring bias, thereby releasing the hooks 774a, 774b from the slots 776a, 776b (as indicated by the arrows in FIG. 8). In other embodiments, the latch mechanisms 770a, 770b may be located on the cleaning head housing 110 and the slots 776a, 776b may be located on the external cover 722. Although two latch mechanisms and four hooks are shown, other numbers of latch mechanisms and hooks may also be used.

[0058] Referring to FIG. 10, this embodiment of the surface cleaning head 700 may receive a removable rotatable agitator 730 that is driven by a drive mechanism 750. In this embodiment, the drive mechanism 750 axially engages a driven end 732 of the rotatable agitator 730 at a driven side of an agitator chamber 720 and a non-driven end 734 of the rotatable agitator 730 is mounted to rotate freely at a non-driven side of the agitator chamber 720. Both the driven end 732 and the non-driven end 734 of the removable rotatable agitator 730 are mounted in the agitator chamber 720 in a manner that allows the agitator 730 to be removed when the external cover 722 is in an open position.

[0059] In this embodiment, the external cover 722 is configured to secure the removable rotatable agitator 730 in the agitator chamber 720. The external cover 722 includes, for example, an engaging structure 728 that engages the non-driven end 734 of the removable rotatable agitator 730. In other embodiments, an agitator engaging member 739 may be movably mounted to the surface cleaning head housing 710 for movement into engagement with the non-driven end 734 of the removable rotatable agitator 730. The agitator engaging member 739 is shown schematically but may be in the form of a clip, slide or latch and may slide and/or pivot in to and out of engagement with the agitator 130.

[0060] Although this embodiment shows a pivotable external cover 722 similar to that shown and described above, the removable rotatable agitator 730 in this embodiment may also be used with other types of openable external covers.

[0061] The surface cleaning head 700 may also include a kill switch that stops power to the drive mechanism 750 when the pivotable external cover 722 is in the open position. A kill switch actuator 721 is located at a point along the perimeter of the agitator chamber 720 to activate the kill switch when the pivotable external cover 722 is opened. In the example embodiment, the kill switch actuator 721 is biased to an open position that opens the kill switch. When the pivotable external cover 722 is in the closed position, the cover 722 engages the kill switch actuator 721 to close the kill switch, allowing power to the drive mechanism 750. When the pivotable external cover 722 moves to the open position, the actuator 721 moves to the biased open position to open the kill switch, stopping power to the drive mechanism 750. In one embodiment, the kill switch actuator 721 may be recessed to prevent being actuated by a user and may be actuated by a protrusion (e.g., a small rod) extending from the cover 722. The actuator 721 may also be in other locations and may be actuated in other ways.

[0062] According to this embodiment of the surface cleaning head 700, the agitator chamber 720 is also configured to receive non-driven agitators, for example, as described above. As shown in FIGS. 11 and 12, the non-

driven agitator 630 described above may be positioned within the agitator chamber 720 without engaging the drive mechanism 750. In this embodiment, the wing 631a at the end 632 of the agitator body 631 slides beneath a drive member 770 of the drive mechanism 750 and provides sufficient clearance for the drive member 770 to rotate without contacting the agitator 630. The bottom portion of the agitator body 631 has a width corresponding to a width of a bottom opening of the agitator chamber 720 (see FIG. 11).

[0063] When the non-driven agitator 630 is positioned within the agitator chamber 720, the air outlet 638 engages with a dirty air inlet 743 in the surface cleaning head 700 (see FIGS. 7A, 8 and 11) and the projections 637 on the bottom portion of the agitator body 631 are received in slots 713 along one side of the agitator chamber 720 (see FIGS. 8 and 12). Because of the resilience of the seal 639 around the air outlet 638, the projections 637 may fit tightly within the slots 713 such that the non-driven agitator 630 snaps into place within the agitator chamber 720. A force being applied by the resilient seal 639 thus holds the non-driven agitator 630 in place. When properly seated within the agitator chamber 720, the slots 713 receive the projections 637 with a friction fit, the spaces 639a, 639b on the bottom of the agitator body 631 receive the bottom guards or bars 711a, 711b extending across the bottom opening of the agitator chamber 720 and the cleaning pad(s) 635a-635c extend through the bottom opening of the agitator chamber 720 (see FIG. 12).

[0064] As shown in greater detail in FIGS. 13 and 14, the drive mechanism 750 includes a motor 752, a rotation transfer mechanism 754, and a splined drive member 770. In this embodiment, the rotation transfer mechanism 754 includes a belt 755 frictionally engaging a drive wheel 753 coupled to the output of the motor 752 and frictionally engaging a driven wheel 755 coupled to the splined drive member 770. The drive mechanism 750 may be capable of rotating the agitator 730 at low speeds of 700 $\pm$100 RPM and high speeds of 3500 $\pm$500 RPM. In other embodiments, other rotation transfer mechanisms may be used including, without limitation, a gear train or a direct drive coupling between the motor and the splined drive member. In other embodiments, a motor may be located internally within the rotatable agitator. In further embodiments, the drive mechanism may include other mechanisms capable of imparting rotation to the rotatable agitator including, without limitation, an air driven turbine.

[0065] As shown in greater detail in FIG. 15, the driven end 732 of the removable rotatable agitator 730 includes a splined driven member 780 configured to mate axially with the splined drive member 770. The splined drive member 770 and the splined driven member 780 thus form a spline coupling or joint that transmits rotation and torque without using a belt. The splined drive member 770 and the splined driven member 780 have spline teeth 772, 782 oriented radially relative to an axis of rotation of the agitator. The spline teeth 772, 782 have corresponding shapes and spaces 778, 788 between the spline teeth 772, 782 such that the spline teeth 772, 782 mesh when the members 770, 780 are axially engaged, as shown in FIG. 16.

[0066] The illustrated embodiment shows the splined drive member 770 with external splines and the splined driven member 780 with internal splines. In other embodiments, the splined drive member 770 may include the internal splines and the splined driven member 780 may include the external splines.

[0067] In the illustrated embodiment, the spline teeth 772, 782 on the splined drive member 770 and the splined driven member 780 are both generally wedge shaped with a radially outer portion 771, 781 being wider than a radially inner portion 773, 783 (see FIG. 16). The spline teeth 772, 782 also have tapered side walls 774, 775, 784, 785 that taper outwardly from radial faces 776, 786 of the spline teeth 772, 782. As shown in FIG. 17, the spline teeth 782 on the splined driven member 780 also have a tapered or chamfered radial face 786 that tapers inwardly (i.e., toward the non-driven end of the agitator) and forms an acute angle relative to a radial line 708 in a range of about 30° to 60°. The spline teeth 772 on the splined drive member 770 may have a tapered or chamfered axial face 777 that tapers inwardly toward the axis of rotation.

[0068] The shape and configuration of the spline teeth 772, 782 in the illustrated embodiment provide self-alignment and facilitate engagement of the splined driven member 780 with the splined drive member 770. The splined drive member 770 and the splined driven member 780 may be engaged in a number of different angular positions and thus do not require a precise angular alignment for engagement. The shape and configuration of the spline teeth 772, 782 in the illustrated embodiment may also reduce or eliminate backlash when the splined drive member 770 drives the splined driven member 780.

[0069] One or both of the splined driven member 780 and splined drive member 770 may also be made of an elastomeric material such as a thermoplastic rubber having a higher durometer (e.g., 90 or greater). The elastomeric material may facilitate engagement of the spline teeth 772, 782 and may provide vibration reduction or isolation when the splined drive member 770 drives the splined driven member 780. Thus, the drive mechanism 750 may rotate the agitator 730 at higher RPMs with reduced vibrations.

[0070] In the illustrated embodiment, each of the splined drive member 770 and the splined driven member 780 have six (6) spline teeth 772, 782 arranged in a star configuration around an axis of rotation. The six spline teeth are capable of withstanding the desired drive forces and torques while also facilitating alignment and preventing backlash; however, other numbers of spline teeth may be possible. Other shapes and configurations of the spline teeth on the splined drive member 770 and splined driven member 780 may also be possible. Furthermore, other couplings or mechanisms for axially coupling rotat-

ing shafts to transmit torque and rotation may also be used including, without limitation, a dog clutch, a non-slip clutch, a Hirth joint and a curvic coupling.

[0071] As shown in greater detail in FIG. 18, the non-driven end 734 of this embodiment of the removable rotatable agitator 730 includes an end cap 790 secured to a bushing 792 that is rotatably mounted on an axle 791. The axle 791 is fixed within and extending from the agitator body 731. The end cap 790 is configured to be supported within the agitator chamber 720 and to secure the bushing 792 such that the axle 791 rotates within the bushing 792 and the rotatable agitator 730 spins about its axis of rotation. In this embodiment, the end cap 790 is removably secured to the bushing 792 with a friction fit but the end cap 790 may also fixed to the bushing 792. In other embodiments, the bushing 792 may be configured to be mounted directly within the agitator chamber 720 without an end cap. Various other configurations may also be used to rotatably support the non-driven end 734 of the rotatable agitator 730 within the agitator chamber 720.

[0072] As shown in greater detail in FIGS. 19 and 20, the end cap 790 includes a tab 796 that is shaped to be easily gripped for removing the non-driven end 734 of the agitator 730 from the agitator chamber 720. The end cap 790 also includes one or more stabilizing structures 793, 795, 797 that engage mating structures within the agitator chamber to prevent the end cap 790 from rotating such that the bushing 792 is held stationary, thereby allowing the axle 791 to rotate freely within the bushing 792 when the rotatable agitator is driven at the driven end 732. This embodiment of the end cap 790 also includes an elastomeric pad 799 that engages the engaging structure 728 on the external cover 722 when the cover is closed to secure the agitator 730 in the agitator chamber 720. The end cap 790 further includes an elastomeric ring 798 to frictionally engage the bushing 792. The elastomeric pad 799 and the elastomeric ring 798 may advantageously prevent or isolate vibrations when the agitator 730 is rotating in the agitator chamber 720 and may both be molded together from the same rubber material. The end cap 790 may further include a washer 794 (e.g., a felt washer) that contacts an end surface 736 of the agitator body 731 to keep dirt away from the bearing 792.

[0073] Referring to FIGS. 21-23, the engagement of the end cap 790 with the agitator chamber 720 is described in greater detail. At the non-driven side, the chamber 720 includes mounting rails 727a, 727b defining a recessed region 729 that receives an end portion of the end cap 790. The end portion of the end cap 790 may thus slide between the mounting rails 727a, 727b as shown in FIG. 22. As shown in FIG. 23, the stabilizing structures 793, 795, 797 engage corresponding structures on the mounting rails 727a, 727b and the engaging structure 728 inside of the cover 722 engages the elastomeric pad 799. Thus, the end cap 790 and the bushing 792 remain stationary when the agitator 730 is rotated. Additionally or alternatively, the cover 722 may engage other portions of the end cap 790 (e.g., the tab 796) to hold the end cap 790 in the chamber 720. In this embodiment, the stabilizing structures 793, 795, 797 have a particular configuration designed or keyed to mate with the mounting rails 727a, 727b (see FIG.23) in a particular orientation such that the end cap 790 is properly positioned to be engaged by the cover 722.

[0074] To mount the rotatable agitator 730 within the agitator chamber 720, the driven end 732 is angled into the chamber 720 to engage the splined drive member 770 with the splined driven member 780 (see FIG. 16). The end cap 790 may then be used to lower the non-driven end 734 of the agitator 730 into the chamber 720 until the end cap 790 is fit between the mounting rails 727a, 727b (see FIG. 22). When the agitator 730 is properly seated within the chamber 720, the external cover 722 may then be closed to cover the chamber 720 and to secure the rotatable agitator 730 within the chamber 720. To remove the rotatable agitator 730, the user may grasp the tab 796 to slide the end cap 790 out from between the mounting rails 727a, 727b and thus lift the non-driven end 734 out of the chamber 720. The user may then continue to lift the agitator 730 until the splined drive member 770 and the splined driven member 780 are disengaged. The user may then clean the agitator 730 and/or insert another type of agitator.

[0075] Referring to FIG. 24, a surface cleaning head 2400 of a stick vacuum cleaner may include an openable agitator chamber covered by an external cover 2422 and containing a removable agitator. The external cover 2422 and the openable chamber and removable agitator located in the surface cleaning head 2400 may be implemented according to any of the embodiments described herein.

[0076] Referring to FIG. 25, a surface cleaning head 2500 of an upright vacuum cleaner may include an openable agitator chamber covered by an external cover 2522 and containing a removable agitator. The external cover 2522 and the openable chamber and removable agitator located in the surface cleaning head 2500 may be implemented according to any of the embodiments described herein.

[0077] A movable external cover may also have other configurations, for example, as shown in FIGS. 26-29. FIG. 26 shows another embodiment of a surface cleaning head 2600 with a pivotable external cover 2622 that pivots rearwardly relative to the cleaning head housing 2610 to the open position. FIG. 27 shows a further embodiment of a surface cleaning head 2700 with multiple-piece pivotable external cover including one cover portion 2722a that pivots forwardly and another cover portion 2722b that pivots rearwardly relative to the cleaning head housing 2710. FIG. 28 shows yet another embodiment of a surface cleaning head 2800 with a slidable external cover 2822 that slides or rolls in a longitudinal direction relative to the cleaning head housing 2810, for example, similar to a garage door. FIG. 29 shows a further embodiment

of a surface cleaning head 2900 with a slidable external cover 2922 that slides laterally relative to the cleaning head housing 2910.

[0078] In any of these embodiments, the external cover may be latched, for example, using a latching mechanism as described above or any other latching mechanism. In any of these embodiments, the external cover may be sealed, for example, using a sealing member as described above or any other sealing member. In each of these embodiments, the external cover may be moved between open and closed positions while remaining engaged with the surface cleaning head housing. In other embodiments, the external cover may be completely removed from the surface cleaning head housing. Other variations and locations for the external cover are also within the scope of the present disclosure.

[0079] Accordingly, a surface cleaning head, consistent with embodiments of the present disclosure, includes an openable agitator chamber to facilitate inspection, cleaning, servicing, and/or replacement of an agitator in the surface cleaning head. The removable agitator may include a rotatable driven agitator that engages a drive mechanism in the agitator chamber or a non-rotatable, non-driven agitator that is received within the agitator without engaging the drive mechanism.

[0080] 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. It will be appreciated by a person skilled in the art that a surface cleaning apparatus may embody any one or more of the features contained herein and that the features may be used in any particular combination or subcombination. 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.

Claims

1. A removable rotatable agitator (130, 730) for use in a surface cleaning head (100, 700, 2400, 2500, 2600, 2700, 2800, 2900), the removable rotatable agitator comprising:

the agitator, or an agitator body (131, 531, 631, 731) having a driven end (132, 732) and a non-driven end (134, 734);
at least one agitator element (136, 536) located on at least a portion of the agitator body between the driven end and the non-driven end, wherein:

the at least one agitator element includes a combination of soft agitator elements and relatively stiff agitator elements;
the relatively stiff agitator elements include bristles arranged in a helical pattern around the agitator body; and
the soft agitator elements include cloth;

a tab (796), or an end cap including a tab, the tab extending radially from at least one end of the agitator body and configured to be gripped by a user to facilitate removing and inserting the non-driven end into an agitator chamber (120, 720) in the surface cleaning head; and
a splined driven member (780) located at the driven end of the agitator body, the splined driven member being configured to mate axially and engage with a splined drive member (770) on a drive mechanism (750) in the surface cleaning head.

2. The rotatable agitator of claim 1, wherein the splined driven member (780) includes internal spline teeth (782).

3. The rotatable agitator of any of claims 1 or 2, wherein the splined driven member (780) includes wedge-shaped spline teeth (782).

4. The rotatable agitator of any of claims 1-3, wherein the tab (796) includes a gripping portion extending axially at an end of the tab to allow the user to grip the tab, wherein the gripping portion defines an outer surface that faces outward when the removable rotatable agitator is positioned in the agitator chamber.

5. The rotatable agitator of claim 4 wherein the gripping portion of the tab (796) has a length less than an outer diameter of the removable rotatable agitator.

6. The rotatable agitator of any of claims 1-5, wherein the splined driven member (780) is made of a thermoplastic material.

7. The rotatable agitator of any of claims 1-6, further comprising:

an axle (791) extending from the non-driven end of the agitator body;
a bushing (792) rotatably mounted on the axle; and
an end cap (790) mounted on the bushing and configured to be mounted without rotation in an agitator chamber of the surface cleaning head.

8. The rotatable agitator of claim 7, wherein the end cap (790) includes the tab (796).

9. The rotatable agitator of claims 7 or 8, wherein the end cap (790) includes stabilizing structures (793,

795, 797) configured to be keyed to corresponding structures in the agitator chamber.

10. The rotatable agitator of any of claims 7-9, wherein the end cap (790) covers at least a portion of the non-driven end (134, 734) of the agitator body (131, 531, 631, 731).

11. A surface cleaning head comprising:

a cleaning head housing (110, 710);
an agitator chamber (120, 720) located in the front end portion (112) of the cleaning head housing, the agitator chamber having a top opening (117) and a bottom opening (119), and wherein the agitator chamber includes a non-driven side and a driven side;
an agitator drive mechanism (150, 750) including a drive member at the driven side of the agitator chamber and an agitator drive motor (752) drivingly coupled to the drive member;
an external cover (122, 722, 2422, 2522, 2622, 2722, 2822, 2922) mounted to the cleaning head housing for covering the top opening of the agitator chamber, wherein the external cover is completely removable from the cleaning head housing; and
a rotatable agitator (130, 730), as recited in any of claims 1-10, rotatably mounted within the agitator chamber (120, 720) such that the agitator is configured to contact a surface through the bottom opening (119), wherein the agitator is accessible and removable through the top opening (177) when the external cover is removed, wherein the rotatable driven agitator includes a non-driven end (134, 754) mounted at the non-driven side of the agitator chamber such that the agitator spins freely at the non-driven end and a driven end (132, 732) including a driven member, wherein the driven member mates axially and engages with the drive member of the drive mechanism such that the drive member transmits torque and rotation to the driven member and the rotatable driven agitator.

12. The surface cleaning head of claim 11 as it depends on any of claims 7-10, wherein the agitator chamber (120, 720) , at the non-driven side, includes mounting rails (727a, 727b) defining a recessed region (729) that slidably receives a portion of the end cap (790).

13. The surface cleaning head of claim 12, as it depends on claim 4, wherein the outer surface of the tab (796) is located proximate to a top portion of the recessed region (729).

14. The surface cleaning head of any of claims 11-13 further comprising a sealing member (725) located between the external cover (122, 722, 2422, 2522, 2622, 2722, 2822, 2922) and the cleaning head housing (110, 710).

15. The surface cleaning head of any of claims 11-14 wherein the external cover (122, 722, 2422, 2522, 2622, 2722, 2822, 2922) includes a transparent region (724) to allow visual inspection of the agitator in the agitator chamber (120, 720).

Patentansprüche

1. Ein entfernbarer rotierbarer Agitator (130, 730) zur Verwendung in einem Oberflächenreinigungskopf (100, 700, 2400, 2500, 2600, 2700, 2800, 2900), wobei der entfernbare rotierbare Agitator Folgendes beinhaltet:

den Agitator oder einen Agitatorkörper (131, 531, 631, 731), der ein angetriebenes Ende (132, 732) und ein nicht angetriebenes Ende (134, 734) aufweist;
mindestens ein Agitatorelement (136, 536), das auf mindestens einem Abschnitt des Agitatorkörpers zwischen dem angetriebenen Ende und dem nicht angetriebenen Ende befindlich ist, wobei:

das mindestens eine Agitatorelement eine Kombination aus weichen Agitatorelementen und relativ steifen Agitatorelementen umfasst;
die relativ steifen Agitatorelemente Borsten umfassen, die in einem spiralförmigen Muster um den Agitatorkörper angeordnet sind; und
die weichen Agitatorelemente Stoff umfassen;

einen Vorsprung (796) oder eine einen Vorsprung umfassende Endbedeckung, wobei sich der Vorsprung radial von mindestens einem Ende des Agitatorkörpers erstreckt und konfiguriert ist, um von einem Benutzer ergriffen zu werden, um das Entfernen und das Einsetzen des nicht angetriebenen Endes in eine Agitatorkammer (120, 720) in dem Oberflächenreinigungskopfzu ermöglichen; und
ein angetriebenes Rippenbauelement (780), das an dem angetriebenen Ende des Agitatorkörpers befindlich ist, wobei das angetriebene Rippenbauelement konfiguriert ist, um mit einem Rippenantriebsbauelement (770) auf einem Antriebsmechanismus (750) in dem Oberflächenreinigungskopf axial zusammenzupassen und damit in Eingriff zu kommen.

2. Rotierbarer Agitator gemäß Anspruch 1, wobei das angetriebene Rippenbauelement (780) innere Rippenzähne (782) umfasst.

3. Rotierbarer Agitator gemäß einem der Ansprüche 1 oder 2, wobei das angetriebene Rippenbauelement (780) keilförmige Rippenzähne (782) umfasst.

4. Rotierbarer Agitator gemäß einem der Ansprüche 1-3, wobei der Vorsprung (796) einen Greifabschnitt umfasst, der sich an einem Ende des Vorsprungs axial erstreckt, um dem Benutzer zu gestatten, den Vorsprung zu ergreifen, wobei der Greifabschnitt eine äußere Oberfläche definiert, die nach außen weist, wenn der entfernbare rotierbare Agitator in der Agitatorkammer positioniert ist.

5. Rotierbarer Agitator gemäß Anspruch 4, wobei der Greifabschnitt des Vorsprungs (796) eine Länge aufweist, die geringer ist als ein Außendurchmesser des entfernbaren rotierbaren Agitators.

6. Rotierbarer Agitator gemäß einem der Ansprüche 1-5, wobei das angetriebene Rippenbauelement (780) aus einem thermoplastischen Material hergestellt ist.

7. Rotierbarer Agitator gemäß einem der Ansprüche 1-6, der ferner Folgendes beinhaltet:

eine Achse (791), die sich von dem nicht angetriebenen Ende des Agitatorkörpers erstreckt;
eine Buchse (792), die rotierbar auf der Achse montiert ist; und
eine Endbedeckung (790), die auf der Buchse montiert ist und konfiguriert ist, um ohne Rotation in einer Agitatorkammer des Oberflächenreinigungskopfs montiert zu sein.

8. Rotierbarer Agitator gemäß Anspruch 7, wobei die Endbedeckung (790) den Vorsprung (796) umfasst.

9. Rotierbarer Agitator gemäß den Ansprüchen 7 oder 8, wobei die Endbedeckung (790) stabilisierende Strukturen (793, 795, 797) umfasst, die konfiguriert sind, um mit entsprechenden Strukturen in der Agitatorkammer verkeilt zu werden.

10. Rotierbarer Agitator gemäß einem der Ansprüche 7-9, wobei die Endbedeckung (790) mindestens einen Abschnitt des nicht angetriebenen Endes (134, 734) des Agitatorkörpers (131, 531, 631, 731) abdeckt.

11. Ein Oberflächenreinigungskopf, der Folgendes beinhaltet:

ein Reinigungskopfgehäuse (110, 710);
eine Agitatorkammer (120, 720), die in dem vorderen Endabschnitt (112) des Reinigungskopfgehäuses befindlich ist, wobei die Agitatorkammer eine obere Öffnung (117) und eine untere Öffnung (119) aufweist und wobei die Agitatorkammer eine nicht angetriebene Seite und eine angetriebene Seite umfasst;
einen Agitatorantriebsmechanismus (150, 750), der an der angetriebenen Seite der Agitatorkammer ein Antriebsbauelement und einen mit dem Antriebsbauelement antreibend gekoppelten Agitatorantriebsmotor (752) umfasst;
eine externe Abdeckung (122, 722, 2422, 2522, 2622, 2722, 2822, 2922), die an dem Reinigungskopfgehäuse montiert ist, zum Abdecken der oberen Öffnung der Agitatorkammer, wobei die externe Abdeckung vollständig von dem Reinigungskopfgehäuse entfernbar ist; und
einen rotierbaren Agitator (130, 730) nach einem der Ansprüche 1-10, der innerhalb der Agitatorkammer (120, 720) rotierbar montiert ist, sodass der Agitator konfiguriert ist, um eine Oberfläche durch die untere Öffnung (119) zu berühren, wobei der Agitator durch die obere Öffnung (177) zugänglich und entfernbar ist, wenn die externe Abdeckung entfernt ist, wobei der rotierbare angetriebene Agitator ein nicht angetriebenes Ende (134, 754), das an der nicht angetriebenen Seite der Agitatorkammer montiert ist, sodass sich der Agitator an dem nicht angetriebenen Ende frei dreht, und ein angetriebenes Ende (132, 732), das ein angetriebenes Bauelement umfasst, umfasst, wobei das angetriebene Bauelement mit dem Antriebsbauelement des Antriebsmechanismus axial zusammenpasst und damit in Eingriff kommt, sodass das Antriebsbauelement Drehmoment und Rotation auf das angetriebene Bauelement und den rotierbaren angetriebenen Agitator überträgt.

12. Oberflächenreinigungskopf gemäß Anspruch 11, wenn abhängig von einem der Ansprüche 7-10, wobei die Agitatorkammer (120, 720) an der nicht angetriebenen Seite Montageschienen (727a, 727b) umfasst, die einen ausgesparten Bereich (729) definieren, der einen Abschnitt der Endbedeckung (790) gleitend aufnimmt.

13. Oberflächenreinigungskopf gemäß Anspruch 12, wenn abhängig von Anspruch 4, wobei die äußere Oberfläche des Vorsprungs (796) nahe einem oberen Abschnitt des ausgesparten Bereichs (729) befindlich ist.

14. Oberflächenreinigungskopf gemäß einem der Ansprüche 11-13, der ferner ein Dichtungsbauelement (725) beinhaltet, das zwischen der externen Abde-

ckung (122, 722, 2422, 2522, 2622, 2722, 2822, 2922) und dem Reinigungskopfgehäuse (110, 710) befindlich ist.

15. Oberflächenreinigungskopf gemäß einem der Ansprüche 11-14, wobei die externe Abdeckung (122, 722, 2422, 2522, 2622, 2722, 2822, 2922) einen transparenten Bereich (724) umfasst, um eine visuelle Inspektion des Agitators in der Agitatorkammer (120, 720) zu gestatten.

Revendications

1. Un agitateur (130, 730) rotatif pouvant être retiré pour une utilisation dans une tête de nettoyage de surface (100, 700, 2400, 2500, 2600, 2700, 2800, 2900), l'agitateur rotatif pouvant être retiré comprenant :

l'agitateur, ou un corps d'agitateur (131, 531, 631, 731) ayant une extrémité entraînée (132, 732) et une extrémité non entraînée (134, 734) ; au moins un élément d'agitateur (136, 536) situé sur au moins une portion du corps d'agitateur entre l'extrémité entraînée et l'extrémité non entraînée, où :

l'au moins un élément d'agitateur inclut une combinaison d'éléments d'agitateur souples et d'éléments d'agitateur relativement durs ;
les éléments d'agitateur relativement durs incluent des soies agencées selon un motif hélicoïdal autour du corps d'agitateur ; et
les éléments d'agitateur souples incluent de l'étoffe ;

une languette (796), ou un capuchon d'extrémité incluant une languette, la languette s'étendant radialement depuis au moins une extrémité du corps d'agitateur et étant configurée pour être agrippée par un utilisateur afin de faciliter le retrait et l'insertion de l'extrémité non entraînée dans une chambre d'agitateur (120, 720) dans le tête de nettoyage de surface ; et
un organe entraîné cannelé (780) situé au niveau de l'extrémité entraînée du corps d'agitateur, l'organe entraîné cannelé étant configuré pour s'accoupler axialement et se mettre en prise avec un organe d'entraînement cannelé (770) sur un mécanisme d'entraînement (750) dans la tête de nettoyage de surface.

2. L'agitateur rotatif de la revendication 1, où l'organe entraîné cannelé (780) inclut des dents de cannelures internes (782).

3. L'agitateur rotatif de n'importe lesquelles des revendications 1 ou 2, où l'organe entraîné cannelé (780) inclut des dents de cannelures cunéiformes (782).

4. L'agitateur rotatif de n'importe lesquelles des revendications 1 à 3, où la languette (796) inclut une portion d'agrippement s'étendant axialement au niveau d'une extrémité de la languette afin de permettre à l'utilisateur d'agripper la languette, où la portion d'agrippement définit une surface externe qui est tournée vers l'extérieur lorsque l'agitateur rotatif pouvant être retiré est positionné dans la chambre d'agitateur.

5. L'agitateur rotatif de la revendication 4 où la portion d'agrippement de la languette (796) a une longueur inférieure à un diamètre externe de l'agitateur rotatif pouvant être retiré.

6. L'agitateur rotatif de n'importe lesquelles des revendications 1 à 5, où l'organe entraîné cannelé (780) est réalisé en un matériau thermoplastique.

7. L'agitateur rotatif de n'importe lesquelles des revendications 1 à 6, comprenant en outre :

un axe (791) s'étendant depuis l'extrémité non entraînée du corps d'agitateur ;
une douille (792) montée de façon à pouvoir tourner sur l'axe ; et
un capuchon d'extrémité (790) monté sur la douille et configuré pour être monté sans rotation dans une chambre d'agitateur de la tête de nettoyage de surface.

8. L'agitateur rotatif de la revendication 7, où le capuchon d'extrémité (790) inclut la languette (796).

9. L'agitateur rotatif des revendications 7 ou 8, où le capuchon d'extrémité (790) inclut des structures de stabilisation (793, 795, 797) configurées pour être calées sur des structures correspondantes dans la chambre d'agitateur.

10. L'agitateur rotatif de n'importe lesquelles des revendications 7 à 9, où le capuchon d'extrémité (790) couvre au moins une portion de l'extrémité non entraînée (134, 734) du corps d'agitateur (131, 531, 631, 731).

11. Une tête de nettoyage de surface comprenant :

un logement (110, 710) de tête de nettoyage ;
une chambre d'agitateur (120, 720) située dans la portion d'extrémité avant (112) du logement de tête de nettoyage, la chambre d'agitateur ayant une ouverture de dessus (117) et une ouverture de dessous (119), et où la chambre

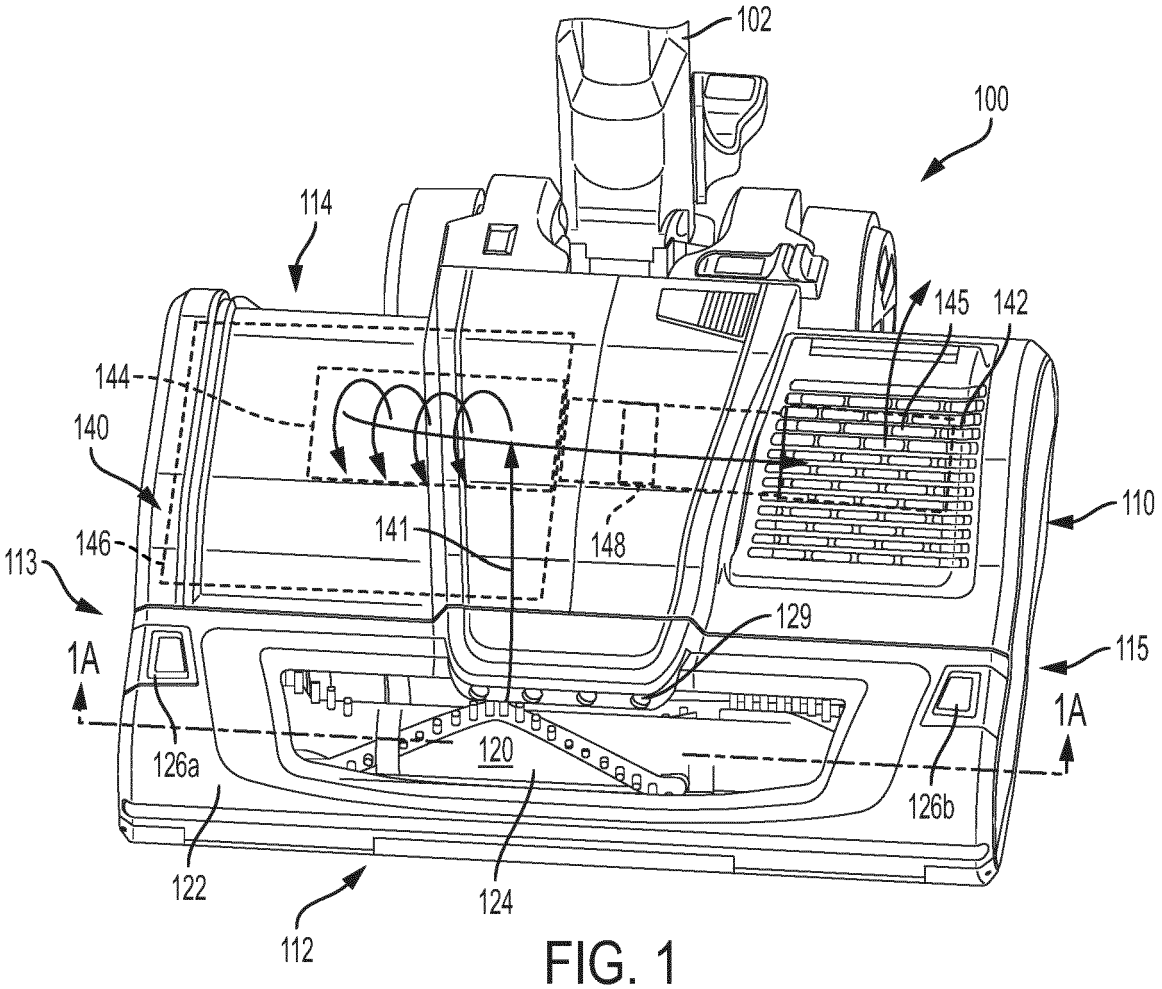
d'agitateur inclut un côté non entraîné et un côté entraîné ;
un mécanisme d'entraînement d'agitateur (150, 750) incluant un organe d'entraînement au niveau du côté entraîné de la chambre d'agitateur et un moteur d'entraînement d'agitateur (752) couplé, de façon à l'entraîner, à l'organe d'entraînement ;
un couvercle extérieur (122, 722, 2422, 2522, 2622, 2722, 2822, 2922) monté sur le logement de tête de nettoyage pour couvrir l'ouverture de dessus de la chambre d'agitateur, où le couvercle extérieur peut être retiré complètement par rapport au logement de tête de nettoyage ; et
un agitateur (130, 730) rotatif, tel qu'exposé dans n'importe lesquelles des revendications 1 à 10, monté de façon à pouvoir tourner au sein de la chambre d'agitateur (120, 720) de telle sorte que l'agitateur est configuré pour entrer en contact avec une surface par l'ouverture de dessous (119), où l'agitateur est accessible et peut être retiré par l'ouverture de dessus (177) lorsque le couvercle extérieur est retiré, l'agitateur entraîné rotatif incluant une extrémité non entraînée (134, 754) montée au niveau du côté non entraîné de la chambre d'agitateur de telle sorte que l'agitateur gire librement au niveau de l'extrémité non entraînée et une extrémité entraînée (132, 732) incluant un organe entraîné, où l'organe entraîné s'accouple axialement et se met en prise avec l'organe d'entraînement du mécanisme d'entraînement de telle sorte que l'organe d'entraînement transmet un couple et une rotation à l'organe entraîné et à l'agitateur entraîné rotatif.

12. La tête de nettoyage de surface de la revendication 11 telle qu'elle dépend de n'importe lesquelles des revendications 7 à 10, où la chambre d'agitateur (120, 720), au niveau du côté non entraîné, inclut des rails de montage (727a, 727b) définissant une région en renfoncement (729) qui reçoit de façon à ce qu'elle puisse coulisser une portion du capuchon d'extrémité (790).

13. La tête de nettoyage de surface de la revendication 12, telle qu'elle dépend de la revendication 4, où la surface externe de la languette (796) est située à proximité d'une portion de dessus de la région en renfoncement (729).

14. La tête de nettoyage de surface de n'importe lesquelles des revendications 11 à 13 comprenant en outre un organe d'étanchéité (725) situé entre le couvercle extérieur (122, 722, 2422, 2522, 2622, 2722, 2822, 2922) et le logement (110, 710) de tête de nettoyage.

15. La tête de nettoyage de surface de n'importe lesquelles des revendications 11 à 14 où le couvercle extérieur (122, 722, 2422, 2522, 2622, 2722, 2822, 2922) inclut une région transparente (724) pour permettre l'inspection visuelle de l'agitateur dans la chambre d'agitateur (120, 720).


102
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114
145
142
144
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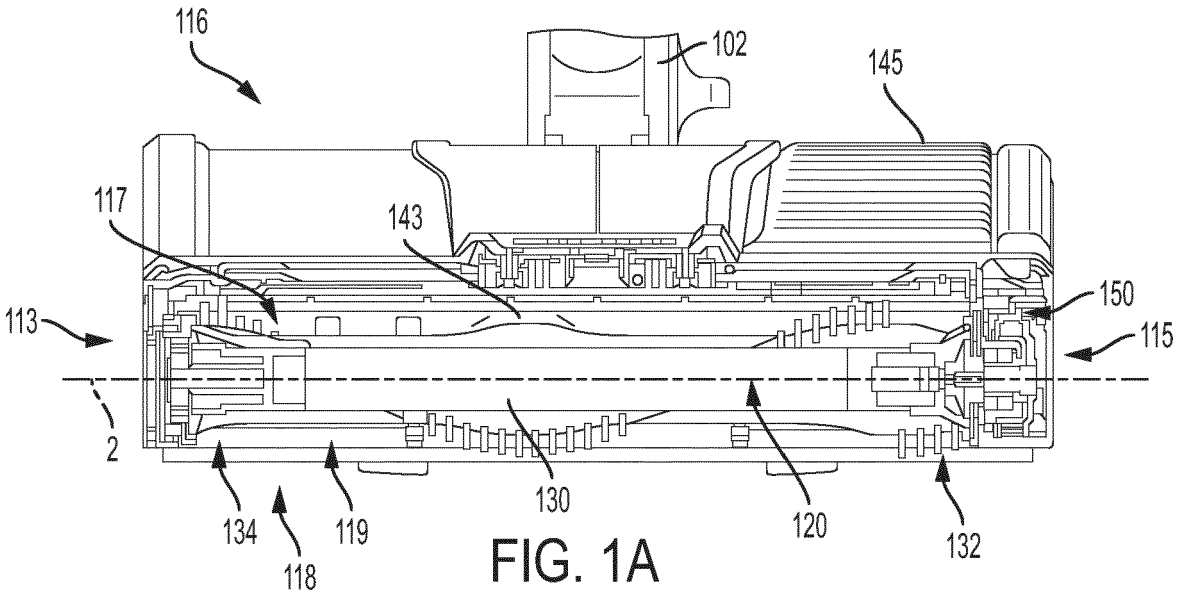
141
148
146
113
129
115
1A
1A
120
126a
126b
122
124
112

FIG. 1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143
150
113
115
2
130
120
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118
132

FIG. 1A

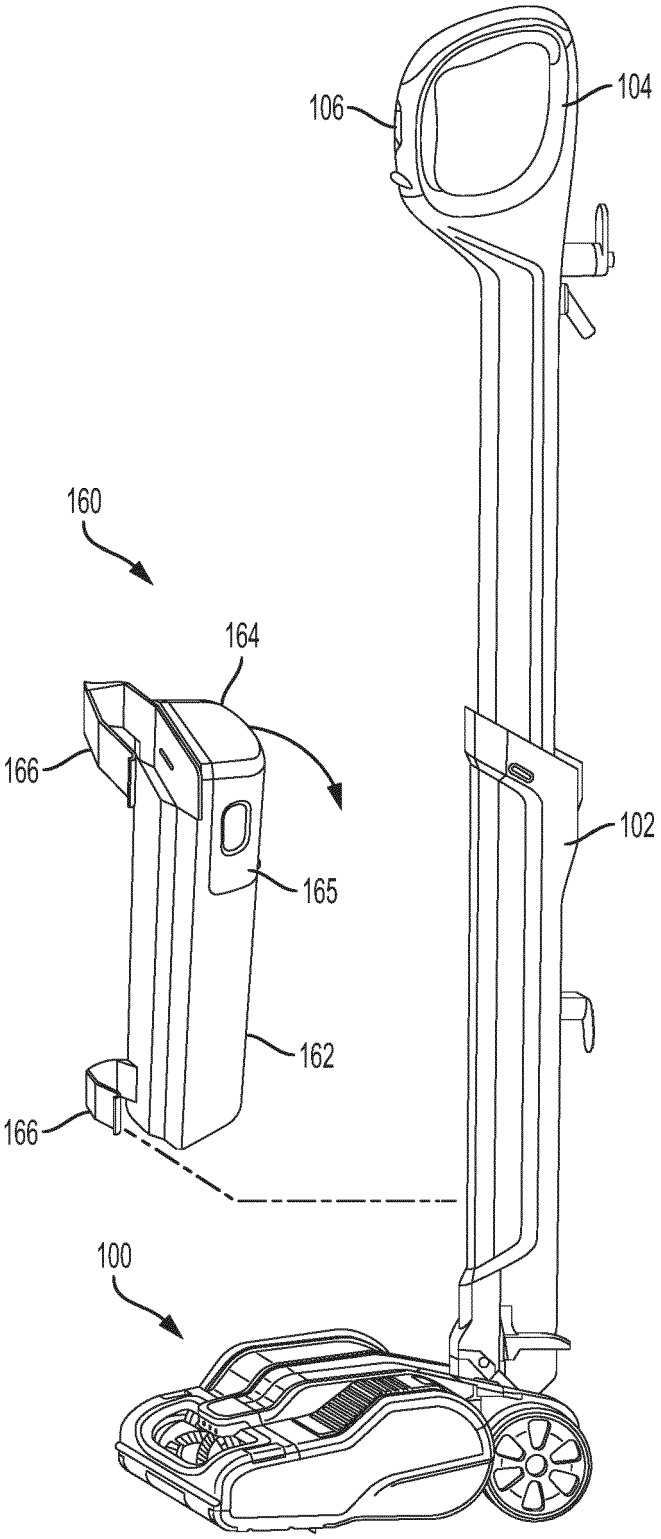
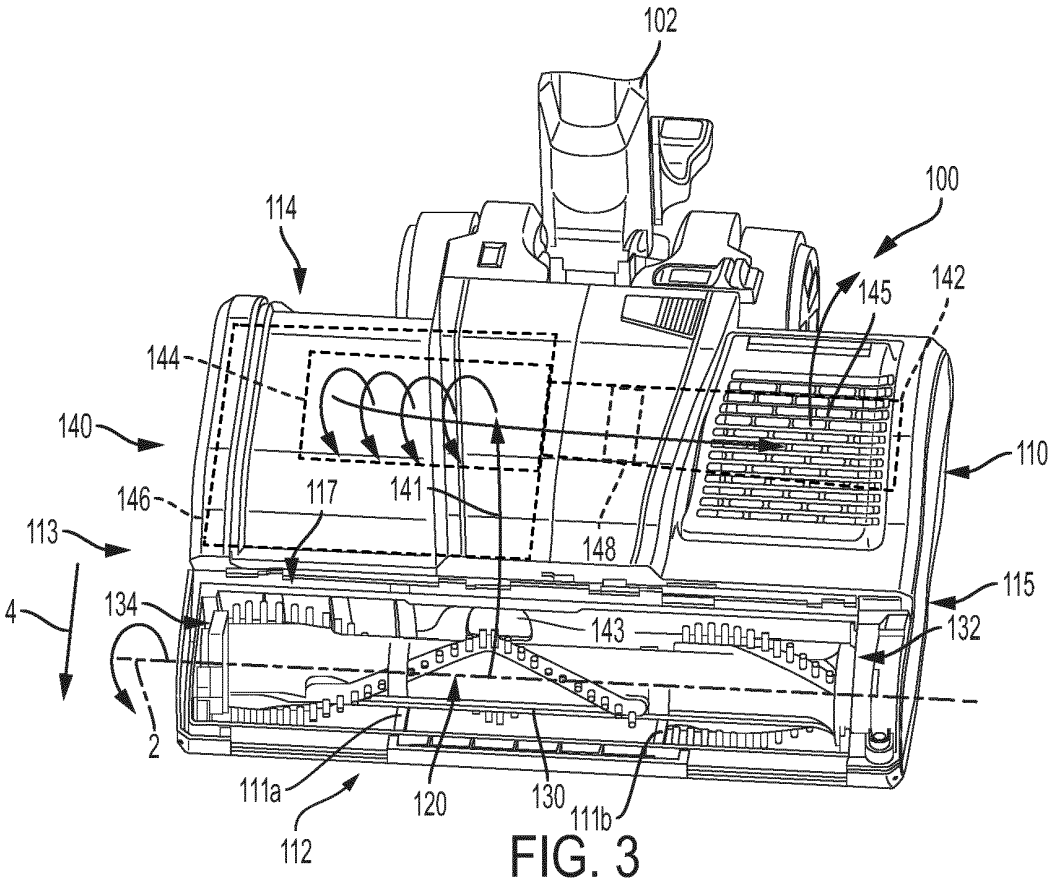


FIG. 2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145
142
144
140
110
146
117
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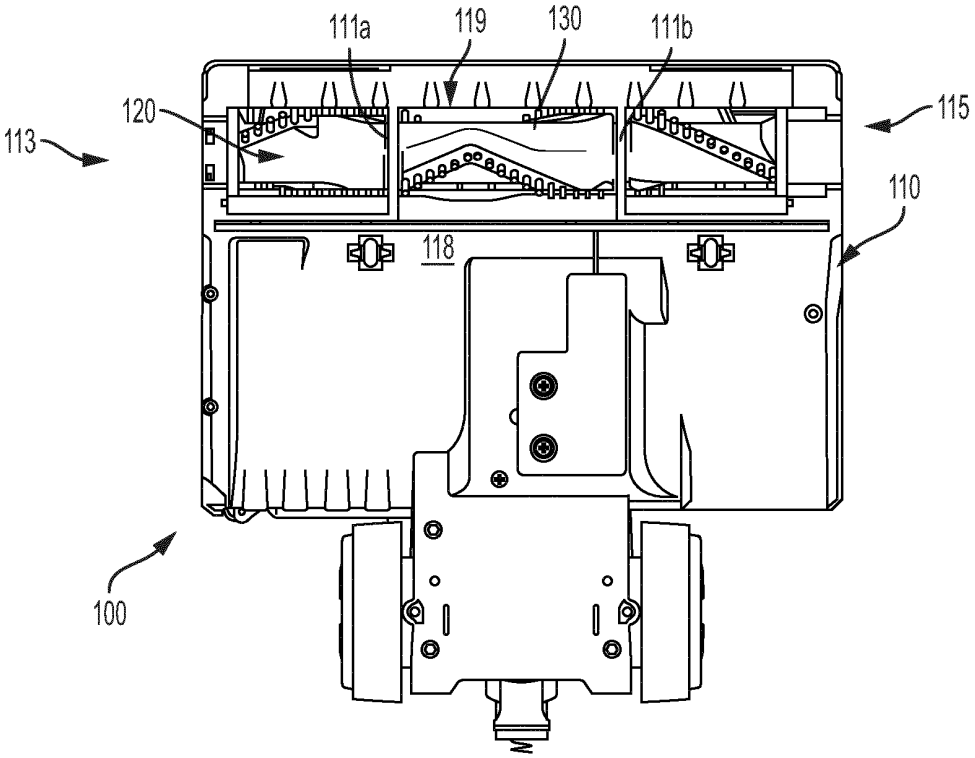
148
113
115
4
134
143
132
2
111a
120
130
111b
112

FIG. 3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119
130
111b
120
115
113
110
118
100

FIG. 3A

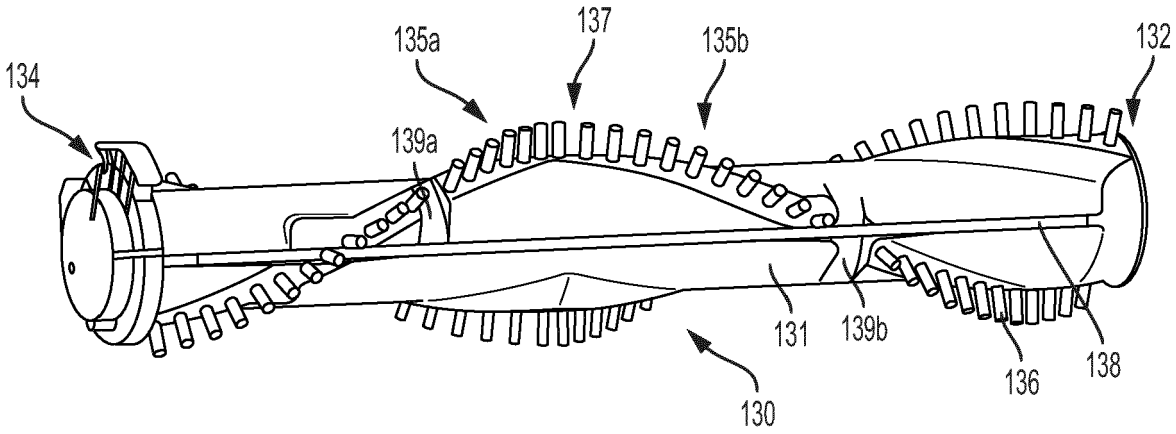


FIG. 4A

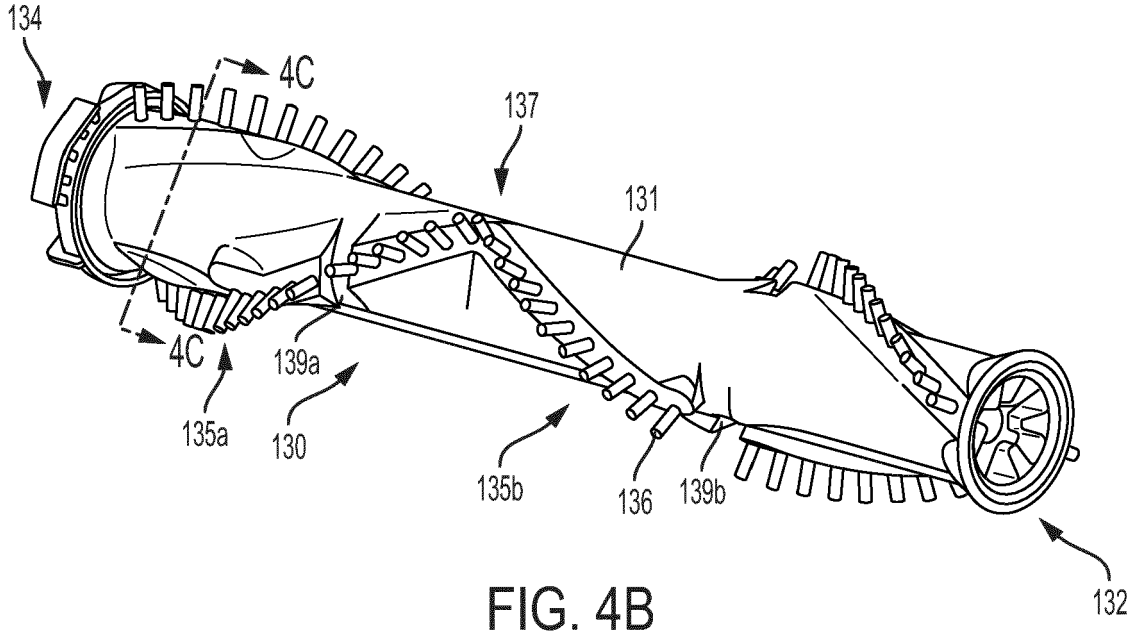


FIG. 4B

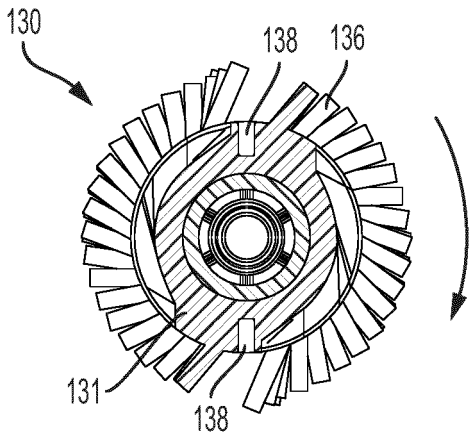


FIG. 4C

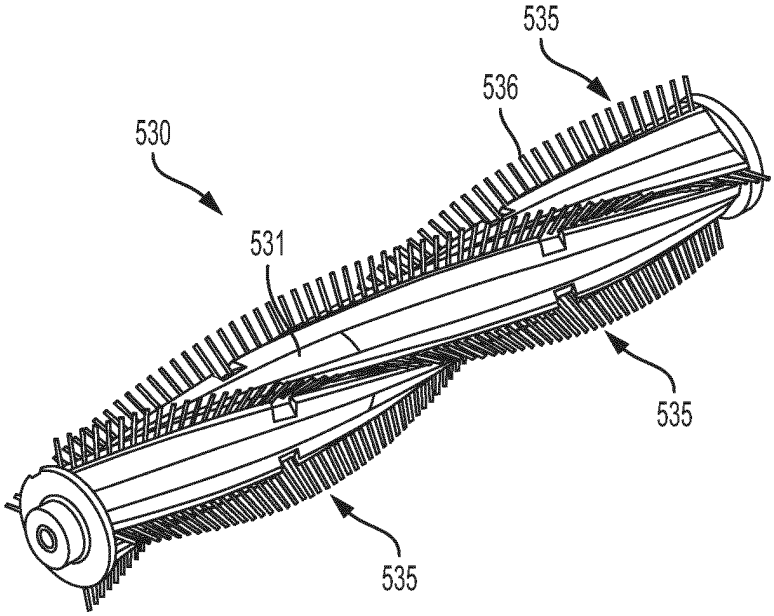


FIG. 5A

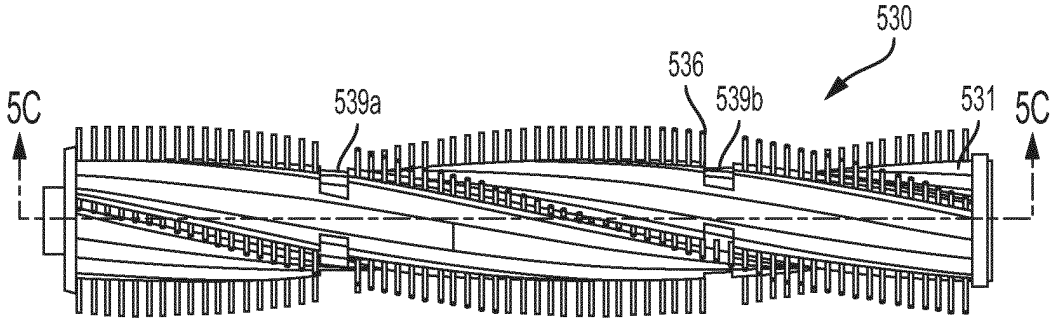


FIG. 5B

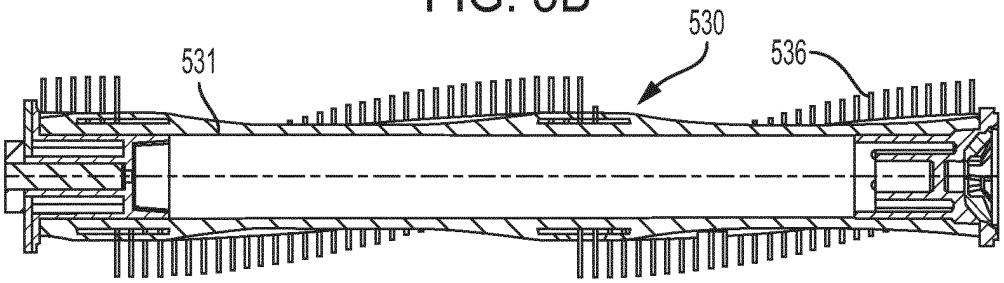


FIG. 5C

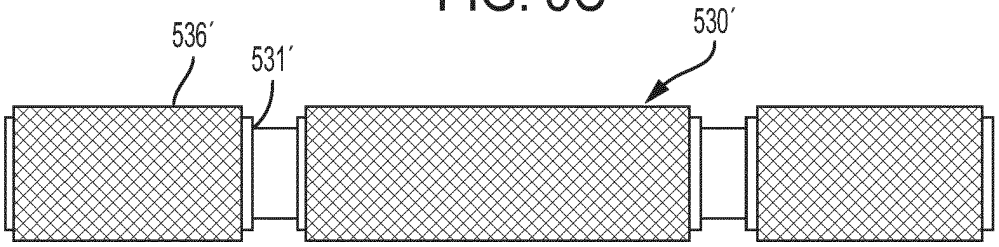


FIG. 5D

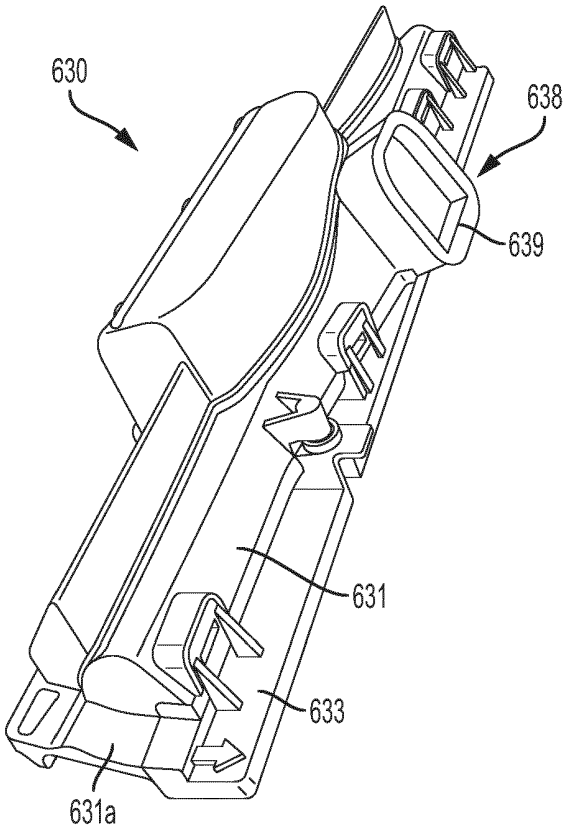


FIG. 6A

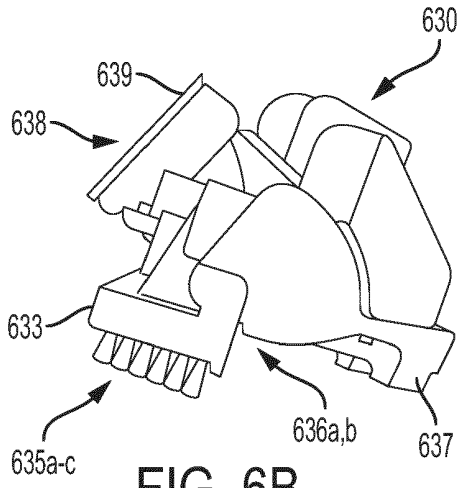


FIG. 6B

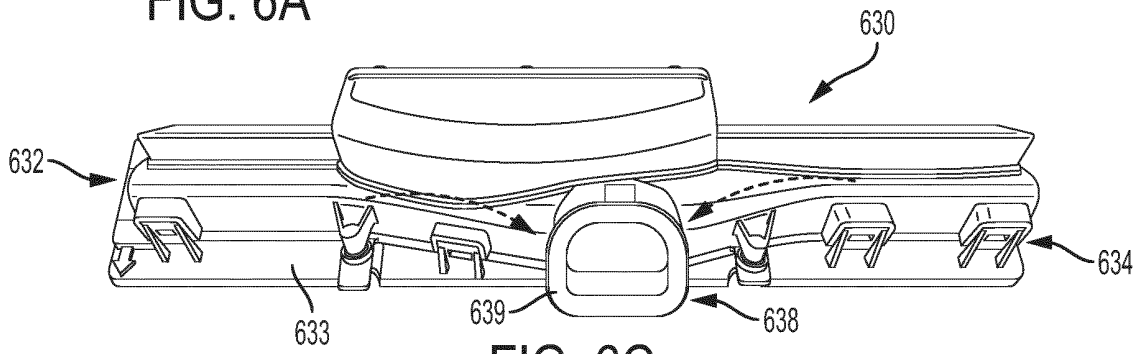


FIG. 6C

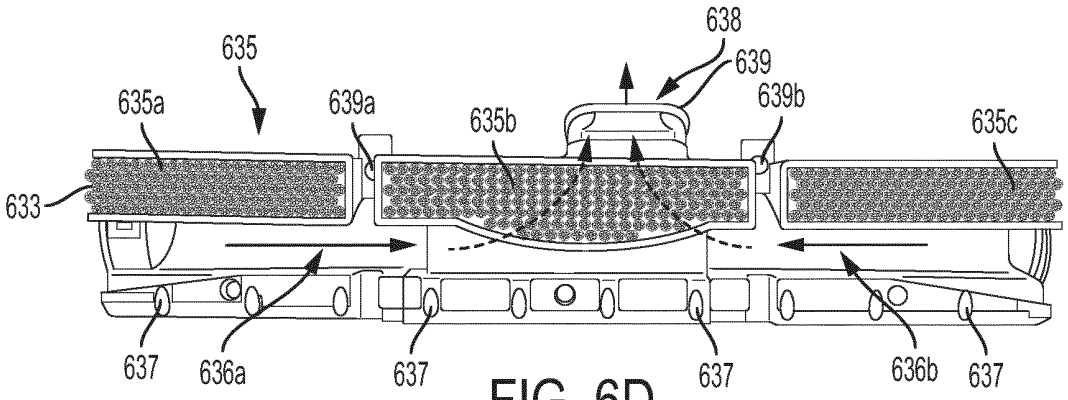
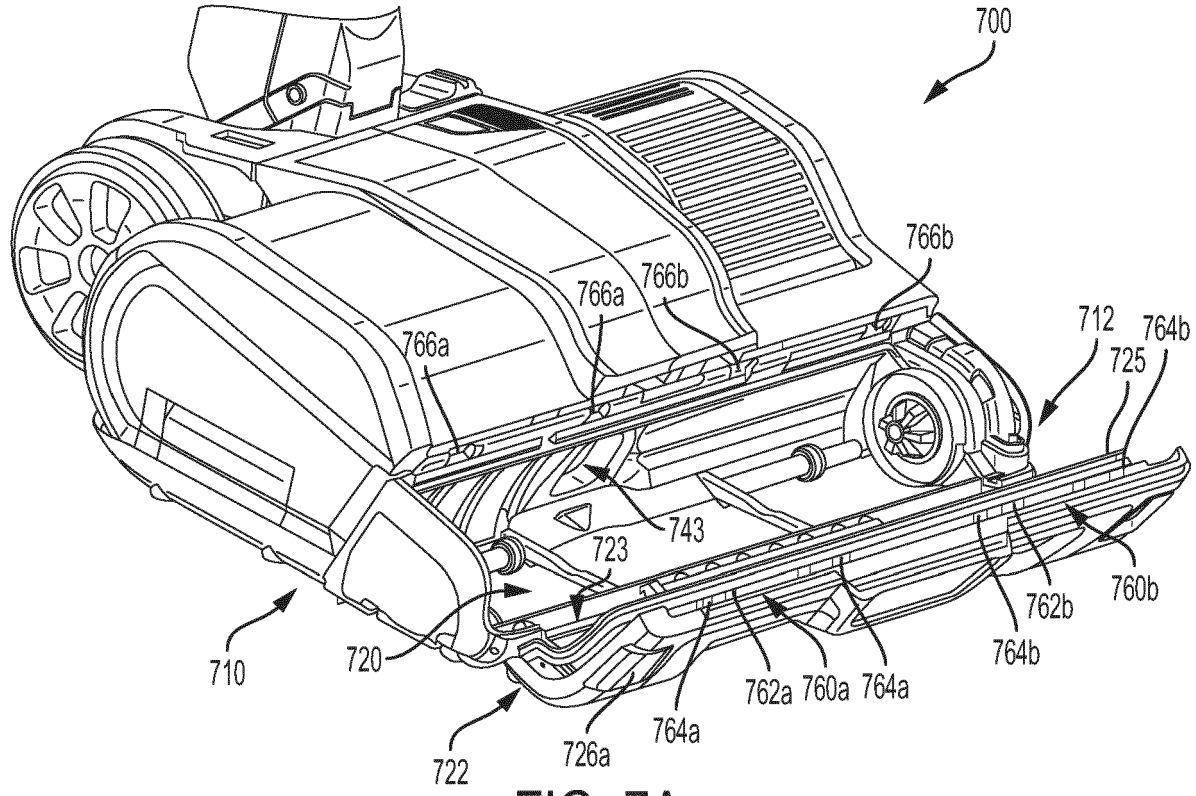


FIG. 6D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743
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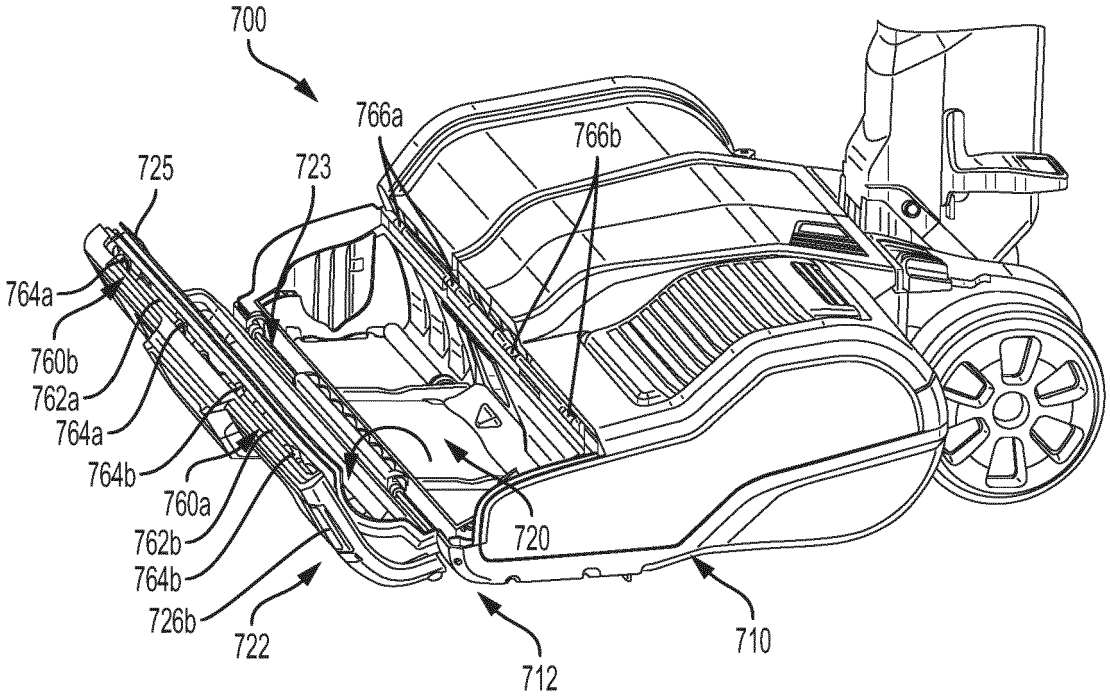
710
720
762a
760a
764a
722
726a
764a

FIG. 7A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712
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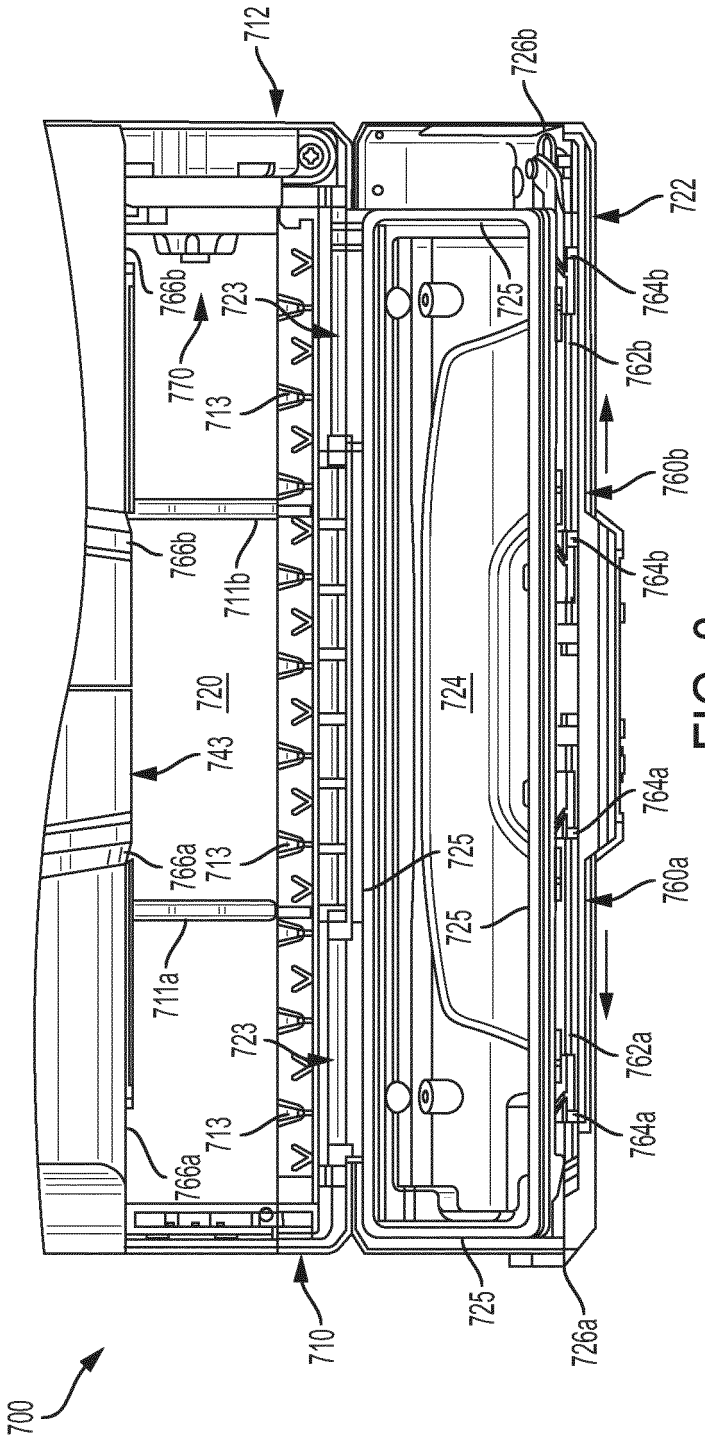
FIG. 7B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726a
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FIG. 8

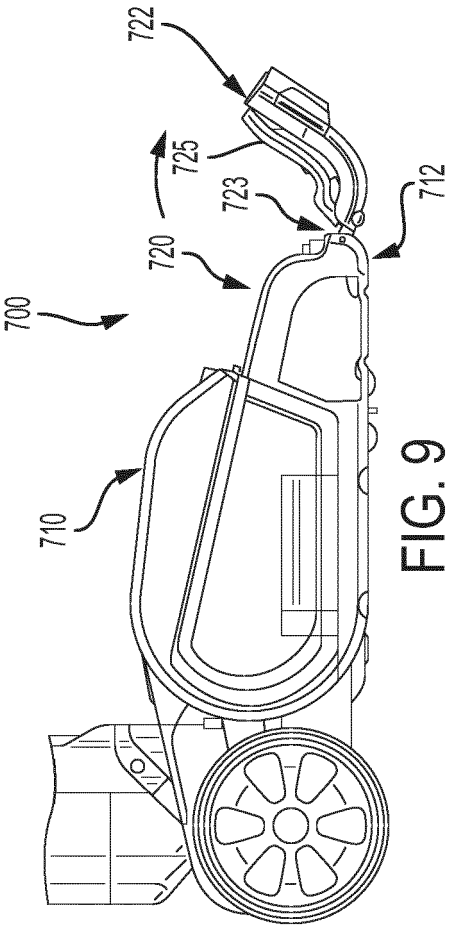
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FIG. 9

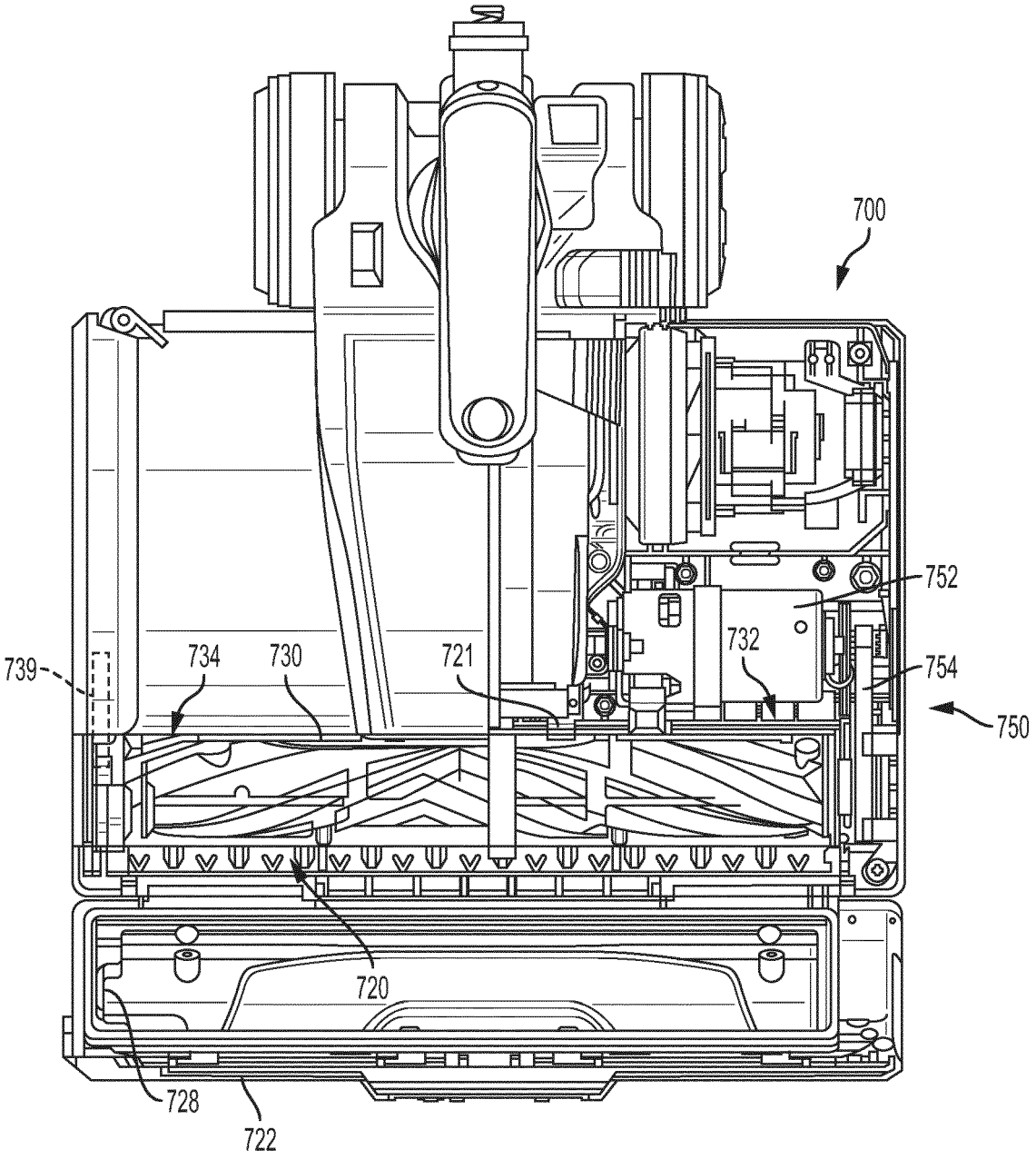

FIG. 10

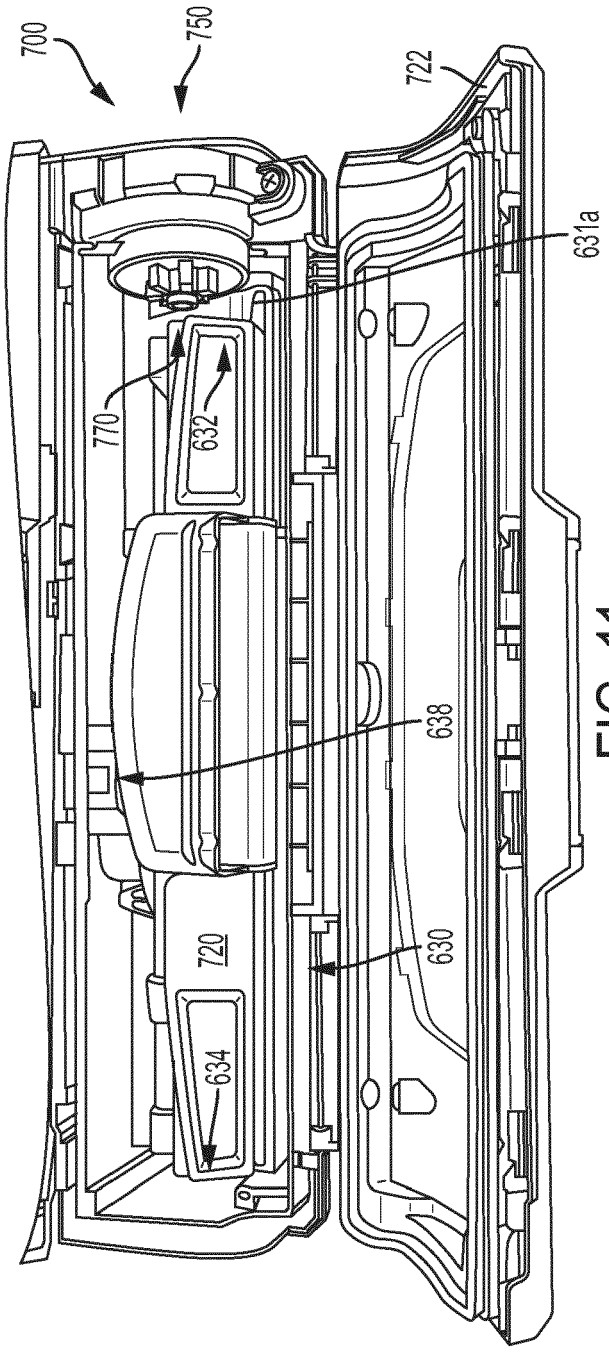
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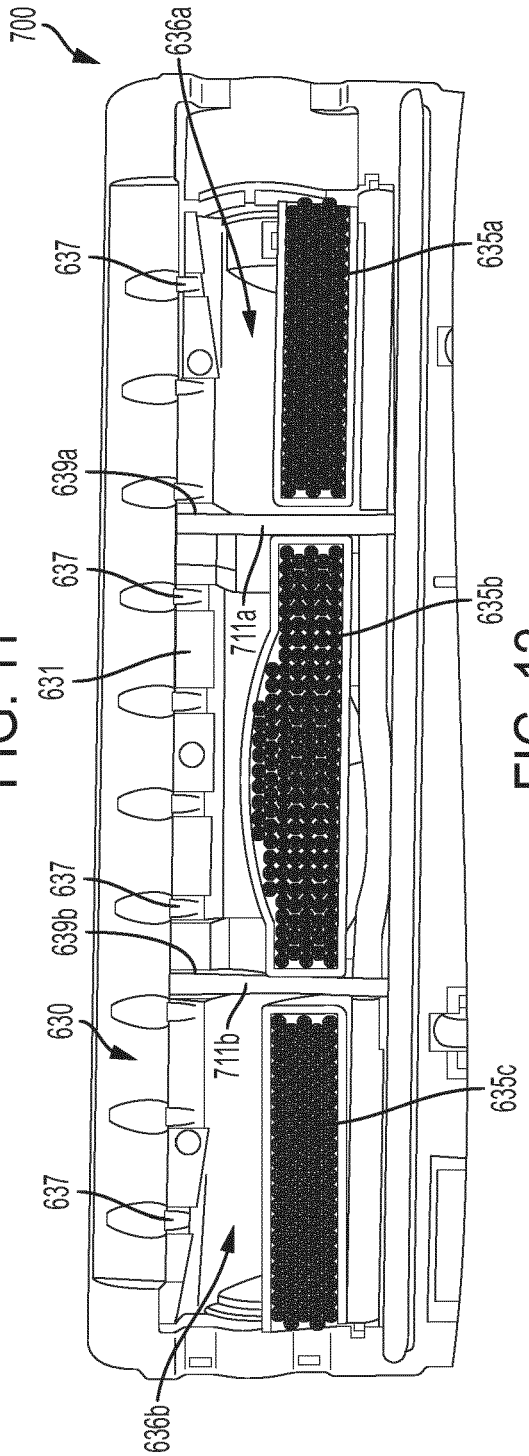
FIG. 11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636b

FIG. 12

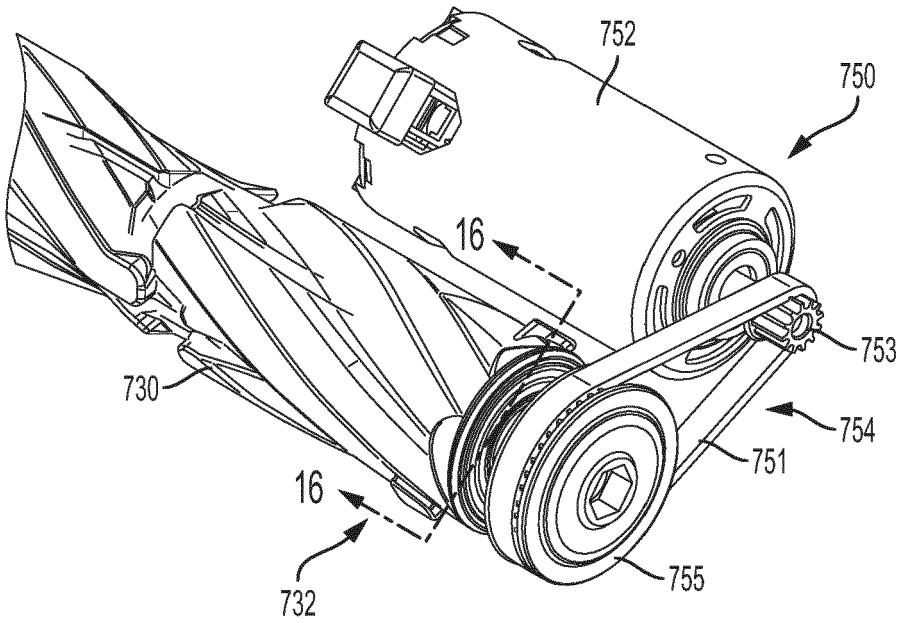
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FIG. 13

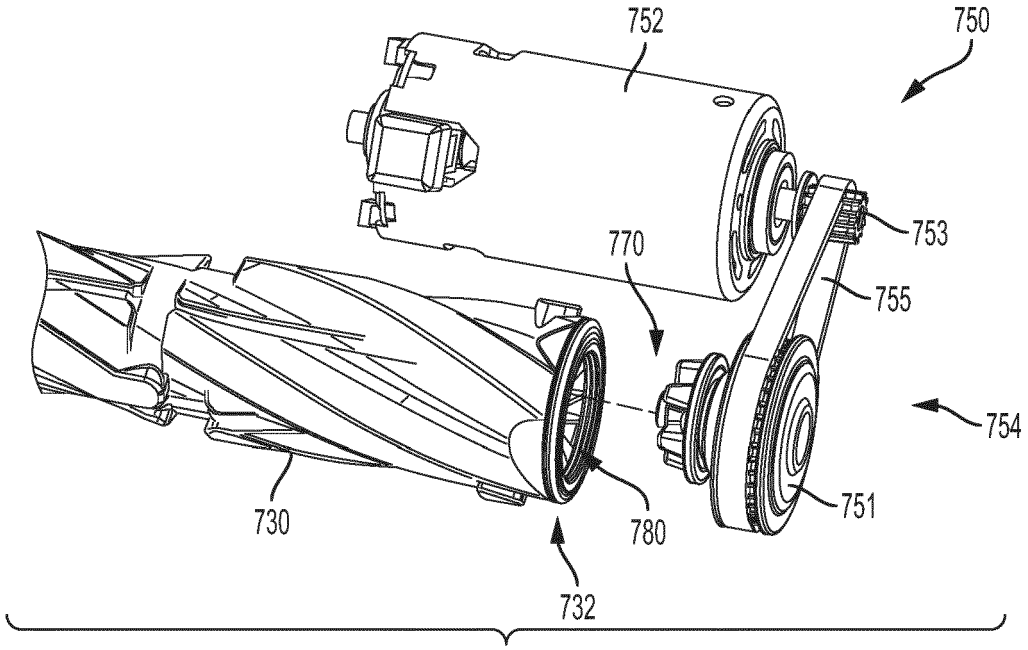
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FIG. 14

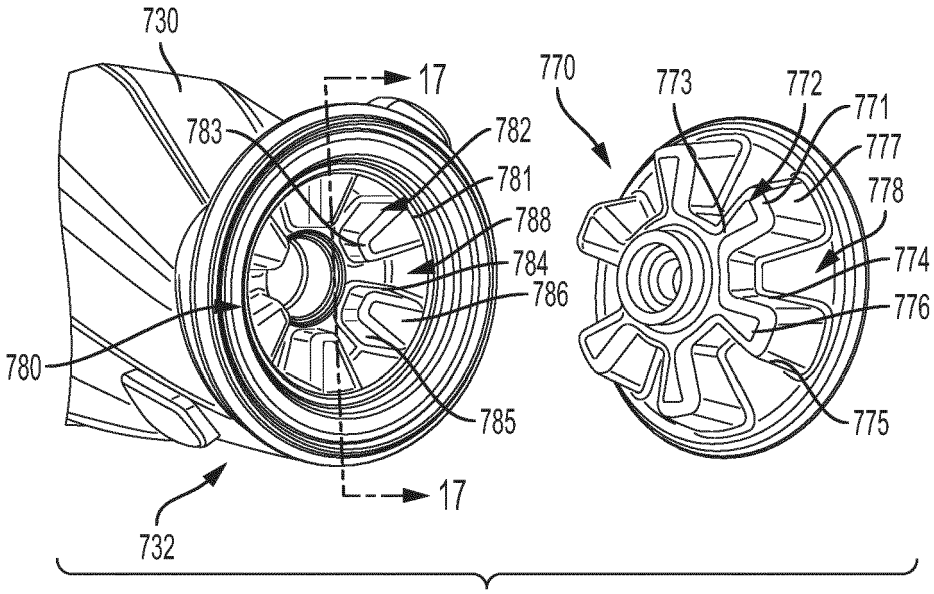

FIG. 15

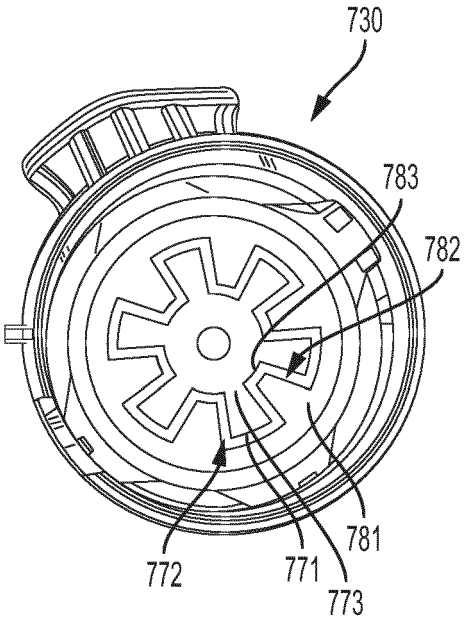

FIG. 16

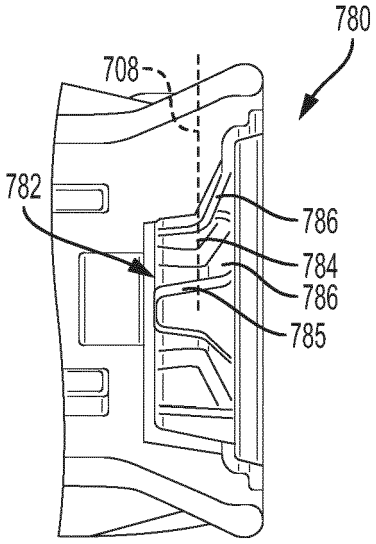

FIG. 17

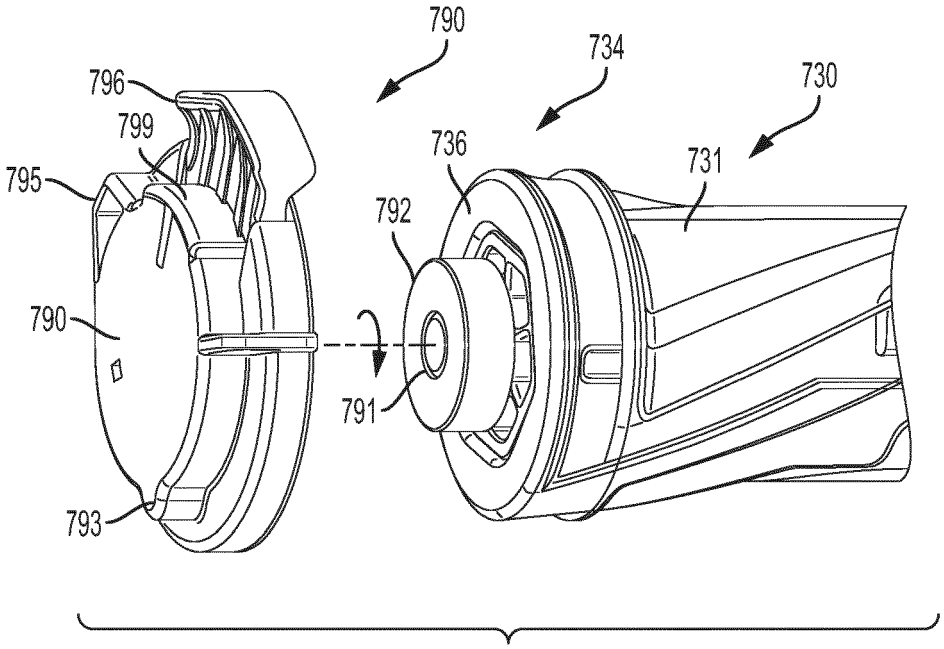

FIG. 18

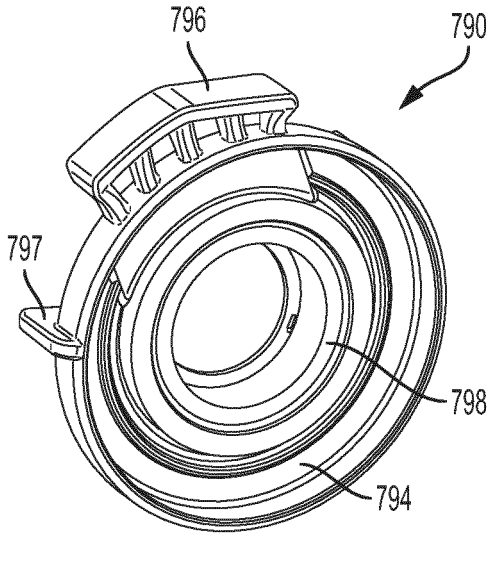

FIG. 19

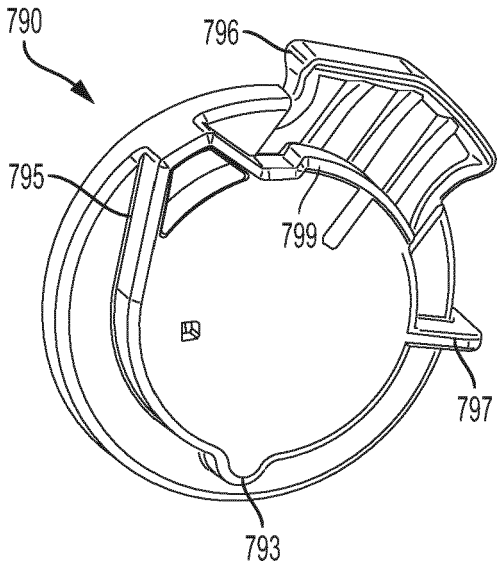

FIG. 20

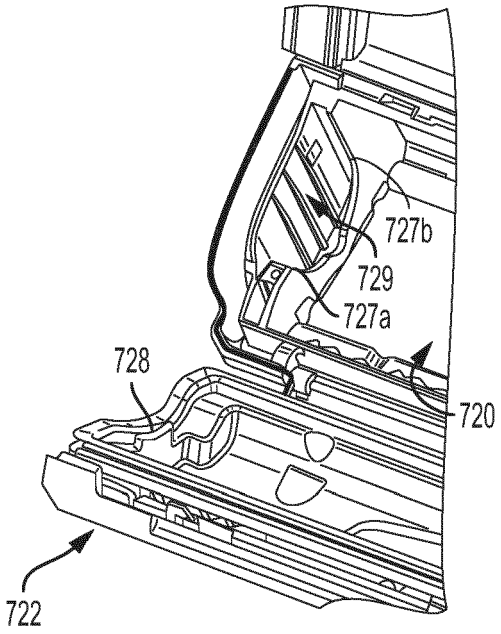

FIG. 21

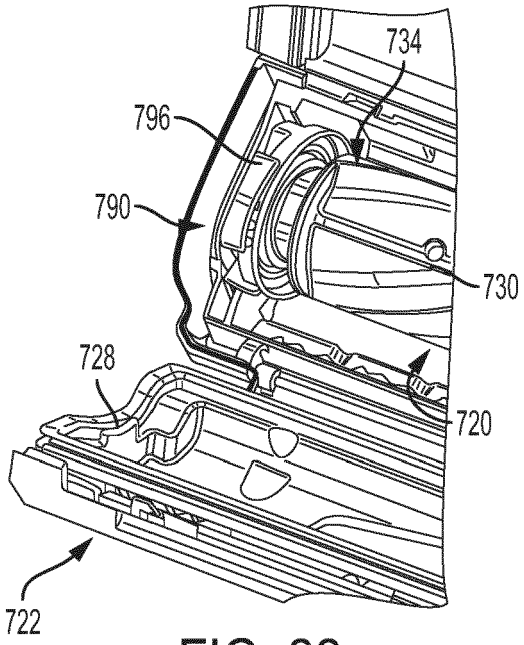

FIG. 22

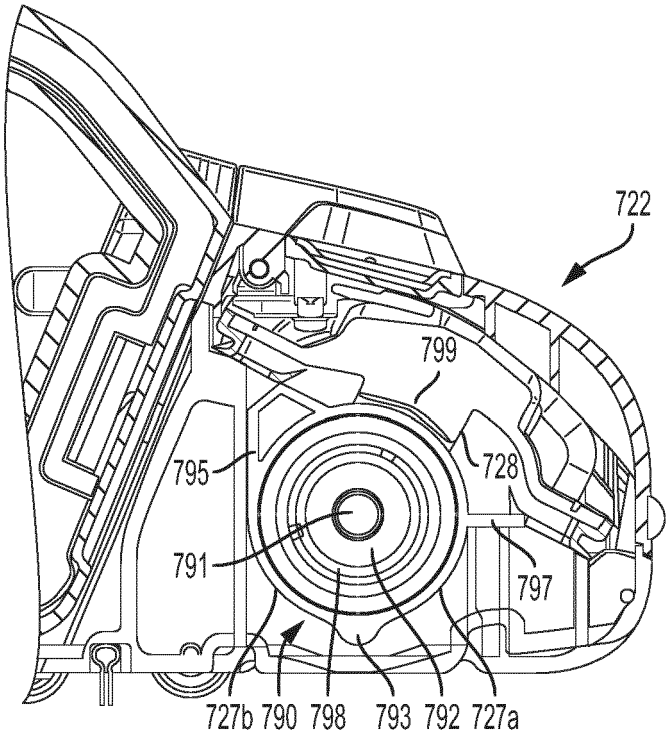

FIG. 23

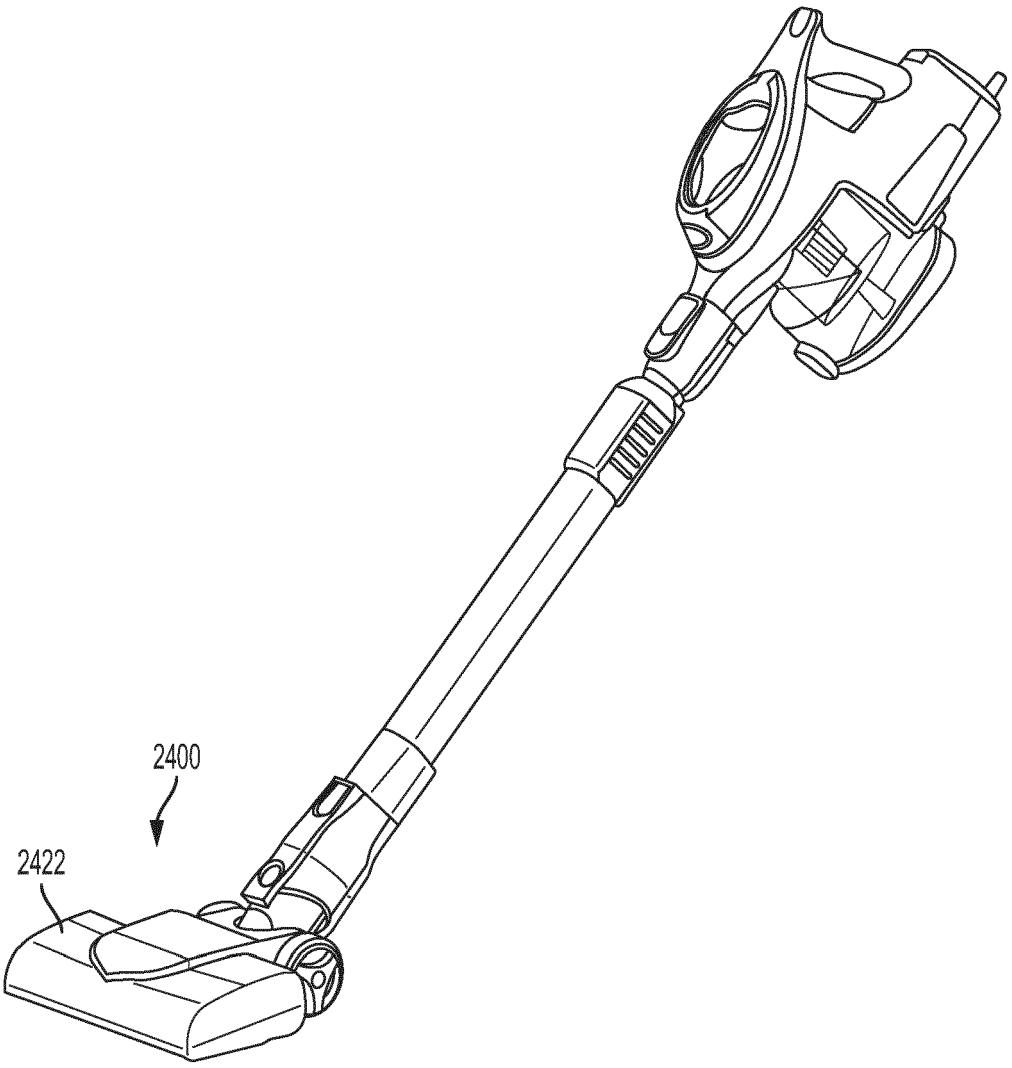

FIG. 24

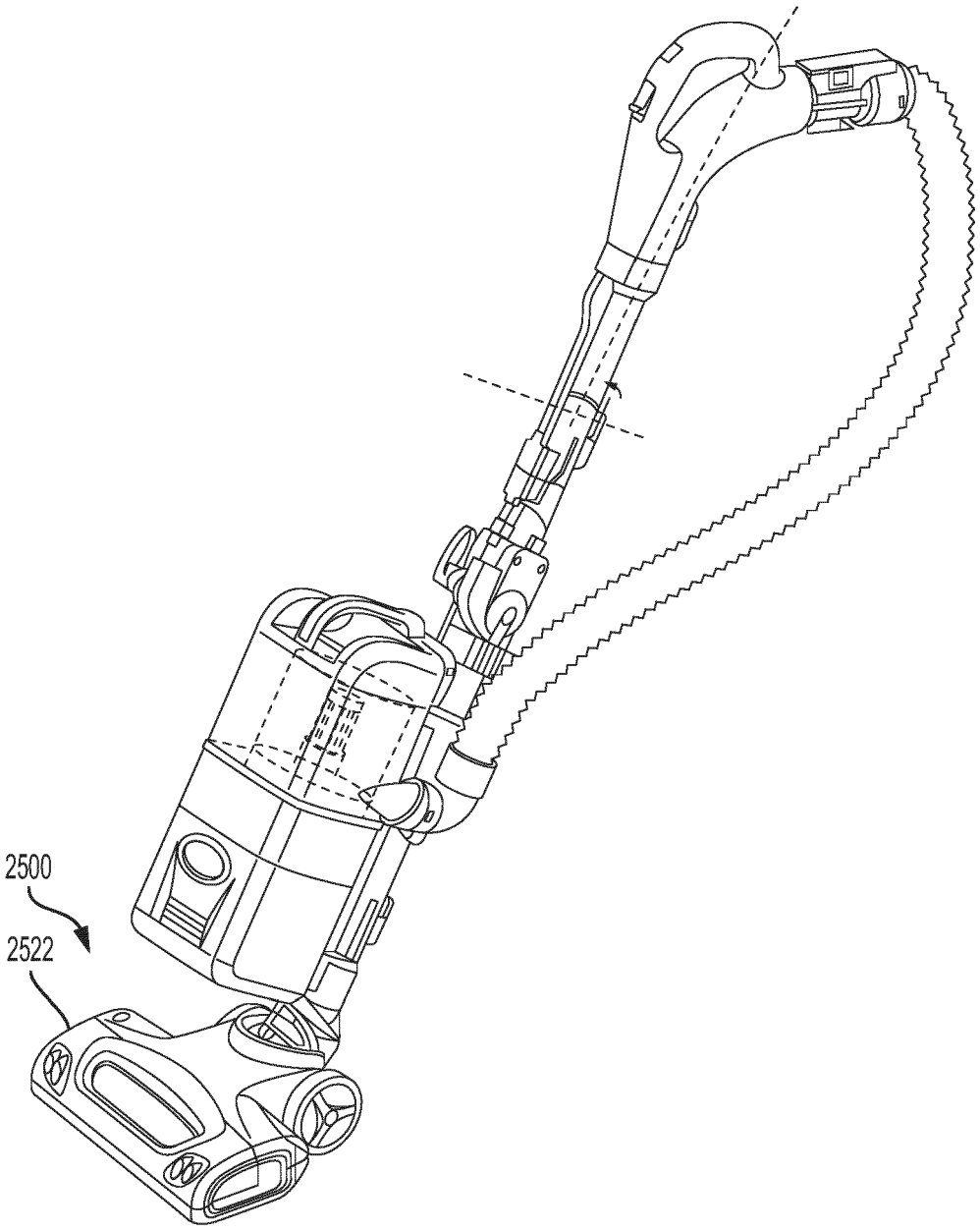

FIG. 25

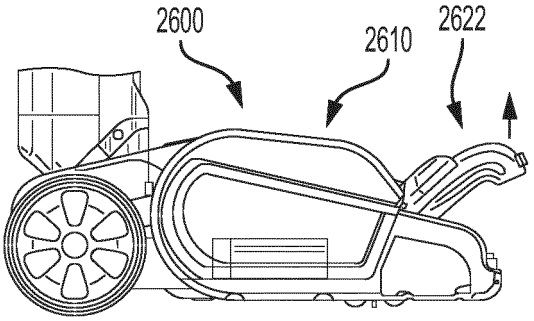

FIG. 26

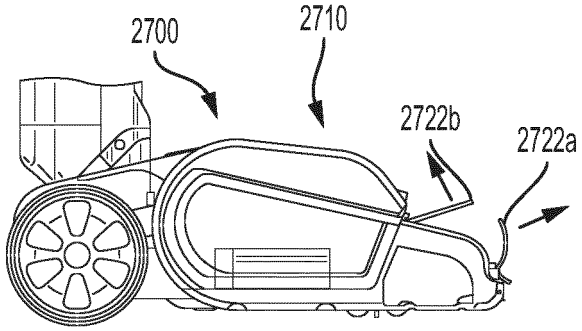

FIG. 27

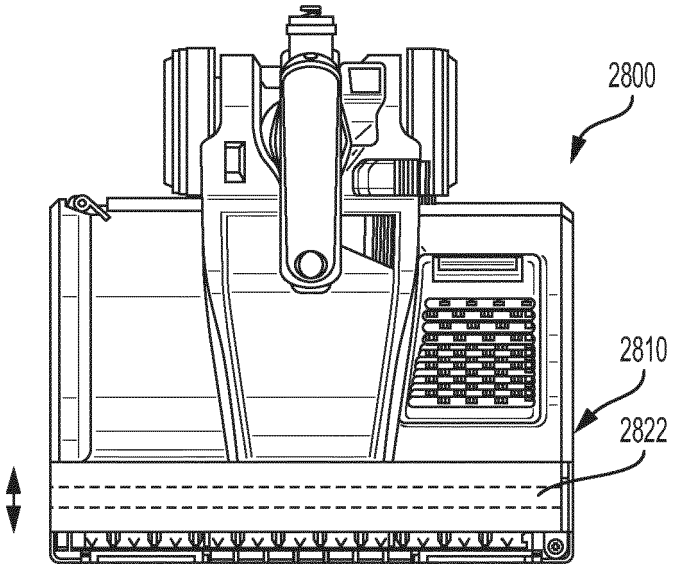

FIG. 28

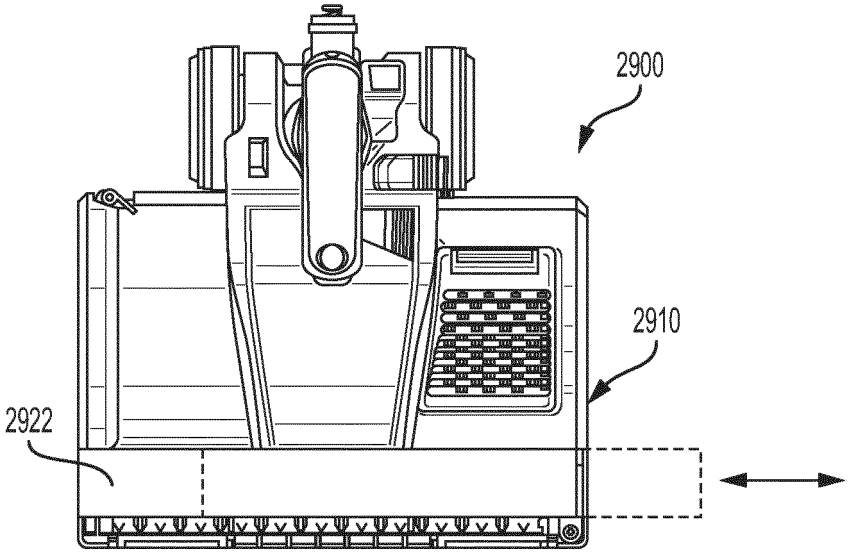

FIG. 29

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2011158596 A1 **[0006]**
- US 7329294 B **[0028]**