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ROBOTIC CLEANER WITH AIR JET ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Application Serial No. 63/330,076 filed on April 12, 2022, entitled Robotic Cleaner with Air Jet Assembly and is continuation-in-part of U.S. Application Serial No. 16/987,801 filed on August 7, 2020, entitled Robotic Cleaner with Air Jet Assembly, which claims the benefit of U.S. Provisional Application Serial No. 62/884,303 filed on August 8, 2019, entitled Robotic Vacuum with Air Jet Assembly, each of which are fully incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure generally relates to surface cleaning apparatuses, and more particularly, to a robotic cleaner configured to generate an air jet.

BACKGROUND INFORMATON

[0003] 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.

[0004] A surface cleaning apparatus may be used to clean a variety of surfaces. Some surface cleaning apparatuses include a rotating agitator (e.g., brush roll). One example of a surface cleaning apparatus includes a vacuum cleaner which may include a rotating agitator and a suction motor. Non-limiting examples of vacuum cleaners include robotic vacuums, multi-surface robotic cleaners (e.g., a robotic cleaner capable of generating a vacuum and performing a mopping function), upright vacuum cleaners, canister vacuum cleaners, stick vacuum cleaners, and central vacuum systems. Another type of surface cleaning apparatus includes a powered broom which includes a rotating agitator (e.g., a brush roll) that collects debris, but does not include a vacuum source.

[0005] Within the field of robotic/autonomous cleaning devices, there are a range of form factors and features that have been developed to meet a range of cleaning needs. However, certain cleaning applications remain a challenge. For example, cleaning along vertical surfaces (e.g., along walls or windows) and within corners may be difficult for robotic cleaning devices. Effectively cleaning along such vertical surfaces while also being capable of reaching into corners raises numerous non-trivial design issues as well as navigational complexities to avoid robotic cleaners getting stuck/obstructed.

BRIEF DESC

DRAWINGS

[0006] These and other features advantages will be better understood by reading the following detailed description, taken together with the drawings wherein:

[0007] FIG. 1 is a top perspective view of a robotic cleaner, consistent with embodiments of the present disclosure.

[0008] FIG. 2 is a side view of the robotic cleaner of FIG. 1, consistent with embodiments of the present disclosure.

[0009] FIG. 3 is a top view of the robotic cleaner of FIG. 1, consistent with embodiments of the present disclosure.

[0010] FIG. 4 is front view of the robotic cleaner of FIG. 1, consistent with embodiments of the present disclosure.

[0011] FIG. 5 is a bottom view of the robotic cleaner of FIG. 1, consistent with embodiments of the present disclosure.

[0012] FIG. 6 is a perspective view of an example ducting system capable of being used with the surface cleaning apparatus of FIG. 1, consistent with embodiments of the present disclosure.

[0013] FIG. 7 is a cross-sectional view of a portion of a robotic cleaner that includes the ducting system of FIG. 6, consistent with embodiments of the present disclosure.

[0014] FIG. 8 is a cross-sectional view of a robotic cleaner that includes the ducting system of FIG. 6, consistent with embodiments of the present disclosure.

[0015] FIG. 9A is a side view of a plurality of example of nozzles that may be used with air jet assemblies, consistent with embodiments of the present disclosure.

[0016] FIG. 9B is a perspective view of the nozzles of FIG. 9A, consistent with embodiments of the present disclosure.

[0017] FIG. 10A is a top view of a plurality of example nozzles that may be used with air jet assemblies, consistent with embodiments of the present disclosure.

[0018] FIG. 10B is a bottom view of the nozzles of FIG. 10A, consistent with embodiments of the present disclosure.

[0019] FIG. 11A is a bottom view of a plurality of example nozzles that may be used with air jet assemblies, consistent with embodiments of the present disclosure.

[0020] FIG. 11B is a perspective side view of the nozzles of FIG. 11A, consistent with embodiments of the present disclosure.

[0021] FIG. 12 is a front view of a robotic cleaner, consistent with embodiments of the present disclosure.

[0022] FIG. 13 is a top view of the robotic cleaner of FIG. 12, consistent with embodiments of the present disclosure.

[0023] FIG. 14 is a bottom perspective view of a portion of a robotic cleaner that includes a fan assembly, consistent with embodiments of the present disclosure.

[0024] FIG. 15A is a magnified view of a portion of an example of the robotic cleaner of FIG. 14 having a nozzle attachment, consistent with embodiments of the present disclosure.

[0025] FIG. 15B shows a perspective view of the robotic cleaner of FIG. 15A, wherein the robotic cleaner includes a plurality of nozzle attachments, consistent with embodiments of the present disclosure.

[0026] FIG. 16 is a magnified view of a portion of a robotic cleaner having an air jet assembly that includes a nozzle attachment, consistent with embodiments of the present disclosure.

[0027] FIG. 17A is a perspective view of a vent that may be used as a component of an air jet assembly, consistent with embodiments of the present disclosure.

[0028] FIG. 17B is a perspective view of a portion of a robotic cleaner having the vent of FIG. 17A, consistent with embodiments of the present disclosure.

[0029] FIG. 18 is a schematic view of a robotic cleaner that includes a ducting system, consistent with embodiments of the present disclosure.

[0030] FIG. 19 is a flow chart of one example of an algorithm for determining when to generate an air jet using a corresponding air jet assembly, consistent with embodiments of the present disclosure.

[0031] FIG. 20 is a schematic example of a robotic cleaner, consistent with embodiments of the present disclosure.

[0032] FIG. 21 is a schematic top view of an example of a robotic cleaner, consistent with embodiments of the present disclosure.

[0033] FIG. 22 is a schematic side view of the robotic cleaner of FIG. 21, consistent with embodiments of the present disclosure.

[0034] FIG. 23 is a perspective view of an example of a robotic cleaner, consistent with embodiments of the present disclosure.

[0035] FIG. 24 is another perspective view of the robotic cleaner of FIG. 23, consistent with embodiments of the present disclosure.

[0036] FIG. 25 is a perspective view of an example of the robotic cleaner of FIG. 23 having a portion removed therefrom, consistent with embodiments of the present disclosure.

[0037] FIG. 26 is a magnified perspective view of the robotic cleaner of FIG. 25, consistent with embodiments of the present disclosure.

[0038] FIG. 27 is another magnified perspective view of the robotic cleaner of FIG. 25, consistent with embodiments of the present disclosure.

[0039] FIG. 28 is a perspective view of an example robotic cleaner of FIG. 23 having a portion removed therefrom, consistent with embodiments of the present disclosure.

[0040] FIG. 29 is a magnified perspective view of the robotic cleaner of FIG. 28, consistent with embodiments of the present disclosure.

[0041] FIG. 30 is a flow chart of an example of a method, consistent with embodiments of the present disclosure.

[0042] FIG. 31 is a flow chart of an example of a method, consistent with embodiments of the present disclosure.

[0043] FIG. 32 is a flow chart of an example of a method, consistent with embodiments of the present disclosure.

[0044] FIG. 33 is a perspective view of an example of a robotic cleaner, consistent with embodiments of the present disclosure.

[0045] FIG. 34 is a top view of the robotic cleaner of FIG. 33 having a portion removed therefrom, consistent with embodiments of the present disclosure.

[0046] FIG. 35 is a top schematic view of a robotic cleaner, consistent with embodiments of the present disclosure.

[0047] FIG. 36 is a top schematic view of an example of the robotic cleaner of FIG. 35, consistent with embodiments of the present disclosure.

[0048] FIG. 37 is a top schematic view of another example of the robotic cleaner of FIG. 35, consistent with embodiments of the present disclosure.

[0049] FIG. 38A is a perspective view of an example of a robotic cleaner, consistent with embodiments of the present disclosure.

[0050] FIG. 38B shows a top view of the robotic cleaner of FIG. 38A, consistent with embodiments of the present disclosure.

[0051] FIG. 38C shows a side view of the robotic cleaner of FIG. 38A, consistent with embodiments of the present disclosure.

[0052] FIG. 39 is a perspective view of the robotic cleaner of FIG. 38A having portions removed therefrom for clarity, consistent with embodiments of the present disclosure.

[0053] FIG. 40 is a magnified perspective view of a portion of the robotic cleaner of FIG. 38A having portions removed therefrom for clarity, consistent with embodiments of the present disclosure.

[0054] FIG. 41 is a perspective view of a nozzle, consistent with embodiments of the present disclosure.

[0055] FIG. 42A is a cross-sectional perspective view of the nozzle of FIG. 41, consistent with embodiments of the present disclosure.

[0056] FIG. 42B is a magnified perspective view of a portion of the nozzle of FIG. 42A, consistent with embodiments of the present disclosure.

[0057] FIG. 43 is a perspective view of the nozzle of FIG. 41, consistent with embodiments of the present disclosure.

[0058] 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

[0059] The present disclosure is generally directed to a robotic cleaner. The robotic cleaner includes a body, an agitator chamber extending along an underside of the body, a suction motor configured to draw air into the agitator chamber, and an air jet assembly coupled to the body. The air jet assembly is configured to shape and direct air passing therethrough, generating an air jet. The air jet is configured to agitate debris adjacent to and/or adhered on a vertical surface (e.g., a wall or other obstacle extending from a floor), edge (e.g., a drop off, such as a staircase), and/or a corner defined at an intersection of two vertical surfaces. The air jet can generally be described as being configured to dislodge debris from one or more surfaces located outside of a movement path of the agitator chamber, increasing an effective cleaning width of the robotic cleaner. Such a configuration may allow the robotic cleaner to clean one or more surfaces that would be otherwise difficult for the robotic cleaner to clean as a result of, for example, a size and/or shape of the robotic cleaner.

[0060] The air jet assembly may include a nozzle having a nozzle inlet and a nozzle exit. The nozzle inlet may be fluidly coupled to one or more of an exhaust of the suction motor and/or a powered fan assembly such that the exhaust of the suction motor and/or the powered fan assembly causes a positive pressure to be generated at the nozzle exit. The nozzle inlet and the nozzle exit may be configured to have a different geometry and/or size. For example, the nozzle inlet may be larger than the nozzle exit such that a velocity of air flowing through the nozzle increases.

[0061] Additionally, or alternatively, the air jet assembly may include a vent. The vent may include one or more louvers configured shape and/or direct air passing through the vent into an air jet. The vent may be positioned such that the generated air jet extends beyond an outer perimeter of the robotic cleaner. Such a configuration may allow the generated air jet to be incident on a vertical surface proximate to the robotic cleaner.

[0062] Although the present disclosure specifically references floor-based robotic cleaning devices, this disclosure is not necessarily limited in this regard. Aspects and embodiments disclosed herein are equally applicable to hand held cleaning devices.

[0063] As used herein, the term “air jet assembly” may generally refer to one or more components, wherein one or more of the one or more components are configured to shape, direct, and/or introduce a velocity change to (e.g., increase a velocity of) air moving therethrough. In some instances, a portion of the air jet assembly extends/projects from a body of a robotic cleaner.

[0064] As used herein, the term “air jet” may generally refer to an airflow that has been modified (e.g., shaped, directed, and/or caused to undergo to a velocity change) by flowing through an air jet assembly. The term air jet is not intended to limit the air jet assembly to a particular shape or configuration.

[0065] As generally referred to herein, the term surface to be cleaned generally refers to a surface on which a robotic cleaning apparatus travels, such as a floor. As may be appreciated, one or more air jet assemblies may also allow the robotic cleaning apparatus to clean a surface that extends transverse to the surface to be cleaned such as a wall or other obstacle.

[0066] Various apparatuses or processes will be described below to provide an example of an embodiment of each claimed invention. No embodiment described below limits any claimed invention and any claimed invention may cover processes or apparatuses that differ

from those described below. The claimed inventions are not limited to apparatuses or processes having all of the features of any one apparatus or process described below or to features common to multiple or all of the apparatuses described below. It is possible that an apparatus or process described below is not an embodiment of any claimed invention. Any invention disclosed in an apparatus or process described below that is not claimed in this document may be the subject matter of another protective instrument, for example, a continuing patent application, and the applicants, inventors or owners do not intend to abandon, disclaim or dedicate to the public any such invention by its disclosure in this document.

[0067] Referring to FIGS. 1-5, an example of a robotic cleaner 100 (e.g., a robotic vacuum cleaner), consistent with embodiments of the present disclosure, is shown and described. Although a particular embodiment of a robotic cleaner is shown and described herein, the concepts of the present disclosure may apply to other types robotic cleaners, including, for example, robotic multi-surface cleaners and robotic mops.

[0068] The robotic cleaner 100 includes a housing (or body) 110 with a front side 112, and a back side 114, left and right sides 116a, 116b, an upper side (or top surface) 118, and a lower side or underside (or bottom surface) 120. In some instances, a bumper 111 may be movably coupled to the housing 110 such that the bumper 111 extends around at least a portion of the housing 110 (e.g., a front portion and/or front half of the housing 110). The top surface 118 of the housing 110 may include controls 102 (e.g., buttons) to initiate certain operations, such as autonomous cleaning, spot cleaning, and docking and indicators (e.g., LEDs) to indicate operations, battery charge levels, errors, and other information. The robotic cleaner 100 may further include one or more air jet assemblies (not shown), which are discussed in further detail below. The air jet assemblies may be fluidly coupled to one or more air ducts or outlets of the robotic cleaner 100 (e.g., clean air outlets, air outlet ports, fan outlets, clean air exhaust ducts, or exhaust ducts).

[0069] In the illustrated example embodiment, and as shown in FIG. 5, the housing 110 further includes a suction conduit 128. The suction conduit 128 includes an agitator chamber 101 having an opening 127 on the underside 120 of the housing 110. The agitator chamber 101 includes (e.g., defines) a dirty air inlet (not shown) that is fluidly coupled to a suction motor (not shown) of the robotic cleaner 100. The opening 127 can be described as defining an open end of the suction conduit 128 through which air is drawn by the suction motor. At least a portion of the agitator chamber 101 may be defined by the housing 110. For example, the

agitator chamber 101 may be defined by a cavity of the housing 110, wherein the cavity includes the opening 127.

[0070] A debris collector 119, such as a removable dust bin, is located in or integrated with the housing 110. The debris collector 119 can be disposed within the suction conduit 128 at a position between the agitator chamber 101 and the suction motor. As such, at least a portion of debris entrained within air flowing into the debris collector 119 may be collected within the debris collector 119.

[0071] The robotic cleaner 100 may also include one or more clean air outlets 121. The one or more clean air outlets 121 may be fluidly coupled to the suction conduit 128. For example, the suction motor may be disposed at location along the suction conduit 128 that is between the one or more clean air outlets 121 and the debris collector 119. Additionally, or alternatively, one or more powered fan assemblies may be fluidly coupled to the one or more clean air outlets 121. For example, the suction motor may be fluidly coupled to a first inlet of the clean air outlets 121 and the fan assembly may be fluidly coupled to a second inlet of the clean air outlets 121. As shown, the one or more clean air outlets 121 can be disposed on the underside 120 of the housing 110.

[0072] The suction conduit 128 may include any suitable combination of rigid conduits, flexible conduits, chambers, and/or other features that may cooperate to direct a flow of air through the robotic cleaner 100. Optionally, one or more filters or filtration members, for example a high efficiency particulate air (HEPA) filter, can be configured such that air traveling through the suction conduit 128 passes through the one or more filters prior to the one or more clean air outlets 121. The one or more clean air outlets 121 may be configured to fluidly connect to one or more air jet assemblies.

[0073] In one embodiment, the robotic cleaner 100 may also include one or more cavities on the underside 120 of the housing 110. The one or more cavities include one or more fan outlets. The one or more fan outlets are fluidly coupled to a secondary air inlet (not shown) such that an air path extends from the secondary air inlet to the one or more fan outlets. The air path may include any suitable combination of rigid conduits, flexible conduits, chambers, and/or other features that may cooperate to direct a flow of air through the robotic cleaner. The one or more fan outlets may be configured to fluidly connect to one or more air jet assemblies.

[0074] The one or more air jet assemblies may include one or more nozzles configured to generate air jets when air passes therethrough, as described in further detail herein. The nozzle may be configured to be articulable such that an angle formed between a surface to be cleaned and an air jet generated by the nozzle can be adjusted. In some instances, the nozzles may be self-articulating (e.g., in response to actuation of one or more articulation motors controlled by, for example, a controller 136).

[0075] The robotic cleaner 100 may include a rotating agitator 122 (e.g., a main brush roll). The rotating agitator 122 rotates about a substantially horizontal axis to urge debris towards the debris collector 119. The rotating agitator 122 is at least partially disposed within the agitator chamber 101 of the suction conduit 128. The rotating agitator 122 may be coupled to a motor 123, such as an AC or DC motor, to impart rotation to the rotating agitator 122 by way of, for example, one or more drive belts, gears, and/or any other driving mechanism.

[0076] The rotating agitator 122 may have bristles, fabric, or other cleaning elements, or any combination thereof around the outside of the agitator 122. The rotating agitator 122 may include, for example, strips of bristles in combination with strips of a rubber or elastomer material. The rotating agitator 122 may also be removable to allow the rotating agitator 122 to be cleaned more easily and allow the user to change the size of the rotating agitator 122, change type of bristles on the rotating agitator 122, and/or remove the rotating agitator 122 entirely depending on the intended application. The robotic cleaner 100 may further include a bristle strip 126 on an underside of the housing 110 and adjacent a portion of the suction conduit 128 (e.g., along a periphery of the opening 127). The bristle strip 126 may include bristles having a length sufficient to at least partially contact the surface to be cleaned. The bristle strip 126 may also be angled, for example, towards the agitator chamber 101 of the suction conduit 128.

[0077] The robotic cleaner 100 may also include several different types of sensors. For example, the robotic cleaner 100 may include one or more forward obstacles sensors 140 (FIG. 4) configured to detect obstacles in a travel path of the robotic cleaner 100. The one or more forward obstacle sensors 140 may be integrated with and/or separate from the bumper 111. For example, the one or more forward obstacles sensors 140 may be configured to cooperate with the bumper 111 such that signals emitted from the forward obstacle sensors 140 can pass through at least a portion of the bumper 111. The one or more forward obstacle sensors 140 may include one or more of infrared sensors, ultrasonic sensors, time-of-flight sensors, a camera (e.g., a stereo or monocular camera), and/or any other sensor.

[0078] One or more bump sensors 142 (e.g., optical switches behind the bumper) detect contact of the bumper 111 with obstacles during operation. One or more wall sensors 144 (e.g., an infrared sensor directed laterally to a side of the housing) detect a side wall when traveling along a wall (e.g., wall following). Cliff sensors 146a-d (e.g., infrared sensors, time-of-flight sensors) can be located adjacent a periphery of the underside 120 of the housing 110 and are configured to detect the absence of a surface on which the robotic cleaner 100 is traveling (e.g., staircases or other drop offs).

[0079] The controller 136 is communicatively coupled to the sensors (e.g., the bump sensors, wheel drop sensors, rotation sensors, forward obstacle sensors, side wall sensors, cliff sensors) and to the driving mechanisms (e.g., the motor 123 configured to cause the rotating agitator 122 to rotate, drive motor(s) 124 configured to control one or more features of an air jet assembly, and/or the wheel drive motors 134) for controlling movement and/or other functions of the robotic cleaner 100. Thus, the controller 136 can be configured to operate the drive wheels 130, air jet assemblies, and/or agitator 122 in response to sensed conditions, for example, according to known techniques in the field of robotic cleaners. The controller 136 may operate the robotic cleaner 100 to perform various operations such as autonomous cleaning (including randomly moving and turning, wall following and obstacle following), spot cleaning, and docking. The controller 136 may also operate the robotic cleaner 100 to avoid obstacles and cliffs and to escape from various situations where the robot may become stuck. The controller 136 may include any combination of hardware (e.g., one or more microprocessors) and software known for use in mobile robots.

[0080] As shown in FIGS. 6-8, a robotic cleaner 600 may include a suction motor 607, a debris collector 602, an agitator chamber 604 having a dirty air inlet 606, and internal ducting 603. The suction motor 607 is fluidly coupled to the dirty air inlet 606 of the agitator chamber 604, the debris collector 602, and the internal ducting 603. The suction motor 607 is configured to generate suction within the agitator chamber 604, causing air to flow through the dirty air inlet 606 and the debris collector 602 and into a suction side of the suction motor 607. The air flowing into the suction motor 607 is exhausted from an exhaust side of the suction motor 607 and into the internal ducting 603. The internal ducting 603 is fluidly coupled to an air outlet 609 such that air flowing through the internal ducting 603 passes through the air outlet 609. The air outlet 609 may include and/or be fluidly coupled to an air jet assembly. As such, the positive air pressure generated on the exhaust side of the suction motor 607 may be directed

through the air outlet 609 and the air jet assembly. The agitator chamber 604, the debris collector 602, the suction motor 607, the internal ducting 603, and the air outlet 609 may generally be described as forming at least part of a suction conduit within the robotic cleaner 600.

[0081] In some instances (e.g., in the absence of internal ducting 603), air may be exhausted through an exhaust port (not shown) on the robotic cleaner 600. In this instance, an exhaust outlet plug 601 may be used to redirect the flow of air from the exhaust port and through the internal ducting 603 and to the air outlet 609.

[0082] FIGS. 9A-11B illustrate example embodiments of nozzles that may be used as components of air jet assemblies. FIGS. 9A and 9B are schematic views of nozzles A-G that may be used as components of air jet assemblies consistent with embodiments of the present disclosure. FIG. 9A is a side view of the nozzles A-G that may be used as components of air jet assemblies consistent with embodiments of the present disclosure. FIG. 9B is a perspective view of the nozzles A-G that may be used as components of air jet assemblies consistent with embodiments of the present disclosure. Nozzles, when used as components of air jet assemblies, may be configured to regulate air flow velocity, direction, and/or shape.

[0083] The air jet assembly is configured to be fluidly coupled to a suction conduit of a robotic cleaner such that air flowing through the suction conduit passes through the air jet assembly. A nozzle of the air jet assembly is configured to regulate a shape, direction, and/or velocity of air passing therethrough. For example, the nozzle may be configured to cause a velocity of air flowing therethrough to increase. As such, a nozzle can generally be described as being capable of being configured produce an air jet having desired properties.

[0084] The nozzle includes a nozzle inlet 905 and a nozzle exit 901. Air flows first through the nozzle inlet 905 and then through the nozzle exit 901 to be exhausted into a surrounding environment. The nozzle inlet 905 may have a different size and/or shape than the nozzle exit 901. For example, a size of the nozzle inlet 905 may measure greater than a size of the nozzle exit 901, increasing a velocity of air flowing through the nozzle. In some instances (e.g., as shown in nozzle D, E, F, and G), the nozzle inlet 905 and the nozzle exit 901 may extend transverse to each other. Such a configuration may allow air passing through the nozzle to be directed towards a desired location.

[0085] As seen in FIGS. 9A and 9B, different nozzles having various shapes may be used as components of air jet assemblies. The nozzle selected as a component in an air jet

assembly may be selected based on desired air jet properties. The size of the nozzle exit 901 partially controls the velocity of the air defining the generated air jet as the air leaves the nozzle exit 901. The angle of the nozzle exit 901 relative to the nozzle inlet 905 partially controls the velocity of the air defining the generated air jet as the air leaves the nozzle exit 901 by controlling the direction of air movement.

[0086] The nozzle exit 901 can be configured to throttle the air flow. As such, an air jet generated using a nozzle having a small nozzle exit 901 will have an air flow that moves at a higher velocity than an air jet generated using a nozzle having a comparatively larger nozzle exit 901. As seen in FIGS. 9A and 9B, nozzles C, E, and G generate an air jet that is comparatively narrower than nozzles A, B, D, and F. Therefore, the air defining the air jet generated by nozzles C, E, and G has a higher velocity than the air defining the air jet generated by nozzles A, B, D, and F. A higher air velocity may provide better agitation of debris stuck on or near walls or that is in a corner.

[0087] The configuration, orientation, and/or position of the air jet assembly may be such that the nozzle exit 901 generates an air jet in a desired direction. For example, air flows into the nozzle inlet 905 according to a first direction (e.g., a direction substantially perpendicular to a surface to be cleaned) and flows from the nozzle exit 901 according to a second direction (e.g., along a direction that is non-perpendicular to the surface to be cleaned), wherein the first direction is different from (or the same as) the second direction. As such, the nozzle can generally be described as being configured to adjust a flow direction of air passing therethrough.

[0088] Referring to FIGS. 9A and 9B, when the air jet assembly is positioned on an underside of the robotic cleaner, embodiments of the air jet assembly that use nozzles A-C generate an air jet that is directed towards the surface to be cleaned at an angle that is substantially perpendicular to the surface to be cleaned. Embodiments that use nozzles D and E generate air jets with a flow of air that moves inboard (or outboard) at a substantially (e.g., within 1°, 2°, 3°, 4°, or 5° of) 45° angle. Embodiments that use nozzles F and G generate air jets with a flow of air that moves inboard (or outboard) at a substantially (e.g., within 1°, 2°, 3°, 4°, or 5° of) 90° angle. In some instances, the nozzles may be further oriented such that the air is directed at an angle relative to the aft of the robotic cleaner. Such an orientation would alter the path of the air jet in relation to the surface to be cleaned such that the air jet extends towards an agitator chamber of the robotic cleaner.

[0089] Additional nozzle embodiments are illustrated in FIGS. 10A-11B. FIG. 10A is a top view of nozzles that may be used as components of air jet assemblies consistent with embodiments of the present disclosure. FIG. 10B is a bottom view of the nozzles of FIG. 10A that may be used as components of air jet assemblies consistent with embodiments of the present disclosure. FIG. 11A is a bottom view of nozzles that may be used as components of air jet assemblies consistent with embodiments of the present disclosure. FIG. 11B is a side view of the nozzles of FIG. 11A that may be used as components of air jet assemblies consistent with embodiments of the present disclosure.

[0090] The placement and angling of the nozzles may be adjusted relative to the housing of the robotic cleaner and the agitator chamber. For example, nozzles can be configured to generate air jets that are directed directly at a cleaning surface (e.g., air jets that extend perpendicular to the cleaning surface) and/or air jets directed at a non-perpendicular angle relative to the cleaning surface. The nozzles can be designed to provide different air jet profiles. For example, the size and shape of the nozzle exits 901 produces air jets with a variety of properties. In some instances, the air jet assemblies can be configured to generate vortical air jets as air exits the nozzle. Some nozzles, as seen in FIG. 11A, have secondary nozzle exits 902 that produce additional air jets.

[0091] FIGS. 12 and 13 show an example of a robotic cleaner 1205 having a clean air exhaust duct 1200. The clean air exhaust duct 1200 is fluidly coupled to an exhaust side of a suction motor of the robotic cleaner 1205. As such, exhaust air from the suction motor passes through the exhaust duct 1200. The exhaust duct 1200 can be fluidly coupled to one or more air jet assemblies 1204 having a nozzle configured to generate an air jet. The nozzle can be configured to generate an air jet that optimizes cleaning performance of the robotic cleaner 1205. For example, the nozzle can be configured to optimize the cleaning performance of a cleaning robot capable of carrying out one or more of vacuuming, mopping, cleaning of edges, cleaning of walls, cleaning of corners, and cleaning of different surface types (e.g., carpets or hard floors).

[0092] As shown, the exhaust duct 1200 may include an external portion (e.g., an external conduit) 1201 that extends along an external surface of the robotic cleaner 1205. In other words, at least a portion of the exhaust duct 1200 may extend along an external surface of the robotic cleaner 1205. The external portion 1201 may be fluidly coupled to the air jet assembly 1204.

[0093] In some instances, the one or more air jet assemblies may be positioned within a bumper (e.g., a displaceable and/or deformable bumper). For example, the bumper can be deformed, relative to its initial shape, in response to the bumper engaging (e.g., contacting) an obstacle. The bumper can be configured to actuate one or more switches (e.g., mechanical, optical, and/or any other switch) when the bumper is displaced in response to engaging an obstacle. The bumper may contract such that the one or more air jet assemblies extend beyond the bumper. As such, at least one of the one or more air jet assemblies may be the cleaning element that is extended the furthest from the body of the robotic cleaner.

[0094] FIG. 14 illustrates an example of a robotic cleaner 1400 that includes a fan assembly 1302 configured to generate a positive air pressure at one or more air jet assemblies. The robotic cleaner 1400 includes one or more fan outlets 1450 on an underside 1452 of a housing 1454 of the robotic cleaner 1400. An air path extends from a secondary air inlet (not shown) and to the one or more fan outlets 1450. In some instances, the one or more air jet assemblies may include a respective one of the one or more fan outlets 1450. The air path may be defined by any suitable combination of rigid conduits, flexible conduits, chambers, and/or other features that may cooperate to direct a flow of air through the robotic cleaner 1400.

[0095] FIGS. 15A-15B illustrate an embodiment of the robotic cleaner 1400 of FIG. 14 with an air jet assembly 1500 including a nozzle attachment 1310. A fan 1315 (shown in hidden lines), is fixed within the housing 1454 of the robotic cleaner 1400. Air output from the fan 1315 passes into the nozzle attachment 1310 and through a nozzle exit 1311. Air jets (illustrated as Arrows A and B) are generated by the air flow from each nozzle exit 1311. The velocity, shape, and/or direction of air defining a respective air jet is based, at least in part, on the size, shape, and/or angle of the nozzle exit 1311. Different nozzle attachments, for example, as shown in FIGS. 9A-11B, produce air jets with different properties.

[0096] FIG. 16 illustrates an embodiment of a robotic cleaner 1600 having an air jet assembly 1602 including a nozzle 1604. Air from a clean air exhaust duct or fan outlet moves through the nozzle 1604 and passes through a nozzle exit 1606, generating a first air jet. In some instances, the nozzle 1604 includes a secondary nozzle exit 1608 configured to generate a second air jet. The first air jet and second air jet may be oriented such that they cooperate to agitate debris near walls or corners. The first and second air jet may further cooperate to urge the agitated debris towards a location over which an agitator chamber of the robotic cleaner 1600 passes, allowing the collection of the debris by the robotic cleaner 1600.

[0097] FIGS. 17A and 17B illustrate an example embodiment of an air jet assembly 1700 that includes a vent 1701. The vent 1701 includes one or more louvers 1702 configured to shape air passing therethrough into an air jet. The vent 1701 can be coupled to a body 1750 of a robotic cleaner 1752 at a location between an upper surface 1754 and an underside 1756 of the robotic cleaner 1752. In other words, the vent 1701 can define at least a portion of a sidewall 1758 of the robotic cleaner 1752, wherein the sidewall 1758 extends substantially (e.g., within 1°, 2°, 3°, 4°, or 5° of) perpendicular to the upper surface 1754 and the underside 1756 of the robotic cleaner 1752. In some instances, the vent 1701 may extend perpendicular to a surface to be cleaned.

[0098] The air jet assembly 1700 can be fluidly coupled to an exhaust side of a suction motor of the robotic cleaner 1752. As such, air exhausted from the suction motor is urged through the vent 1701. The one or more louvers 1702 can direct and/or shape air passing through the vent 1701, forming an air jet. For example, the one or more louvers 1702 can be configured to generate an air jet that urges debris into a movement path of the robotic cleaner 1752. In some instances, one or more louvers 1702 may be configured such that the air jet extends forward of one or more robotic cleaner wheels 1704. Such a configuration may reduce and/or prevent ingress of debris into the robotic cleaner 1752 as a result of rotational movement of the robotic cleaner wheels 1704. As such, in some instances, the vent 1701 can generally be described as being positioned and/or configured to mitigate or prevent debris ingress into the robotic cleaner 1752 as a result of rotation of the one or more robotic cleaner wheels 1704.

[0099] In some instances, the one or more louvers 1702 may be articulable. For example, the one or more louvers 1702 may be coupled to an articulation motor configured to articulate the one or more louvers 1702 in response to signals received from a controller of the robotic cleaner 1752. Additionally, or alternatively, the vent 1701 may further include a secondary air outlet 1703 configured to generate a secondary air jet. The secondary air outlet 1703 may include one or more of one or more secondary louvers, a nozzle, and/or any other component configured to generate an air jet.

[00100] FIG. 18 is a schematic view of an example ducting system capable of being used with a robotic cleaner 1440. FIG. 18 illustrates radial perimeter air jet zones 1401 from which air jets 1420 extend. The air jets 1420 agitate debris at a perimeter of the robotic cleaner 1440. As such, the air jets 1420 may be generally described as being a perimeter agitator. The air jets 1420 urge debris towards a path of an agitator 1402 and an agitator chamber 1403. As the

robotic cleaner 1440 moves along the surface to be cleaned 1441, air enters the agitator chamber 1403, moves through a suction motor and passes through a filter (not shown). Exhaust air 1405 passes from the suction motor and is directed towards an exhaust vent 1404. The exhaust air 1405 travels through an internal air path formed via a bumper duct 1406. The bumper duct 1406 fluidly connects to the radial perimeter air jet zones 1401. The exhaust air 1405 passes into the radial perimeter air jet zones 1401 and exits in the form of air jets 1420 via one or more air jet assemblies 1407. These one or more air jet assemblies 1407 may include one or more of one or more vents and/or one or more nozzles.

[00101] In the absence of agitation along the edge of the robotic cleaner 1440, the effective cleaning width of the robotic cleaner 1440 is the width 1432 of the opening to the agitator chamber 1403 disposed along an underside 1800 of the robotic cleaner 1440. In operation, the radial perimeter air jet zones 1401 increase an effective cleaning width 1431 of the robotic cleaner by urging debris into the path of the agitator 1402 and the agitator chamber 1403.

[00102] In some instances, the robotic cleaner 1440 may include at least one air jet assembly (including, for example, one or more of a nozzle or a vent) that extends (or is disposed) within a sidewall of the robotic cleaner 1440 that extends substantially perpendicular to the underside 1800 of the robotic cleaner 1440. For example, at least one air jet assembly may be configured to direct an air jet in a direction of a wall or other obstacle positioned alongside the robotic cleaner. In this example, the air jet assembly may be configured to generate an air jet that extends in a direction of forward movement of the robotic cleaner and generally towards the wall or other obstacle. As such, the air jet may urge debris deposited along the wall or other obstacle in a direction towards a forward movement path of the robotic cleaner 1440.

[00103] In some instances, the robotic cleaner 1440 may include a plurality air jet assemblies 1407, wherein at least one air jet assembly 1407 has a configuration that is different from that of at least one other air jet assembly 1407. For example, at least one air jet assembly 1407 may include a vent 1421 disposed on or in a sidewall of the robotic cleaner 1440 and at least one air jet assembly having a nozzle that is disposed on the underside 1800 of the robotic cleaner 1440, wherein the air jet assemblies 1407 cooperate to urge debris towards the agitator chamber 1403.

[00104] In some instances, one or more air jet assemblies 1407 may be controlled based on environmental conditions (e.g., obstacles, floor type, and/or any other condition). For example, when one or more sensors of the robotic cleaner 1440 detect an obstacle, such as a wall, air flow may be directed to the air jet assembly 1407 closest the obstacle.

[00105] FIG. 19 is a flow chart of one example of an algorithm for determining when to cause one or more air jets to be generated from a respective air jet assembly (which may generally be referred to as engaging an air jet assembly), consistent with embodiments of the present disclosure.

[00106] In an example algorithm, the robotic cleaner begins cleaning 2001 a surface according to a cleaning mode. As the robotic cleaner moves across the surface it operates using baseline cleaning and navigation behavior 2002. The baseline cleaning and navigation behavior may include using front air jet assemblies during the cleaning process. The front air jet assemblies may be engaged 2003 during normal cleaning operation in order to generate an air jet configured to urge debris to a location under the robotic cleaner such that the debris moves into the path of an agitator chamber. As the robotic cleaner moves across the surface to be cleaned, the robotic cleaner may encounter a variety of different obstacles. The robotic cleaner may have a variety of different sensors including those that detect walls 2004. When a wall is not detected 2006, the robotic cleaner determines whether to continue operation 2016. If the robotic cleaner determines to continue operation 2017, the robotic cleaner resumes operating using baseline cleaning and navigation behavior 2002. If the robotic cleaner determines not to continue operation 2018, the robotic cleaner ends cleaning mode 2020.

[00107] When a wall is detected 2005 by the robotic cleaner, a controller may then use the available sensor data to determine if the robotic cleaner has encountered a corner 2007. When a corner has not been detected 2009, the robotic cleaner initiates wall cleaning and navigation behavior 2010. The controller redirects air flow generated by suction motor exhaust or fans from front air jet assemblies 2011. The redirected air flow is directed towards a side air jet assembly. In embodiments with multiple side air jet assemblies, the redirected air flow is directed towards the side air jet assembly closest to the detected wall 2012.

[00108] When a corner has been detected 2008, the robotic cleaner initiates corner cleaning and navigation behavior 2013. The controller redirects a portion of air flow generated by suction motor exhaust and/or one or more fans from front air jet assemblies 2014. The redirected portion of air flow is directed towards a side air jet assembly. In embodiments with

multiple side air jet assemblies, the portion of redirected air flow is directed towards the side air jet assembly closest to the detected wall 2015. As such, the front air jet assemblies and side air jet assemblies may generally be described as being configured to work together to urge debris out of corners, creating a wider cleaning path.

[00109] FIG. 20 shows a schematic example of a robotic cleaner 2500 having a body 2502, an agitator chamber 2504 defined in the body 2502, a suction motor 2506 fluidly coupled to the agitator chamber 2504 and configured to cause air to flow into the agitator chamber 2504, and at least one air jet assembly 2508. The at least one air jet assembly 2508 can be configured to generate an air jet 2510. The air jet 2510 is configured to urge debris towards the agitator chamber 2504. In some instances, there may be two or more air jet assemblies 2508, each being configured to generate a respective air jet 2510. In this instance, the two or more air jet assemblies 2508 may be configured to urge debris towards the agitator chamber 2504. In instances having two or more air jet assemblies 2508, at least one air jet assembly 2508 may have a configuration that is different from that of at least one other air jet assembly 2508.

[00110] While the air jet 2510 is shown as extending inboard, other configurations are possible. For example, the air jet 2510 may extend outboard from the robotic cleaner 2500 such that the air jet 2510 extends beyond a perimeter of the robotic cleaner 2500. In this example, the air jet 2510 may be incident on a vertical surface (e.g., a wall or other obstacle) and the vertical surface may urge the air jet 2510 back in a direction of the robotic cleaner 2500 (e.g., towards the agitator chamber 2504). At least a portion of any debris adjacent the vertical surface may become entrained within air defining the air jet 2510 and be urged toward the agitator chamber 2504.

[00111] The air jet assembly 2508 may include any combination of components described herein including, for example, a vent and/or a nozzle, wherein the vent and/or nozzle is configured to generate a respective air jet 2510. The air jet assembly 2508 may be coupled to an underside of the body 2502 and/or to a sidewall of the body 2502. For example, when the robotic cleaner 2500 includes two or more air jet assemblies 2508, at least one air jet assembly 2508 may be coupled to the sidewall of the body 2502 and at least one other air jet assembly 2508 may be coupled to the underside of the body 2502.

[00112] In some instances, and as shown, the robotic cleaner 2500 may further include an obstacle detection sensor 2512. The obstacle detection sensor 2512 may be coupled to the body 2502 and be configured to detect an obstacle. The obstacle detection sensor 2512 can

output a signal to a controller 2514. The controller 2514 may be configured to determine a location of a detected obstacle relative to the robotic cleaner 2500 based, at least in part, on the signal output from the obstacle detection sensor 2512. Based, at least in part, on the determined location of the detected obstacle, the controller 2514 can cause an air jet 2510 to be generated from an air jet assembly 2508 that is closest to the obstacle.

[00113] FIG. 21 shows a schematic example of a robotic cleaner 3100. As shown, the robotic cleaner 3100 includes a body 3102 having an agitator chamber 3104 (shown in hidden lines) that is configured to receive one or more agitators 3106 (shown in hidden lines) and one or more driven wheels 3108 (shown in hidden lines) configured to urge the robotic cleaner 3100 across a surface to be cleaned 3110 (e.g., a floor). In some instances, the robotic cleaner 3100 may include a side brush 3101 (shown in hidden lines) configured to rotate about a rotation axis that extends transverse to (e.g., perpendicular to) the surface to be cleaned 3110. A suction motor 3112 (shown in hidden lines) is fluidly coupled to the agitator chamber 3104 and configured to urge air to flow into the agitator chamber 3104. A dust cup 3114 (shown in hidden lines) may be fluidly coupled to the suction motor 3112 and the agitator chamber 3104 such that at least a portion of debris entrained within air flowing into the agitator chamber 3104 is deposited in the dust cup 3114. An exhaust side of the suction motor 3112 is coupled to one or more air jet assemblies 3116. Additionally, or alternatively, a fan assembly may be included in the robotic cleaner 3100, wherein the fan assembly may be fluidly coupled to the one or more air jet assemblies 3116 to generate an air jet (e.g., as discussed in further detail in relation to FIGS. 35-42).

[00114] As shown, at least a portion of the one or more air jet assemblies 3116 can be disposed along a peripheral edge 3118 of the body 3102. The one or more air jet assemblies 3116 can be positioned along the peripheral edge 3118 such that an air jet 3119 generated by the air jet assembly 3116 extends in a direction outwardly from the body 3102 (e.g., radially outwardly when the body 3102 has a generally circular cross-section). Additionally, or alternatively, the one or more air jet assemblies 3116 can be positioned such that the air jet 3119 generated by the air jet assembly 3116 extends in a downward direction toward the surface to be cleaned 3110. For example, the air jet 3119 generated by the one or more air jet assemblies 3116 may extend outwardly from the body 3102 and in a direction of the surface to be cleaned 3110. In this example, and as shown in FIG. 32, when the robotic cleaner 3100 travels along a vertical surface 3200 (e.g., a wall) extending from the surface to be cleaned

3110, the air jet 3119 may intersect with the vertical surface 3200 before intersecting the surface to be cleaned 3110. Such a configuration may result in the formation of a vortex between the body 3102, the vertical surface 3200, and the surface to be cleaned 3110, which may improve debris agitation. In other words, the air jet assembly 3116 (e.g., a nozzle of the air jet assembly 3116) may be configured to encourage the formation of a vortex between the body 3102, the vertical surface 3200, and the surface to be cleaned 3110.

[00115] The one or more air jet assemblies 3116 may be positioned along the peripheral edge 3118 at a location that minimizes a separation distance 3202 between the one or more air jet assemblies 3116 and the vertical surface 3200 when the robotic cleaner 3100 is traveling along the vertical surface 3200. For example, the one or more air jet assemblies 3116 may be disposed on an assembly axis 3120. The assembly axis 3120 extends transverse to (e.g., perpendicular to) a forward direction of movement 3122 of the robotic cleaner 3100 and extends along a widest width 3124 of the body 3102, the widest width 3124 extends in a direction transverse to (e.g., perpendicular to) the forward direction of movement 3122. In some instances, the one or more air jet assemblies 3116 may be positioned forward and/or rearward of the widest width 3124.

[00116] FIGS. 23 and 24 show perspective views of a robotic cleaner 3300, which may be an example of the robotic cleaner 3100 of FIG. 21. The robotic cleaner 3300 may also be an example of the robotic cleaner 4500 of FIG. 35. As shown, the robotic cleaner 3300 includes a body 3302, a bumper 3304 moveably coupled to the body 3302 and configured to move in response to engaging an obstacle, a navigation sensor 3306 configured to detect one or more obstacles within an environment that are remote from the robotic cleaner 3300, and one or more air jet assemblies 3308. As shown, the body 3302 includes a bottom wall 3310 that defines at least a portion of an underside of the robotic cleaner 3300, a top wall 3312 that defines at least a portion of a top surface of the robotic cleaner 3300, and a sidewall 3314 extending between the bottom and top walls 3310 and 3312. As shown, the sidewall 3314 includes at least a portion of the one or more air jet assemblies 3308. For example, the sidewall 3314 may define a receptacle 3317 for receiving at least a portion of the one or more air jet assemblies 3308. In this example, the one or more air jet assemblies 3308 may be coupled to the receptacle 3317 using one or more of one or more mechanical fasteners (e.g., snap fits or screws), one or more adhesives, welding (e.g., ultrasonic welding), and/or any other form of coupling. By way of

further example, the sidewall 3314 may define at least a portion of the one or more air jet assemblies 3308.

[00117] As shown, the one or more air jet assemblies 3308 include a nozzle 3316 that is configured to increase a velocity of air passing therethrough. The nozzle 3316 defines a nozzle outlet central axis 3318 along which an air jet flows. The nozzle outlet central axis 3318 extends in an outward direction away from the sidewall 3314, in a forward direction, relative to a forward direction of movement (e.g., in a direction of the bumper 3304), and in a downward direction (e.g., in a direction of the bottom wall 3310 of the body 3302). For example, the nozzle outlet central axis 3318 can extend from the nozzle 3316 at an outward angle θ , a forward angle ε , and a downward angle β . The outward angle θ extends between the nozzle outlet central axis 3318 and a vertical plane 3320 that intersects the bottom and top walls 3310 and 3312 and that extends transverse to (e.g., perpendicular to) a forward movement direction of movement of the robotic cleaner 3300. The forward angle ε extends between the nozzle outlet central axis 3318 and a vertical plane 3321 that intersects the bottom and top walls 3310 and 3312 and extends parallel to the forward direction of movement of the robotic cleaner 3300. The downward angle β extends between the nozzle outlet central axis 3318 and a horizontal plane 3322, the horizontal plane 3322 extends between the bottom and top walls 3310 and 3312.

[00118] The forward angle ε can be configured such that an air jet exiting the nozzle 3316 urges debris towards a location in a movement path of the robotic cleaner 3300 that is forward of one or more driven wheels of the robotic cleaner 3300 (e.g., such that the air jet does not urge debris into the driven wheels). The forward angle ε may be further configured to mitigate the redistribution of debris when the robotic cleaner 3300 turns to traverse a corner (e.g., the intersection of two walls). The forward angle ε may, for example, be within a range of 20° to 40° . By way of further example, the forward angle ε may be within a range of 20° to 30° . By way of still further example, the forward angle ε may be within a range of 30° to 40° .

[00119] The downward angle β may be configured such that the air jet intersects a vertical surface (e.g., a wall) before intersecting a surface to be cleaned (e.g., a floor). In some instances, the downward angle β may be configured to maximize a downward velocity of the air jet with the air jet intersecting the vertical surface before intersecting the surface to be cleaned. The downward angle β may, for example, be within a range of 20° to 40° . By way of further example, the downward angle β may be within a range of 20° to 30° . By way of still

further example, the downward angle β may be within a range of 30° to 40° . By way of still further example, the downward angle β may be within a range of 28° to 32° . By way of still further example, the downward angle β may be within a range of 29° to 31° . By way of still further example, the downward angle β may be 30° .

[00120] The outward angle θ may be, for example, in a range of 5° to 80° . By way of further example, the outward angle θ may be in a range of 15° to 60° . By way of still further example, the outward angle θ may be in a range of 20° to 40° . By way of still further example, the outward angle θ may be in a range of 5° to 30° . By way of still further example, the outward angle θ may be in a range of 10° to 40° . By way of still further example, the outward angle θ may be in a range of 10° to 20° . By way of still further example, the outward angle θ may be in a range of 15° to 30° .

[00121] The outward angle θ , the forward angle ε , and/or the downward angle β influence an ability of the air jet to urge debris into a movement path of the robotic cleaner 3300. For example, the downward angle β may be configured such that a downward velocity of the air jet is sufficient to prevent debris (e.g., fibrous debris such as hair) from being urged upwards in a direction above the robotic cleaner 3300. Additionally, or alternatively, the forward angle ε may be configured such that the air jet urges debris (e.g., fibrous debris such as hair) forwardly towards a movement path of the robotic cleaner 3300. When the robotic cleaner 3300 traverses a corner, the air jet may interact with the corner, urging the debris into a movement path of the robotic cleaner 3300.

[00122] FIG. 25 shows an example of the robotic cleaner 3300 having the top wall 3312 removed therefrom. As shown, the air jet assembly 3308 includes a duct 3500 configured to fluidly couple a suction motor (not shown) of the robotic cleaner 3300 to the nozzle 3316. The duct 3500 may be a substantially rigid duct and/or a flexible duct (e.g., a flexible tube). The air jet assembly 3308 may further include a coupling wall 3502 configured to be received within the receptacle 3317 defined by the sidewall 3314. In some instances, the coupling wall 3502 may be substantially flush with sidewall 3314 such that the body 3302 has a substantially continuous surface extending between the bottom and top walls 3310 and 3312. In some instances, two or more of the duct 3500, the nozzle 3316, and/or the coupling wall 3502 may be formed as one monolithic piece. For example, the duct 3500, the nozzle 3316, and the coupling wall 3502 may be formed as single monolithic piece. In other instances, each of the duct 3500, the nozzle 3316, and the coupling wall 3502 may be formed as separate pieces and

coupled together (e.g., using an adhesive, a mechanical coupling, and/or any other form of coupling).

[00123] As shown in FIGS. 26 and 27, the air jet assembly 3308 may include a valve 3600 configured to be actuated between a closed position (see, FIG. 26) and an open position (see, FIG. 27). The valve 3600 may be fluidly coupled to the nozzle 3316 such that the valve 3600 is positioned within a flow path extending between the outlet of the suction motor and the nozzle 3316. The valve 3600 may be configured to selectively allow air to flow through the nozzle 3316. In other words, the valve 3600 may be configured to enable a selective generation of an air jet. For example, the valve 3600 may be transitioned to the open position when the robotic cleaner 3300 is moving along a wall and the valve may be transitioned to the closed position when the robotic cleaner 3300 is moving within an open space (e.g., a position away from a wall).

[00124] FIG. 28 shows an example of the robotic cleaner 3300 having the top wall 3312 removed therefrom and FIG. 29 shows a magnified view of a portion of the robotic cleaner 3300. As shown, the duct 3500 is a flexible tube extending between the nozzle 3316 and a valve 3800. The valve 3800 may be actuated between the open and closed position using a valve motor 3802.

[00125] FIG. 30 shows a method 4000 for cleaning with a robotic cleaner having an air jet assembly (e.g., the robotic cleaner 3100 of FIG. 21). One or more steps of the method 4000 may be embodied as one or more instructions stored in one or more memories (e.g., one or more non-transitory memories), wherein the one or more instructions are configured to be executed on one or more processors. For example, a robot controller may be configured to cause one or more steps of the method 4000 to be carried out. Additionally, or alternatively, one or more steps of the method 4000 may be carried out in any combination of software, firmware, and/or circuitry (e.g., an application-specific integrated circuit).

[00126] As shown, the method 4000 may include a step 4002. The step 4002 includes causing the robotic cleaner 3100 to traverse an environment until the robotic cleaner 3100 encounters a vertical surface (e.g., a wall).

[00127] The method 4000 may include a step 4004. The step 4004 includes causing the robotic cleaner 3100 to follow the vertical surface. For example, when the vertical surface is one or more walls defining a room, the robotic cleaner 3100 may be caused to follow the walls until the robotic cleaner 3100 traverses at least a portion (e.g., an entire portion) of the perimeter

of the room. When following the vertical surface, the robotic cleaner 3100 may be caused to minimize a separation distance between the air jet assembly 3116 and the vertical surface. As such, the robotic cleaner 3100 is caused to follow the vertical surface with the air jet assembly 3116 facing the vertical surface. In some instances, a movement speed of the robotic cleaner 3100 may be reduced when following the vertical surface when compared to a movement speed when not following the vertical surface (e.g., when traversing a central portion of a room). Such a configuration may allow the separation distance between the air jet assembly 3116 and the vertical surface to be minimized. In some instances, when the robotic cleaner 3100 includes one or more side brushes 3101, at least one of the one or more side brushes 3101 may be operated at an increased speed when following the vertical surface when compared to not following the vertical surface. In some instances, the side brush 3101 that is on a side of the robotic cleaner 3100 that is opposite the air jet assembly 3116 may be operated at the increased speed. In some instances, when following the vertical surface, a velocity of the air jet 3119 may be increased. For example, a speed of the suction motor may be increased (relative to a speed used when cleaning away from the vertical surface) to increase a quantity of suction motor exhaust air. In this example, the suction motor 3112 may be increased to at least 95% of a maximum speed. Additionally, or alternatively, the velocity of the air jet 3119 may be increased by increasing a rotational speed of a fan, the fan being separate from the suction motor 3112.

[00128] The method 4000 may include a step 4006. The step 4006 includes, in response to encountering an intersection of two vertical surfaces (which may generally be referred to as a corner), causing the robotic cleaner 3100 to traverse the corner at a reduced turning speed relative to a turning speed when not traversing a corner. For example, the turning speed may be reduced by at least 40%, at least 45%, at least 50%, or at least 55%.

[00129] In some instances, in response to the robotic cleaner 3100 commencing a cleaning operation for a room defined at least partially by a plurality of walls, the robotic cleaner 3100 can be caused to carry out the method 4000 to clean adjacent the walls prior to the robotic cleaner 3100 cleaning a central portion of the room. Such a configuration may encourage more effective debris pickup (e.g., at least a portion of debris adjacent the wall may be urged into a central portion of the room when cleaning adjacent the walls).

[00130] FIG. 31 shows a method 4100 for cleaning adjacent a vertical surface (e.g., a wall) with a robotic cleaner having an air jet assembly (e.g., the robotic cleaner 3100 of FIG.

21). One or more steps of the method 4100 may be embodied as one or more instructions stored in one or more memories (e.g., one or more non-transitory memories), wherein the one or more instructions are configured to be executed on one or more processors. For example, a robot controller may be configured to cause one or more steps of the method 4100 to be carried out. Additionally, or alternatively, one or more steps of the method 4100 may be carried out in any combination of software, firmware, and/or circuitry (e.g., an application-specific integrated circuit).

[00131] The method 4100 may include a step 4102. The step 4102 includes causing the robotic cleaner 3100 to follow a vertical surface (e.g., a wall) in response to detecting the vertical surface.

[00132] The method 4100 may include a step 4104. The step 4104 includes causing an air jet to be generated with the air jet assembly 3116.

[00133] The method 4100 may include a step 4106. The step 4106 includes causing the robotic cleaner 3100 to determine a distance between the robotic cleaner 3100 and the vertical surface.

[00134] The method 4100 may include a step 4108. The step 4108 includes comparing the determined distance to a threshold. In response to the determined distance being greater than the threshold, increasing a volume of air delivered to the air jet assembly 3116. In response to the determined distance being less than the threshold, decreasing a volume of air delivered to the air jet assembly 3116 (e.g., discontinuing the generation of an air jet).

[00135] FIG. 32 shows a method 4200 for cleaning at an intersection of two vertical surfaces (which may generally be referred to as a corner) with a robotic cleaner having an air jet assembly (e.g., the robotic cleaner 3100 of FIG. 21). One or more steps of the method 4200 may be embodied as one or more instructions stored in one or more memories (e.g., one or more non-transitory memories), wherein the one or more instructions are configured to be executed on one or more processors. For example, a robot controller may be configured to cause one or more steps of the method 4200 to be carried out. Additionally, or alternatively, one or more steps of the method 4200 may be carried out in any combination of software, firmware, and/or circuitry (e.g., an application-specific integrated circuit).

[00136] The method 4200 may include a step 4202. The step 4202 includes causing the robotic cleaner 3100 to follow a vertical surface while generating an air jet.

[00137] The method 4200 may include a step 4204. The step 4204 includes causing the robotic cleaner 3100 to detect an intersection of two vertical surfaces (which may generally be referred to as a corner).

[00138] The method 4200 may include a step 4206. The step 4206 may include causing the robotic cleaner 3100 to discontinue generating the air jet in response to detecting the corner. In response to discontinuing generation of the air jet, the robotic cleaner 3100 may be caused to rotate in a first rotation direction (e.g., counter-clockwise) for a first rotation angle. The first rotation angle may be, for example, in a range of 15° to 45°. By way of further example, the first rotation angle may be 30°.

[00139] The method 4200 may include a step 4208. The step 4208 includes causing the robotic cleaner 3100 to resume generating the air jet in response to completing rotation through the first rotation angle. In response to resuming generation of the air jet, the robotic cleaner 3100 may be caused to rotate in a second rotation direction (e.g., clockwise) for a second rotation angle, the second rotation direction being opposite the first rotation direction. The second rotation angle may be greater than the first rotation angle. The second rotation angle may be, for example, in a range of 45° to 75°. By way of further example, the second rotation angle may be 60°.

[00140] The method 4200 may include a step 4210. The step 4210 includes causing the robotic cleaner 3100 to discontinue generating the air jet in response to completing rotation through the second rotation angle. In response to discontinuing generation of the air jet, the robotic cleaner 3100 may be caused to rotate in the first rotation direction for a third rotation angle. The third rotation angle may be the same as the second rotation angle. The third rotation angle may be, for example, in a range of 45° to 75°. By way of further example, the third rotation angle may be 60°.

[00141] The method 4200 may include a step 4212. The step 4212 includes causing the robotic cleaner 3100 to resume generating the air jet in response to completing rotation through the third rotation angle. In response to resuming generation of the air jet, the robotic cleaner 3100 may be caused to rotate in the second rotation direction for a fourth rotation angle. The fourth rotation angle may be the same as the third rotation angle. The fourth rotation angle may be, for example, in a range of 45° to 75°. By way of further example, the fourth rotation angle may be 60°.

[00142] The method 4200 may include a step 4214. The step 4214 includes causing the robotic cleaner 3100 to traverse the corner to follow the intersecting vertical surface. When following the intersecting vertical surface, the robotic cleaner 3100 may be caused to generate an air jet.

[00143] The method 4200 may include a step 4216. The step 4216 includes causing the robotic cleaner 3100 to discontinue following the vertical surface and to discontinue generation of the air jet. In some instances, the step 4216 may be carried out in the alternative to the step 4214.

[00144] FIG. 33 shows a perspective view of a robotic cleaner 4300, which may be an example of the robotic cleaner 3100 of FIG. 21. As shown, the robotic cleaner 4300 includes a body 4302, a moveable bumper 4304 moveably coupled to the body 4302, one or more side brushes 4306, a navigation sensor 4308, and an air jet assembly 4310. As shown, the air jet assembly 4310 includes a vent 4312 defined in the moveable bumper 4304. The vent 4312 may be positioned between a forward most portion of the robotic cleaner 4300 (relative to a forward movement direction of the robotic cleaner 4300) and a side most portion of the robotic cleaner 4300.

[00145] As shown in FIG. 34, the vent 4312 is fluidly coupled to a duct 4400, the duct being fluidly coupled to an exhaust side of a suction motor 4402. In some instances, the duct 4400 may include a valve assembly 4404 configured to selectively fluidly couple the suction motor 4402 to the vent 4312.

[00146] FIG. 35 shows a schematic example of a robotic cleaner 4500, which may be an example of the robotic cleaner 3100 of FIG. 21. As shown, the robotic cleaner 4500 includes a body 4502 having an agitator chamber 4504 (shown in hidden lines) that is configured to receive one or more agitators 4506 (shown in hidden lines) and one or more driven wheels 4508 (shown in hidden lines) configured to urge the robotic cleaner 4500 across a surface to be cleaned 4510 (e.g., a floor). In some instances, the robotic cleaner 4500 may include a side brush 4501 (shown in hidden lines) configured to rotate about a rotation axis that extends transverse to (e.g., perpendicular to) the surface to be cleaned 4510. A suction motor 4512 (shown in hidden lines) is fluidly coupled to the agitator chamber 4504 and configured to urge air to flow into the agitator chamber 4504. A dust cup 4514 (shown in hidden lines) may be fluidly coupled to the suction motor 4512 and the agitator chamber 4504 such that at least a portion of debris entrained within air flowing into the agitator chamber 4504 is deposited in

the dust cup 4514. One or more air jet assemblies 4516 (shown in hidden lines) may be disposed at a peripheral edge 4518 of the body 4502 of the robotic cleaner 4500.

[00147] The one or more air jet assemblies 4516 are fluidly coupled to a fan 4520 (shown in hidden lines). The fan 4520 is configured to cause air to flow through the one or more air jet assemblies 4516, forming an air jet. The fan 4520 may be communicatively coupled to a controller 4522 (shown in hidden lines) of the robotic cleaner 4500. The controller 4522 may be configured to adjust an operation of the fan 4520. For example, the controller 4522 may adjust the operation of the fan 4520 based, at least in part, on inputs received from one or more sensors 4524 (shown in hidden lines) configured to detect conditions within an environment (e.g., proximity of a vertical surface such as a wall and/or a quantity and/or size of debris adjacent a vertical surface).

[00148] Adjusting operation of the fan 4520 may include enabling and disabling the fan 4520, changing the fan speed, and/or any other operational adjustment. For example, the controller 4522 may be configured to enable the fan 4520 in response to at least one of the one or more sensors 4524 detecting the presence of a vertical surface (e.g., a wall) and to disable the fan 4520 in response to the one or more sensors 4524 not detecting the vertical surface. As such, an air jet may be generated when the robotic cleaner 4500 is following a vertical surface but not when traversing a central portion of an area, potentially reducing power consumption. By way of further example, the controller 4522 may cause the fan 4520 to operate at higher speeds with increasing distance from a vertical surface and/or based on a quantity of detected debris adjacent the vertical surface (e.g., when the one or more sensors 4524 includes a debris detection sensor). By way of still further example, a user of the robotic cleaner 4500 may adjust the operation of the fan 4520 manually (e.g., using an interface on the robotic cleaner 4500 and/or through an application on a computing device such as a mobile phone or tablet). In this example, a user may select between a plurality of different fan speeds (e.g., at least 3 fan speeds) such as, for example, a high, medium, and low fan speed. Additionally, or alternatively, the user may select an automatic fan speed. The automatic fan speed may be determined by the controller 4522 of the robotic cleaner 4500 using, for example, the one or more sensors 4524. The user may also cause the fan 4520 to be disabled. In some instances, the user may indicate areas (e.g., rooms and/or regions within rooms) in which the fan 4520 is to be disabled (e.g., using a map of the environment displayed on a device such as a mobile phone).

[00149] FIG. 36 shows a schematic example of the robotic cleaner 4500, wherein the fan 4520 and suction motor 4512 cooperate to urge air into the one or more air jet assemblies 4516. As shown, a suction motor exhaust 4600 of the suction motor 4512 and a fan exhaust 4602 of the fan 4520 is fluidly coupled to a duct 4604 (shown in hidden lines) of at least one of the one or more air jet assemblies 4516. The duct 4604 fluidly couples the suction motor 4512 and fan 4520 to a nozzle 4601 of at least one of the one or more air jet assemblies 4516. The duct 4604 may, in some instances, be at least partially (e.g., entirely) formed from a body of the robotic cleaner 4500. Alternatively, the duct 4604 may be a separate component that couples to a body of the robotic cleaner 4500.

[00150] In operation, the controller 4522 may be configured to selectively enable/disable to the fan 4520 to adjust a velocity of the generated air jet. When the fan 4520 is disabled, a baseline air jet may be generated using only the exhaust of the suction motor 4512. When the fan 4520 is enabled, the suction motor 4512 and the fan 4520 may cooperate to form an augmented air jet, the augmented air jet may have a velocity that is greater than that of the baseline air jet. The velocity of the augmented air jet may be adjusted by adjusting a speed of the fan 4520. For example, the controller 4522 may adjust a fan speed based, at least in part, on a user input and/or using the one or more sensors 4524. The fan 4520 may be generally described as having a plurality of non-zero speeds (e.g., at least three non-zero fan speeds). In some instances, the fan speed may be varied (e.g., continuously) such that a pulsed air jet is formed.

[00151] FIG. 37 shows a schematic example of the robotic cleaner 4500, wherein the fan 4520 and suction motor 4512 do not cooperate to urge air into the one or more air jet assemblies 4516. As shown, a first duct 4700 of the air jet assembly 4516 fluidly couples the fan exhaust 4602 of the fan 4520 to at least one nozzle 4701 of at least one of the one or more air jet assemblies 4516 and a second duct 4702 fluidly couples the suction motor exhaust 4600 to an exhaust port and/or another nozzle of another one of the one or more air jet assemblies 4516. Such a configuration may allow at least one of the one or more air jet assemblies 4516 to be positioned without considering proximity of the air jet assembly 4516 to the suction motor 4512. The ducts 4700 and/or 4702 may, in some instances, be at least partially (e.g., entirely) formed from a body of the robotic cleaner 4500. Alternatively, one or more of the ducts 4700 and/or 4702 may be a separate component that couples to a body of the robotic cleaner 4500.

[00152] In operation, the controller 4522 may be configured to selectively enable/disable the fan 4520 and/or to adjust a fan speed of the fan 4520 in order to adjust a velocity of the generated air jet. When the fan 4520 is disabled, the air jet assembly 4516 fluidly coupled to the fan 4520 does not generate an air jet. When the fan 4520 is enabled, air is caused to flow through the air jet assembly 4516 fluidly coupled to the fan 4520. A speed of the fan 4520 may be adjusted to adjust a velocity of the generated air jet. The fan 4520 may be generally described as having a plurality of non-zero fan speeds (e.g., at least three non-zero fan speeds). In some instances, the fan speed may be varied (e.g., continuously) such that a pulsed air jet is formed.

[00153] FIG. 38A shows a perspective view of a robotic cleaner 4800, which may be an example of the robotic cleaner 4500 of FIG. 35 and FIG. 39 shows another perspective view of the robotic cleaner 4800 having portions removed therefrom for clarity. As shown, the robotic cleaner 4800 includes a body 4802, a navigation sensor 4804 extending from a top wall 4806 of the body 4802, a user interface 4808 disposed on the top wall 4806, one or more driven wheels 4807 configured to urge the body 4802 across a surface to be cleaned (e.g., a floor) 4801, a displaceable bumper 4810 movably coupled to the body 4802 (e.g., along one or more of a vertical and/or horizontal axis), at least one (e.g., only one, two or more, and/or any other number) side brush 4811, and an air jet assembly 4812 configured to generate an air jet that extends outwardly from the body 4802. In some instances, the robotic cleaner 4500 may include a wet cleaning assembly 4821 having a liquid tank 4823 and an absorbent pad 4825. The absorbent pad 4825 may be configured to be agitated (e.g., oscillated linearly and/or rotated) relative to the surface to be cleaned 4801.

[00154] The air jet assembly 4812 may include a nozzle 4814 configured to shape and/or direct air passing therethrough. The air jet assembly 4812 is coupled to (or defined in) a sidewall 4813 extending between the top wall 4806 and a bottom wall 4815 of the body 4802. For example, at least a portion of the air jet assembly 4812 (e.g., the nozzle 4814) may be disposed at a widest width of the robotic cleaner 4800, wherein the widest width 4856 (FIG. 38B) extends in a direction generally parallel to a rotation axis of the one or more driven wheels 4807. By way of further example, at least a portion of the air jet assembly 4812 (e.g., the nozzle 4814) may be positioned forward or rearward of the widest width 4856.

[00155] As shown, the air jet assembly 4812 and the at least one side brush 4811 are positioned on a common side of the body 4802. The air jet assembly 4812 and the at least one

side brush 4811 are configured to urge debris into a movement bath of the robotic cleaner 4800. As such, the air jet assembly 4812 can be configured to cooperate with the at least one side brush 4811. For example, the air jet assembly 4812 can be configured to urge debris into a swept area of the at least one side brush 4811. The swept area of the at least one side brush 4811 may generally be described as an area of the surface to be cleaned 4801 along which the at least one side brush 4811 moves through when rotating about a side brush axis 4819 that extends transverse to (e.g., perpendicular to) the surface to be cleaned 4801. In some instances, one or more of the air jet assembly 4812 and/or at least one side brush 4811 may be positioned forward of the wet cleaning assembly 4821 (relative to a forward direction of movement of the robotic cleaner 4800). Such a configuration may reduce a quantity of loose dry debris that gets collected by the absorbent pad 4825 (e.g., loose fibrous debris such as hair).

[00156] The air jet assembly 4812 may include a nozzle 4814. The nozzle 4814 is shown as being recessed into the body 4802 (instead of protruding from the body 4802 such as the nozzle 3316 of FIGS. 23 and 24). The nozzle 4814 may be positioned closer to the top wall 4806 than the bottom wall 4815. For example, the nozzle 4814 may be positioned within an upper 40% of the sidewall 4813. In some instances, a separation distance from a bottom most portion of the nozzle 4814 and the surface to be cleaned 4801 may be about (e.g., within 1%, 2%, 3%, 4%, or 5% of) 50 millimeters (mm).

[00157] A nozzle outlet central axis 4817 of the nozzle 4814 may have a similar orientation as that described herein in relation to the nozzle outlet central axis 3318 of FIGS. 23 and 24. For example, FIG. 38B shows a top view of the robotic cleaner 4800. As shown, the nozzle outlet central axis 4817 forms a forward angle γ with a front-rear cross axis 4850 (e.g., a central front-rear cross axis) that extends parallel to a forward movement direction of the robotic cleaner 4800. In other words, the forward angle γ extends between the nozzle outlet central axis 4817 and the front-rear cross-axis 4850. As also shown, the nozzle outlet central axis 4817 forms an outward angle ψ with a side-side cross axis 4852 (e.g., a central side-side cross axis) that extends transverse to (e.g., perpendicular to) the front-rear cross axis 4850. In other words, the outward angle ψ extends between the nozzle outlet central axis 4817 and the side-side cross axis 4852. FIG. 38C shows a side view of the robotic cleaner 4800. As shown, the nozzle outlet central axis 4817 forms a downward angle ϕ with a horizontal plane 4854 (e.g., a plane that extends between the top wall 4806 and the bottom wall 4815 and that is substantially parallel to the surface to be cleaned 4801). In other words, the downward angle

ϕ extends between the nozzle outlet central axis 4817 and the horizontal plane 4854. The forward angle γ , the outward angle ψ , and the downward angle ϕ can be configured such that the nozzle outlet central axis 3318 (and the generated air jet) extends from the robotic cleaner 4800 in a direction of forward movement of the robotic cleaner 4800 (e.g., a forward direction that extends towards the displaceable bumper 4810), a downward direction towards the surface to be cleaned 4801 (e.g., in a downward direction that extends toward the bottom wall 4815 of the body 4802 of the robotic cleaner 4800), and an outward direction away from a central portion of the robotic cleaner 4800 (e.g., in an outward direction that extends away from the sidewall 4813 of the body 4802).

[00158] The forward angle γ may be, for example, in a range of 30° to 60° . By way of further example, the forward angle γ may be in a range of 40° to 50° . By way of still further example, the forward angle γ may be about (e.g., within 1%, 2%, 3%, 4%, or 5% of) 41° . The outward angle ψ may be, for example, in a range of 25° to 45° . By way of further example, the outward angle ψ may be in a range of 30° to 40° . By way of still further example, the outward angle ψ may be about (e.g., within 1%, 2%, 3%, 4%, or 5% of) 36° . The downward angle ϕ may be, for example, in a range of 15° to 35° . By way of further example, the downward angle ϕ may be in a range of 20° to 30° . By way of still further example the downward angle ϕ may be about (e.g., within 1%, 2%, 3%, 4%, or 5% of) 27° .

[00159] The air jet assembly 4812 includes an intake grill 4816. The intake grill 4816 is fluidly coupled to an intake side 4900 of a fan 4902. As such, when enabled, at least a portion of the air drawn into the fan 4902 is drawn through the intake grill 4816. The intake grill 4816 may include one or more ribs 4818. The ribs 4818 may be angled such that air is drawn into the intake grill 4816 in a downward direction (toward the surface to be cleaned 4801) and/or in a direction generally opposite that in which the air jet is directed (e.g., a rearward direction relative to a forward direction of travel). For example, the ribs 4818 may be configured to discourage an interference between air drawn into the intake grill and air exhausted from the nozzle 4814 as an air jet. Such a configuration may reduce a quantity of debris suctioned into the fan 4902.

[00160] Exhaust from a suction motor 4906 may flow around the fan 4902 before being exhausted into a surrounding environment. As such, in some instances, a bridging duct 4904 may extend between the intake grill 4816 and an intake side 4900 of the fan 4902. Such a

configuration may substantially isolate the intake side 4900 of the fan 4902 from the exhaust of the suction motor 4906 within the body 4802 of the robotic cleaner 4800.

[00161] As shown in FIG. 40, the fan 4902 is fluidly coupled to the nozzle 4814 (e.g., directly or through an air jet duct). As such, air drawn into the fan 4902 is caused to flow through the nozzle 4814, forming an air jet. As shown, the nozzle 4814 is recessed within the body 4802 of the robotic cleaner 4800. Recessing the nozzle 4814 within the body 4802 of the robotic cleaner 4800 may allow the robotic cleaner 4800 to more closely approach an edge of a vertical obstacle (e.g., a wall) when compared to a protruding nozzle.

[00162] FIG. 41 shows a perspective view of the nozzle 4814 and FIG. 42A shows a cross-sectional view of the nozzle 4814 taken along the line XLII-XLII of FIG. 41. The nozzle 4814 can be configured such that the generated air jet has a velocity (e.g., as measured at an outlet of the nozzle 4814) within a range of, for example, 10 meters per second (m/s) to 20 m/s. By way of further example, the nozzle 4814 can be configured such that the generated air jet has a velocity within a range of 12 m/s and 16 m/s. By way of still further example, the nozzle 4814 can be configured such that the generated air jet has a velocity within a range of 13 m/s and 15 m/s. By way of still further example, the nozzle 4814 can be configured such that the generated air jet has a velocity of substantially (e.g., within 1%, 2%, 3%, 4%, or 5% of) 14 m/s.

[00163] The velocity of the air jet may be based, at least in part, on a position of the nozzle 4814 on the robotic cleaner 4800. For example, as a separation distance between the nozzle 4814 and a vertical surface (e.g., a wall) adjacent the robotic cleaner 4800 increases the velocity of the air jet may be increased. Such a configuration may encourage sufficient movement of debris. By way of further example, as a separation distance between the nozzle 4814 and a vertical surface (e.g., a wall) adjacent the robotic cleaner 4800 decreases the velocity of the air jet may be decreased. Such a configuration may mitigate debris pluming. The velocity of the air jet may be fixed (e.g., a fixed velocity that is based, at least in part, on an average separation distance between the nozzle 4814 and a wall when the robotic cleaner 4800 is engaging in a wall-following behavior) or variable (e.g., based, at least in part, on predetermined velocities and/or based on desired air jet behaviors such as pulsing).

[00164] A nozzle inlet central axis 5100 and the nozzle outlet central axis 4817 may form a inlet-outlet intersection angle α . The inlet-outlet intersection angle α may be within a range of 90° to 165°. The nozzle inlet central axis 5100 extends substantially perpendicular to

an inlet of the nozzle 4814 and the nozzle outlet central axis 4817 extends substantially perpendicular to an outlet of the nozzle 4814.

[00165] As also shown, the nozzle 4814 may include a bend point 5102. The bend point 5102 corresponds to a location where air flowing through the nozzle 4814 changes direction. The location of the bend point 5102 may have an impact on flow characteristics of air flowing out of the nozzle 4814. In some instances, the bend point 5102 may be closer to a nozzle outlet 5205 than to a nozzle inlet 5203. For example, a separation distance 5104 between the bend point 5102 and the nozzle inlet 5203 may be at least twice a separation distance 5106 between the bend point 5102 and the nozzle outlet 5205. In other instances, the bend point 5102 may be closer to the nozzle inlet 5203 than to the nozzle outlet 5205. For example, the separation distance 5106 between the bend point 5102 and the nozzle outlet 5205 may be at least twice the separation distance 5104 between the bend point 5102 and the nozzle inlet 5203.

[00166] As shown in FIG. 42A, a flow splitter 5200 may be positioned within an air flow path 5201 extending through the nozzle 4814. The flow splitter 5200 has a first flow side 5202 and a second flow side 5204, wherein a portion of the air flow path 5201 extends along each of the first and second flow sides 5202 and 5204. As shown, the first flow side 5202 may be substantially planar and the second flow side 5204 may be convex (e.g., triangular or arcuate shaped). In other words, with reference to FIG. 42B (which shows a magnified view of the flow splitter 5200), a second surface length 5250 over which air flows on the second flow side 5204 is greater than a first surface length 5252 over which air flows on the first flow side 5202. Having different surface lengths over which air flows on the first and second flow sides 5202 and 5204 may introduce a velocity difference in air flowing over the first and second flow sides 5202 and 5204. As a result, a vortex of air may be formed downstream of a trailing edge 5206 of the flow splitter 5200. Creation of a vortex in the air may improve debris agitation.

[00167] The flow splitter 5200 is positioned between the nozzle inlet 5203 and the nozzle outlet 5205 of the nozzle 4814. For example, the flow splitter 5200 may be centrally positioned within the nozzle 4814 such that a separation distance between the trailing edge 5206 of the flow splitter 5200 and the nozzle outlet 5205 is substantially (e.g., within 1%, 2%, 3%, or 5% of) the same as a separation distance between a leading edge 5207 of the flow splitter 5200 and the nozzle inlet 5203. By way of further example, the flow splitter 5200 may be positioned within the nozzle 4814 such that the separation distance between the trailing edge 5206 and the nozzle outlet 5205 is less than the separation distance between the leading edge

5207 and the nozzle inlet 5203. By way of still further example, the flow splitter 5200 may be positioned within the nozzle 4814 such that the separation distance between the trailing edge 5206 and the nozzle outlet 5205 is greater than the separation distance between the leading edge 5207 and the nozzle inlet 5203.

[00168] As also shown in FIG. 42A, the nozzle 4814 may include a first region 5208 and a second region 5210. The first region 5208 may have a substantially rectangular cross-section and the second region 5210 may have a substantially circular or oval shaped cross-section. The first region 5208 may have a cross-sectional area that is greater than a cross-sectional area of the second region 5210. For example, a cross-sectional area of the first region 5208, at a largest point, may be in a range of 200 square millimeters (mm^2) and 225 mm^2 and a cross-sectional area of the second region 5210, at a largest point, may be in a range of 70 mm^2 to 90 mm^2 . By way of further example, a cross-sectional area of the first region 5208, at a largest point, may be about (e.g., within 1%, 2%, 3%, 4%, or 5% of) 212 mm^2 and a cross-sectional area of the second region 5210, at a largest point, may be about 78 mm^2 . By way of still further example, a ratio of the cross-sectional area of the first region 5208, at a largest point, to a cross-sectional area of the second region 5210, at a largest point, may be in a range of 2:1 to 4:1. By way of still further example, a ratio of the cross-sectional area of the first region 5208, at a largest point, to a cross-sectional area of the second region 5210, at a largest point, may be about 2.7:1.

[00169] As shown, the second region 5210 may include a first width 5212, a second width 5214, and a third width 5216, the second width 5214 being between the first and third widths 5212 and 5216. The second width 5214 may be greater than the first and third widths 5212 and 5216. For example, a nozzle sidewall 5218 of the second region 5210 may have an arcuate shape. By way of further example, the nozzle sidewall 5218 of the second region 5210 may generally be described as forming a truncated sphere-shaped chamber, wherein the opposing truncated ends are defined by respective openings. In some instances, the first, second, and third widths 5212, 5214, and 5216 may be the same. For example, the first, second, and third widths 5212, 5214, and 5216 may each be about 8 mm, about 10 mm, about 12 mm, or about 14 mm. In this example, the second region 5210 may generally be described as having a substantially cylindrical shape. In some instances, the first width 5212 may be greater than the second width 5214 and the second width 5214 may be greater than the third width 5216. For example, the first, second, and third widths 5212, 5214, and 5216 may be configured such

that the second region 5210 tapers from the first width 5212 to the third width 5216 (e.g., with a less than 1° taper).

[00170] FIG. 43 shows a perspective view of the nozzle 4814. As shown, the flow splitter 5200 is disposed within nozzle 4814. For example, the flow splitter 5200 may be disposed within nozzle 4814 such that a first side separation distance 5300 between the first flow side 5202 and the nozzle sidewall 5218 at a first side of the nozzle 4814 is substantially the same as a second side separation distance 5302 between the second flow side 5204 and the nozzle sidewall 5218 at a second, opposite, side of the nozzle 4814. By way of further example, the first side separation distance 5300 may be greater than (or less than) the second side separation distance 5302. In some instances, the first and second separation distances 5300 and 5302 may be configured such that objects of a predetermined size are prevented from being inserted into the nozzle 4814 beyond a predetermined position (e.g., to prevent objects from being inserted into the fan 4902).

[00171] An example of a robotic cleaner, consistent with the present disclosure, may include a body, an agitator chamber defined in the body, a suction motor fluidly coupled to the agitator chamber and configured to cause air to flow into the agitator chamber, and at least one air jet assembly coupled to the body, the air jet assembly being configured to generate an air jet, the air jet being configured to urge debris toward the agitator chamber.

[00172] In some instances, the at least one air jet assembly may be fluidly coupled to an exhaust side of the suction motor. In some instances, the at least one air jet assembly may include a vent configured to generate the air jet. In some instances, the at least one air jet assembly may include a nozzle configured to generate the air jet. In some instances, the at least one air jet assembly may be coupled to a sidewall of the body that extends between an underside of the body and an upper surface of the body. In some instances, the at least one air jet assembly may include a vent. In some instances, the at least one air jet assembly may be disposed on an underside of the body. In some instances, the robotic cleaner may further include a plurality of air jet assemblies, wherein at least one air jet assembly has a different configuration than that of at least one other air jet assembly. In some instances, at least one air jet assembly may include a vent and at least one other air jet assembly may include a nozzle. In some instances, at least one air jet assembly may be coupled to a sidewall of the body that extends between an underside of the body and an upper surface of the body and at least one

other air jet assembly may be coupled to the underside of the body. In some instances, the at least one air jet assembly may be fluidly coupled to a fan.

[00173] Another example of a robotic cleaner, consistent with the present disclosure, may include a body, an obstacle detection sensor coupled to the body, the obstacle detection sensor being configured to detect an obstacle, an agitator chamber defined in the body, a suction motor fluidly coupled to the agitator chamber and configured to cause air to flow into the agitator chamber, and a plurality of air jet assemblies coupled to the body, the plurality of air jet assemblies each being configured to generate an air jet, each air jet being configured to urge debris toward the agitator chamber.

[00174] In some instances, the plurality of air jet assemblies may be configured to generate a respective air jet based, at least in part, on an output generated by the obstacle detection sensor. In some instances, at least one air jet assembly may include a vent and at least one other air jet assembly may include a nozzle. In some instances, at least one air jet assembly may be coupled to a sidewall of the body that extends between an underside of the body and an upper surface of the body and at least one other air jet assembly may be coupled to the underside of the body. In some instances, at least one air jet assembly may be fluidly coupled to an exhaust side of the suction motor. In some instances, at least one air jet assembly may be fluidly coupled to a fan. In some instances, at least one air jet assembly may include a vent configured to generate the air jet. In some instances, at least one air jet assembly may include a nozzle configured to generate the air jet. In some instances, the plurality of air jet assemblies may be positioned along a perimeter of the body.

[00175] An example of a robotic cleaner, consistent with the present disclosure, may include a body having a top wall, a bottom wall, and a sidewall extending between the top wall and the bottom wall, a suction motor, and at least one air jet assembly configured to encourage generation of a vortex between the body, a surface to be cleaned, and a vertical surface extending from the surface to be cleaned.

[00176] In some instances, the robotic cleaner may further include a wet cleaning assembly. In some instances, the at least one air jet assembly may include a nozzle having a flow splitter, the flow splitter includes a first flow side and a second flow side, wherein a second surface length of the second flow side is greater than a first surface length of the first flow side. In some instances, the at least one air jet assembly may include a nozzle that defines a nozzle outlet central axis, the nozzle outlet central axis extending in an outward direction that extends

away from the sidewall of the body, in a forward direction, relative to a direction of forward movement of the robotic cleaner, and in a downward direction that extends toward the bottom wall of the body. In some instances, the at least one air jet assembly may include a nozzle that defines a nozzle outlet central axis, the nozzle outlet central axis extends at: a forward angle that is defined between the nozzle outlet central axis and a front-rear cross axis that extends parallel to a direction of forward movement of the robotic cleaner and a downward angle that is defined between the nozzle outlet central axis and a horizontal plane that extends between the bottom wall and the top wall. In some instances, the forward angle may be in a range of 30° to 60° and the downward angle may be in a range of 15° to 35°. In some instances, the forward angle may be about 41° and the downward angle may be about 27°.

[00177] Another example of a robotic cleaner, consistent with the present disclosure, may include a body having a top wall, a bottom wall, and a sidewall extending between the top wall and the bottom wall, a suction motor, and at least one air jet assembly, at least a portion of the at least one air jet assembly being received within a receptacle defined in the sidewall of the body, the at least one air jet assembly being configured to generate an air jet that extends outwardly from the sidewall of the body.

[00178] In some instances, the at least one air jet assembly may be fluidly coupled to a fan. In some instances, the robotic cleaner may further include a wet cleaning assembly. In some instances, the at least one air jet assembly may include a nozzle that defines a nozzle outlet central axis, the nozzle outlet central axis extending in an outward direction that extends away from the sidewall of the body, in a forward direction, relative to a direction of forward movement of the robotic cleaner, and in a downward direction that extends toward the bottom wall of the body. In some instances, the at least one air jet assembly may include a nozzle that defines a nozzle outlet central axis, the nozzle outlet central axis extends at: a forward angle that is defined between the nozzle outlet central axis and a front-rear cross axis that extends parallel to a direction of forward movement of the robotic cleaner and a downward angle that is defined between the nozzle outlet central axis and a horizontal plane that extends between the bottom wall and the top wall. In some instances, the forward angle may be in a range of 30° to 60° and the downward angle may be in a range of 15° to 35°. In some instances, the at least one air jet assembly may include a nozzle having a flow splitter.

[00179] Another example of a robotic cleaner, consistent with the present disclosure, may include a body having a top wall, a bottom wall, and a sidewall extending between the top

wall and the bottom wall, a suction motor, and at least one air jet assembly disposed on an assembly axis, the assembly axis extends perpendicular to a direction of forward movement of the robotic cleaner and extends along a widest width of the body that extends in a direction perpendicular to the direction of forward movement, the at least one air jet assembly being configured to generate an air jet that extends outwardly from the sidewall of the body.

[00180] In some instances, the at least one air jet assembly may be fluidly coupled to a fan. In some instances, the at least one air jet assembly may include a nozzle. In some instances, the nozzle may define a nozzle outlet central axis, the nozzle outlet central axis extending in an outward direction that extends away from the sidewall of the body, in a forward direction, relative to the direction of forward movement of the robotic cleaner, and in a downward direction that extends toward the bottom wall of the body. In some instances, the nozzle may define a nozzle outlet central axis, the nozzle outlet central axis extends at: a forward angle that is defined between the nozzle outlet central axis and a front-rear cross axis that extends parallel to the direction of forward movement of the robotic cleaner and a downward angle that is defined between the nozzle outlet central axis and a horizontal plane that extends between the bottom wall and the top wall. In some instances, the forward angle may be in a range of 30° to 60° and the downward angle may be in a range of 15° to 35°.

[00181] 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 sub-combination. 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 claims.

What is claimed is:

1. A robotic cleaner comprising:
 - a body having a top wall, a bottom wall, and a sidewall extending between the top wall and the bottom wall;
 - a suction motor; and
 - at least one air jet assembly configured to encourage generation of a vortex between the body, a surface to be cleaned, and a vertical surface extending from the surface to be cleaned.
2. The robotic cleaner of claim 1 further comprising a wet cleaning assembly.
3. The robotic cleaner of claim 1, wherein the at least one air jet assembly includes a nozzle having a flow splitter, the flow splitter includes a first flow side and a second flow side, wherein a second surface length of the second flow side is greater than a first surface length of the first flow side.
4. The robotic cleaner of claim 1, wherein the at least one air jet assembly includes a nozzle that defines a nozzle outlet central axis, the nozzle outlet central axis extending in an outward direction that extends away from the sidewall of the body, in a forward direction, relative to a direction of forward movement of the robotic cleaner, and in a downward direction that extends toward the bottom wall of the body.
5. The robotic cleaner of claim 1, wherein the at least one air jet assembly includes a nozzle that defines a nozzle outlet central axis, the nozzle outlet central axis extends at:
 - a forward angle that is defined between the nozzle outlet central axis and a front-rear cross axis that extends parallel to a direction of forward movement of the robotic cleaner; and
 - a downward angle that is defined between the nozzle outlet central axis and a horizontal plane that extends between the bottom wall and the top wall.

6. The robotic cleaner of claim 5, wherein the forward angle is in a range of 30° to 60° and the downward angle is in a range of 15° to 35°.
7. The robotic cleaner of claim 6, wherein the forward angle is about 41° and the downward angle is about 27°.
8. A robotic cleaner comprising:
 - a body having a top wall, a bottom wall, and a sidewall extending between the top wall and the bottom wall;
 - a suction motor; and
 - at least one air jet assembly, at least a portion of the at least one air jet assembly being received within a receptacle defined in the sidewall of the body, the at least one air jet assembly being configured to generate an air jet that extends outwardly from the sidewall of the body.
9. The robotic cleaner of claim 8, wherein the at least one air jet assembly is fluidly coupled to a fan.
10. The robotic cleaner of claim 8, further comprising a wet cleaning assembly.
11. The robotic cleaner of claim 8, wherein the at least one air jet assembly includes a nozzle that defines a nozzle outlet central axis, the nozzle outlet central axis extending in an outward direction that extends away from the sidewall of the body, in a forward direction, relative to a direction of forward movement of the robotic cleaner, and in a downward direction that extends toward the bottom wall of the body.
12. The robotic cleaner of claim 8, wherein the at least one air jet assembly includes a nozzle that defines a nozzle outlet central axis, the nozzle outlet central axis extends at:
 - a forward angle that is defined between the nozzle outlet central axis and
 - a front-rear cross axis that extends parallel to a direction of forward movement of the robotic cleaner; and

a downward angle that is defined between the nozzle outlet central axis and a horizontal plane that extends between the bottom wall and the top wall.

13. The robotic cleaner of claim 12, wherein the forward angle is in a range of 30° to 60° and the downward angle is in a range of 15° to 35°.

14. The robotic cleaner of claim 8, wherein the at least one air jet assembly includes a nozzle having a flow splitter.

15. A robotic cleaner comprising:
a body having a top wall, a bottom wall, and a sidewall extending between the top wall and the bottom wall;
a suction motor; and
at least one air jet assembly disposed on an assembly axis, the assembly axis extends perpendicular to a direction of forward movement of the robotic cleaner and extends along a widest width of the body that extends in a direction perpendicular to the direction of forward movement, the at least one air jet assembly being configured to generate an air jet that extends outwardly from the sidewall of the body.

16. The robotic cleaner of claim 15, wherein the at least one air jet assembly is fluidly coupled to a fan.

17. The robotic cleaner of claim 15, wherein the at least one air jet assembly includes a nozzle.

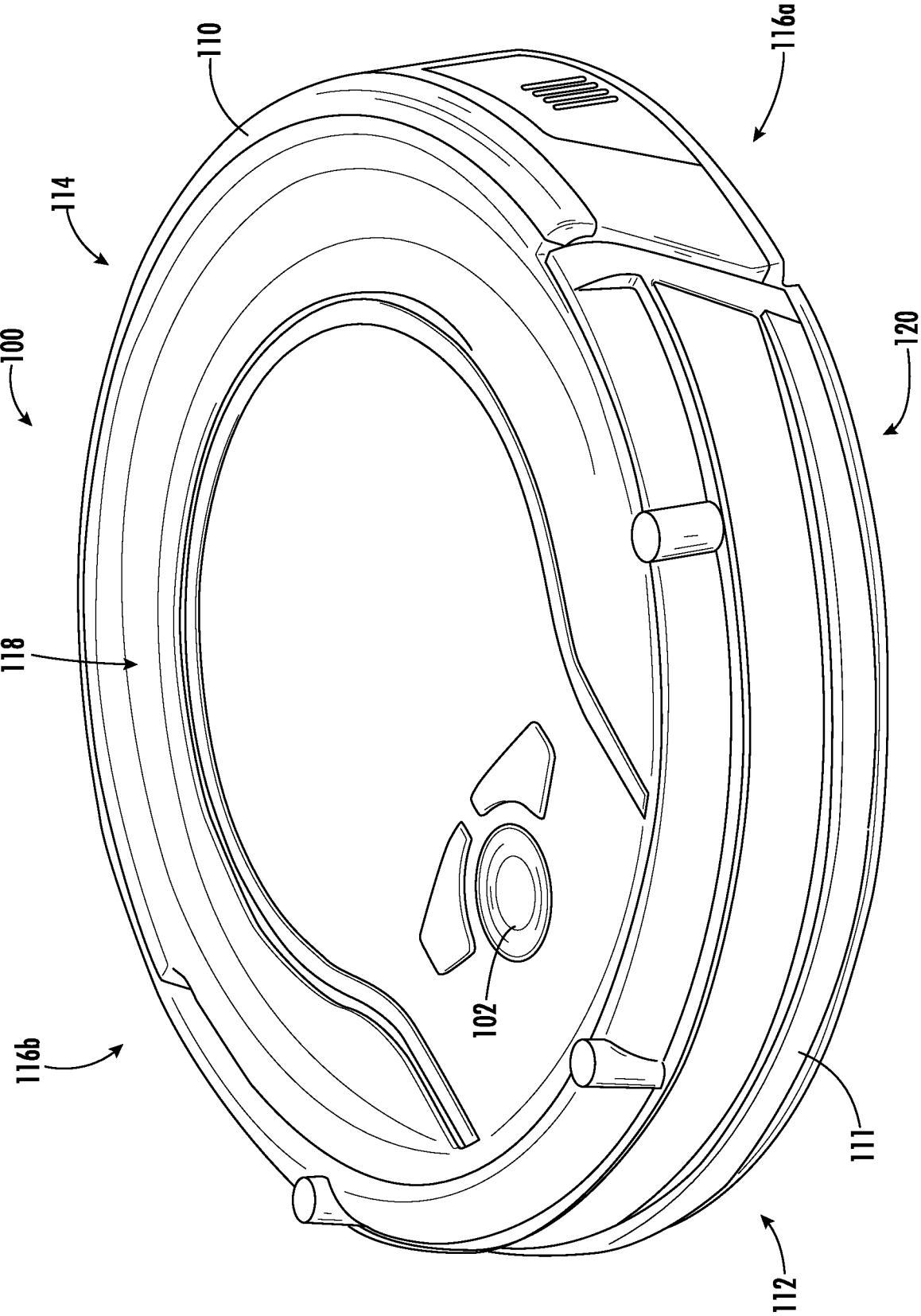
18. The robotic cleaner of claim 17, wherein the nozzle defines a nozzle outlet central axis, the nozzle outlet central axis extending in an outward direction that extends away from the sidewall of the body, in a forward direction, relative to the direction of forward movement of the robotic cleaner, and in a downward direction that extends toward the bottom wall of the body.

19. The robotic cleaner of claim 17, wherein the nozzle defines a nozzle outlet central axis, the nozzle outlet central axis extends at:

a forward angle that is defined between the nozzle outlet central axis and a front-rear cross axis that extends parallel to the direction of forward movement of the robotic cleaner; and

a downward angle that is defined between the nozzle outlet central axis and a horizontal plane that extends between the bottom wall and the top wall.

20. The robotic cleaner of claim 19, wherein the forward angle is in a range of 30° to 60° and the downward angle is in a range of 15° to 35°.



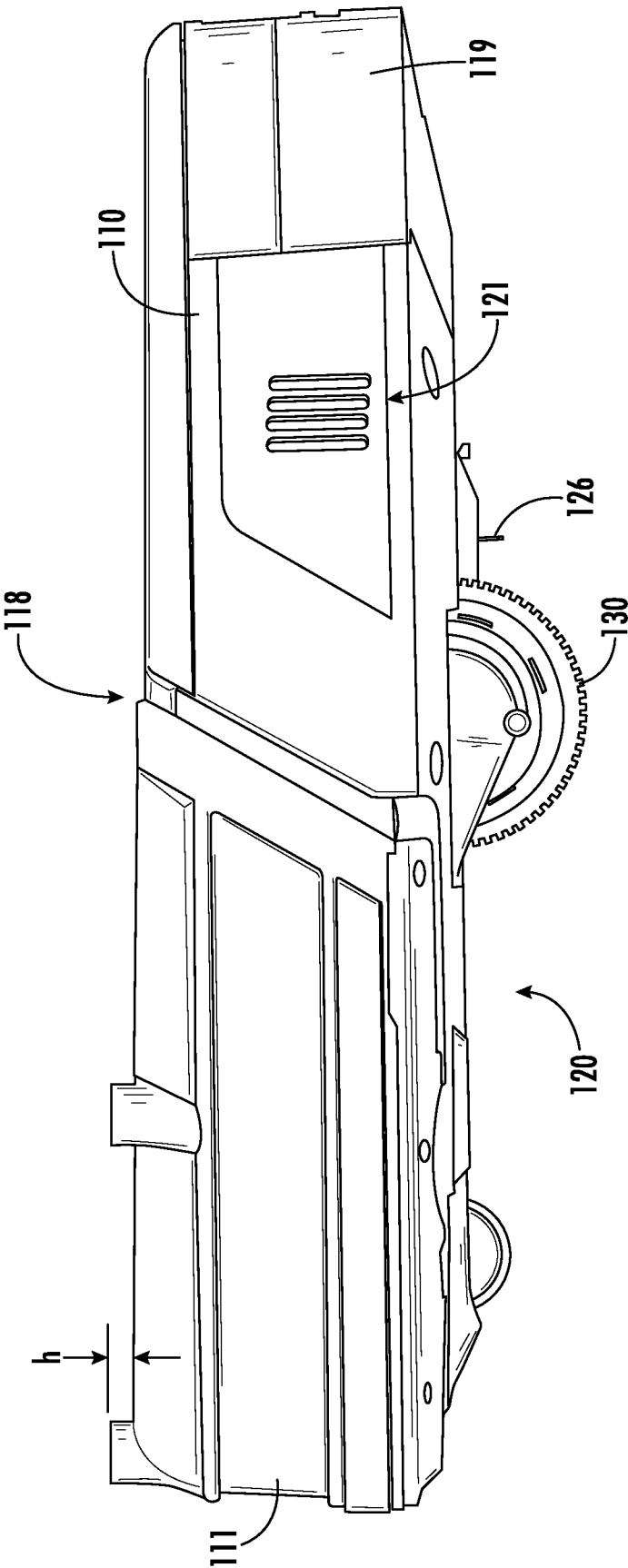


FIG. 2

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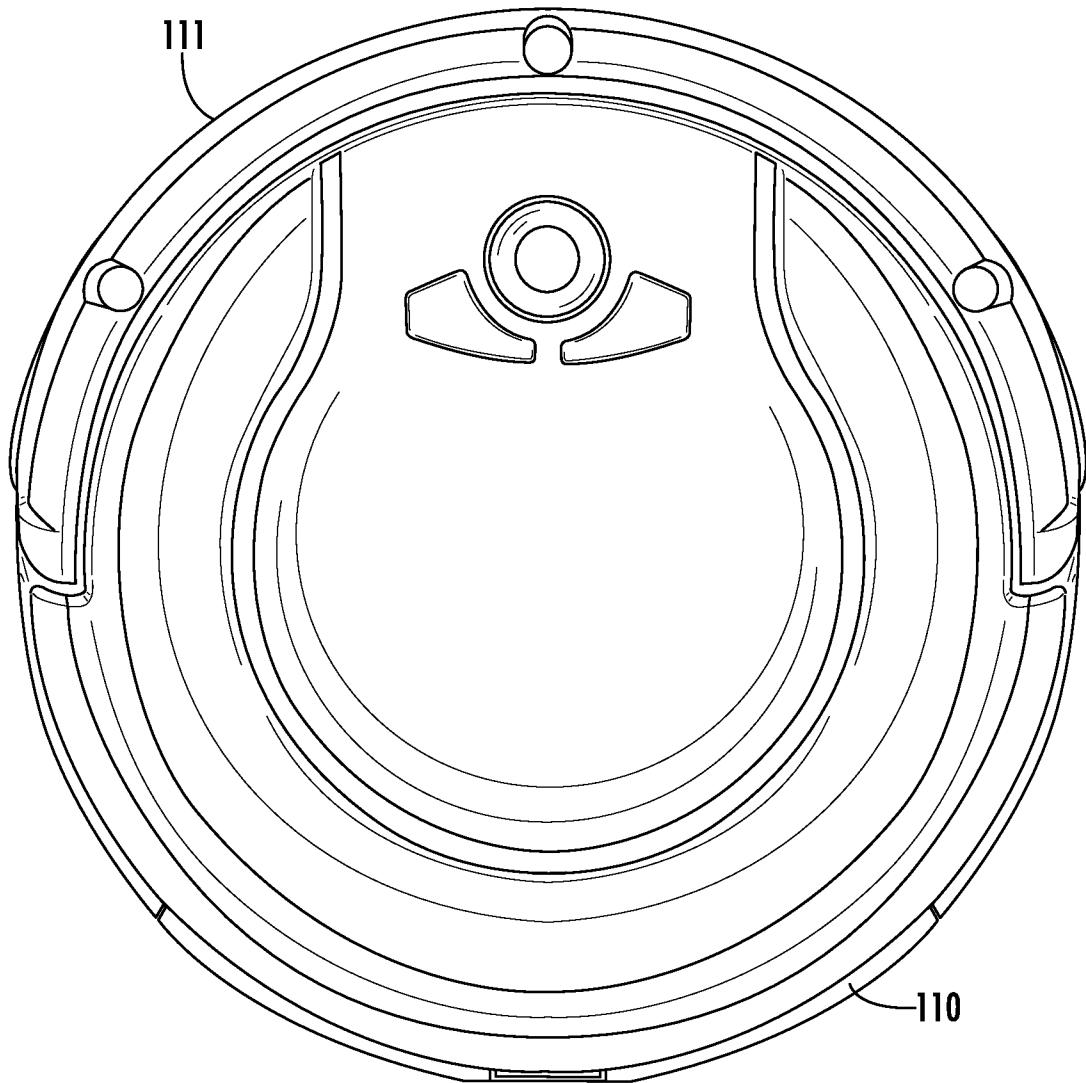


FIG. 3

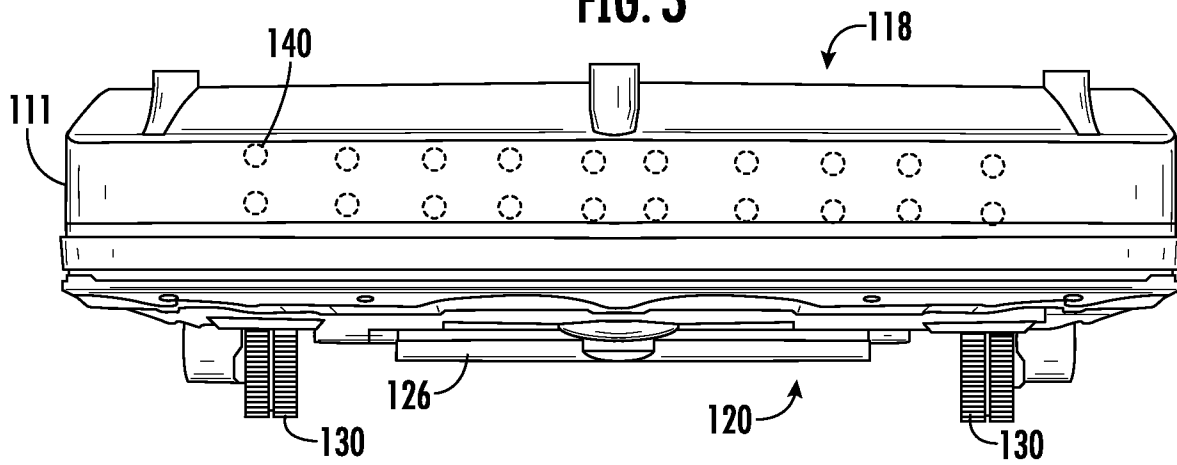


FIG. 4

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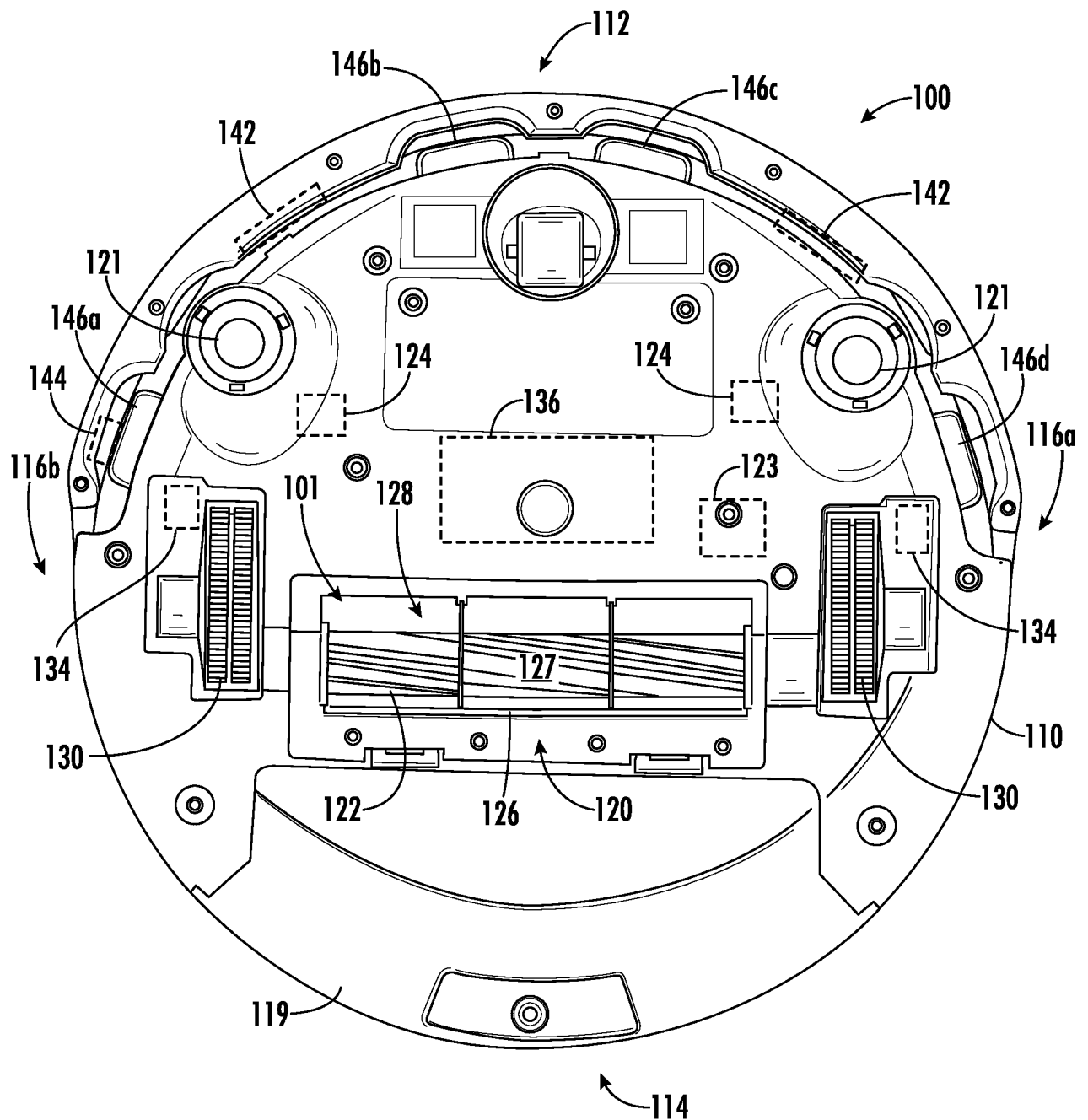


FIG. 5

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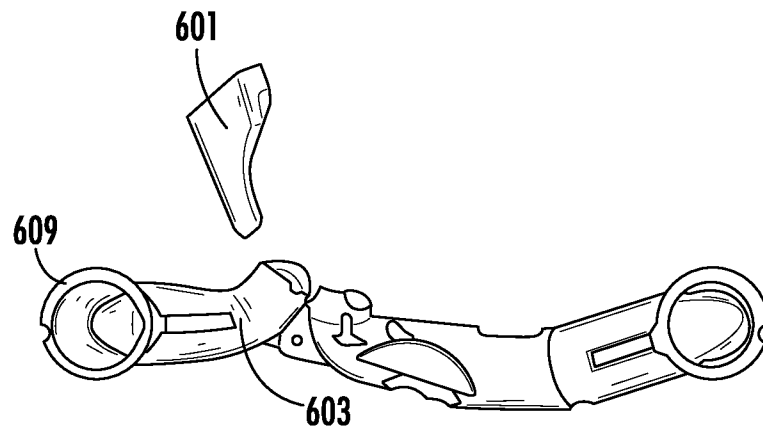


FIG. 6

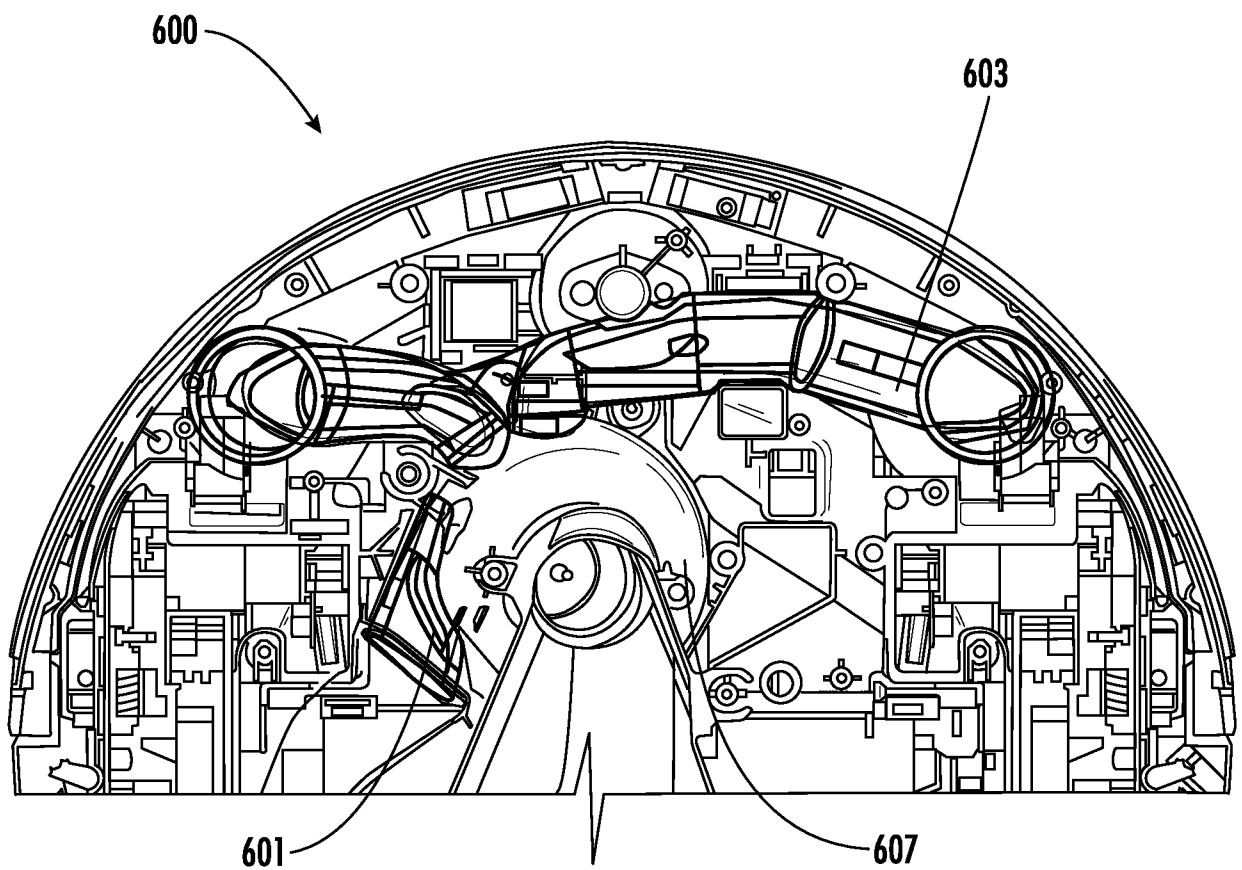


FIG. 7

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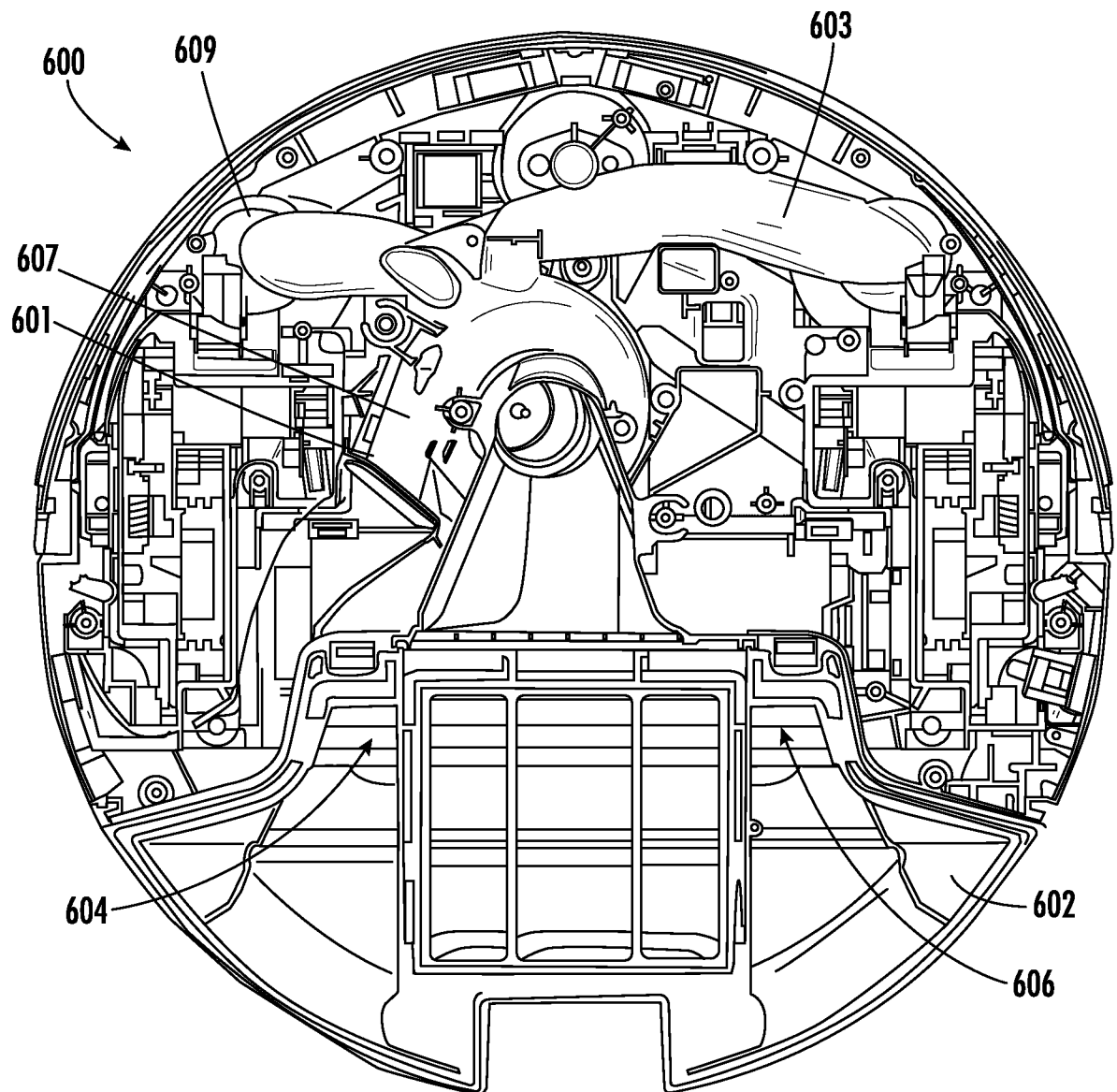


FIG. 8

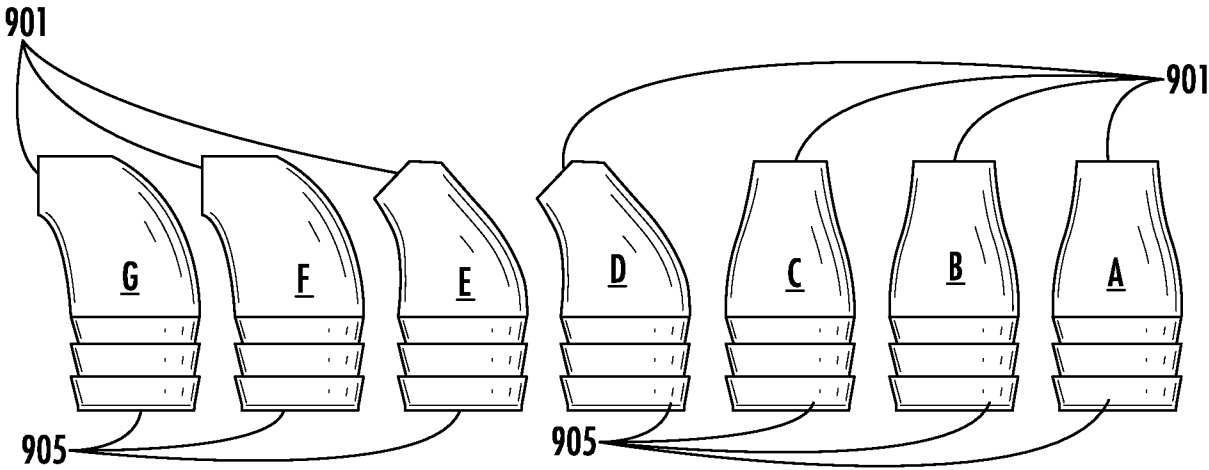


FIG. 9A

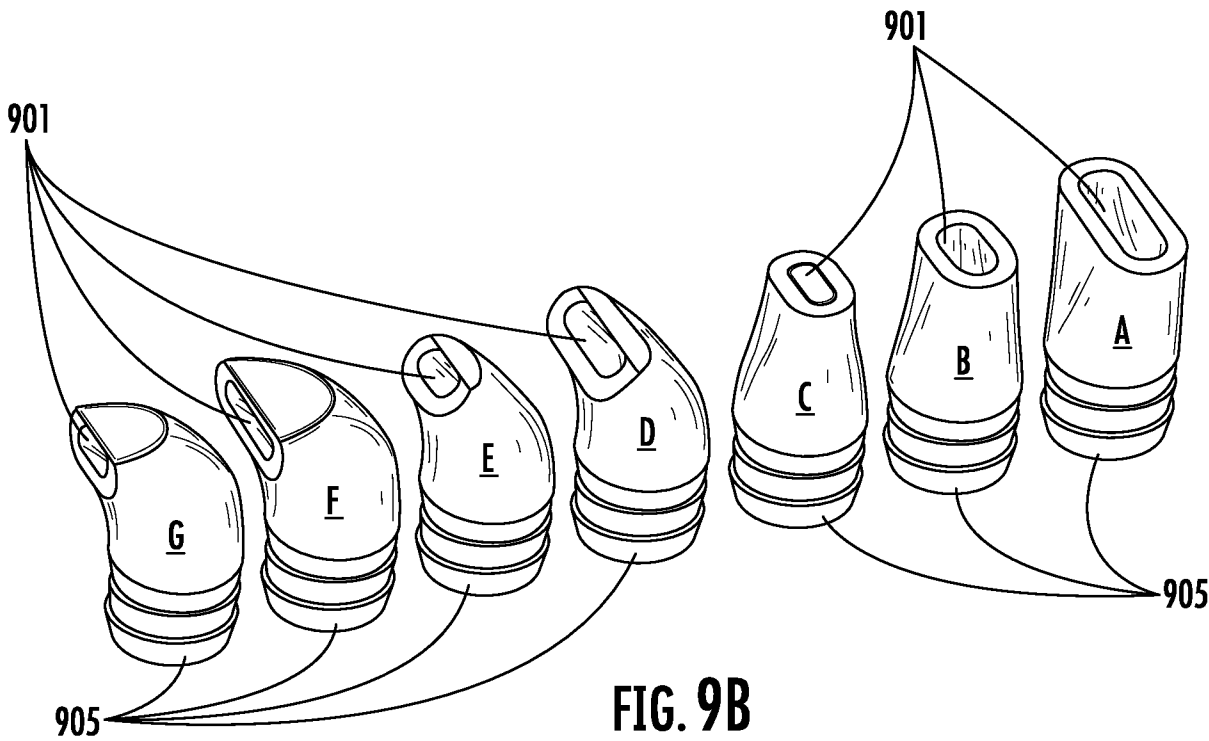


FIG. 9B

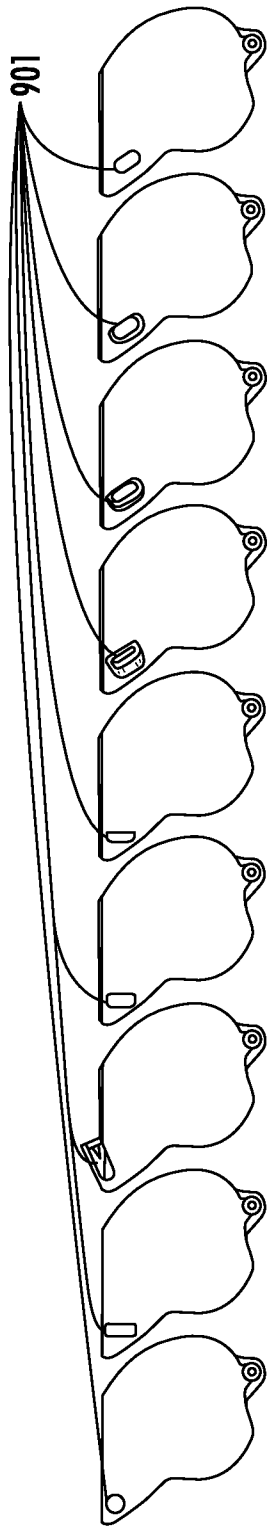


FIG. 10A

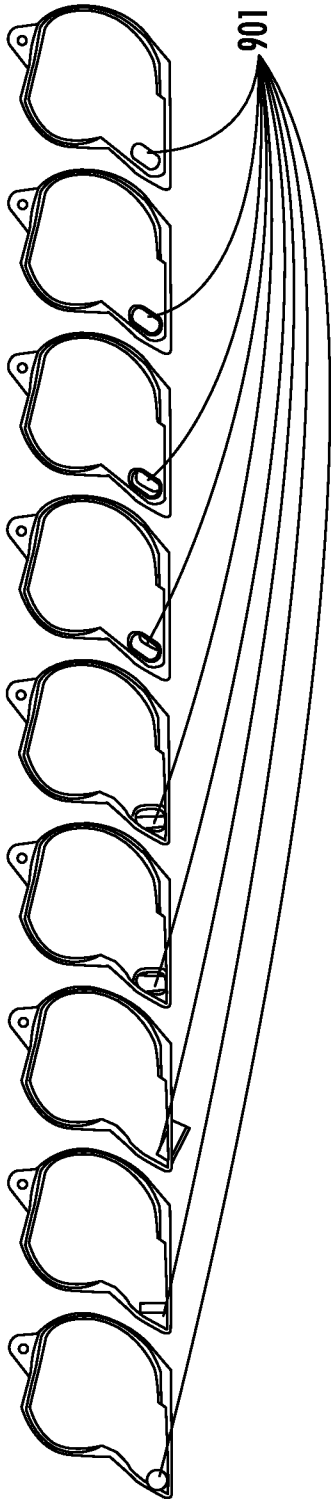


FIG. 10B

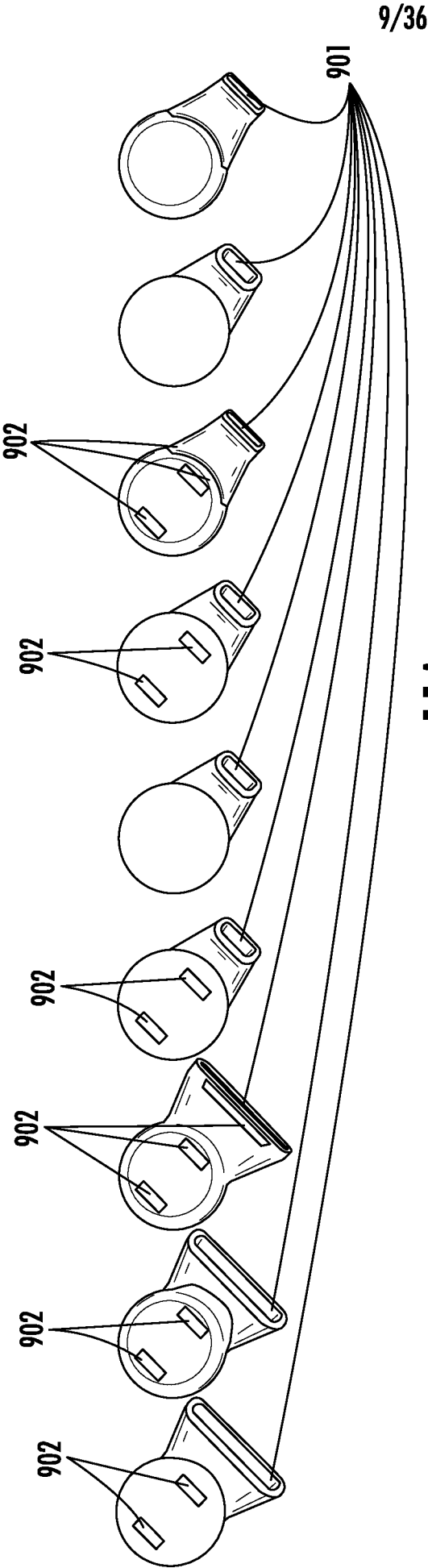


FIG. 11A

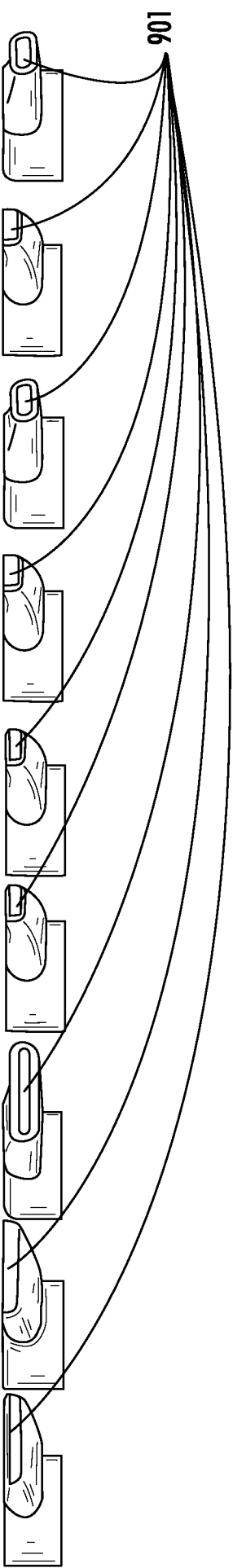


FIG. 11B

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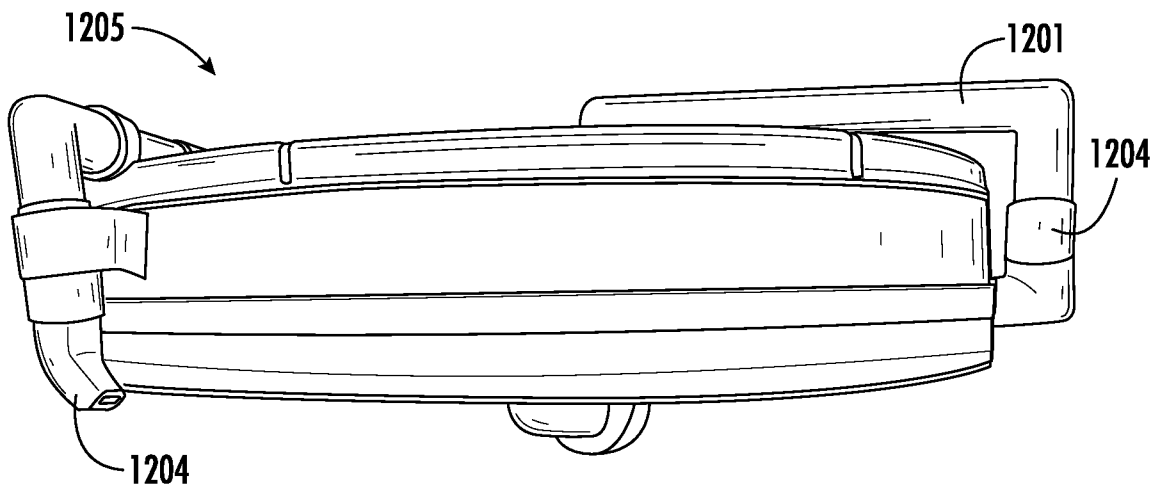


FIG. 12

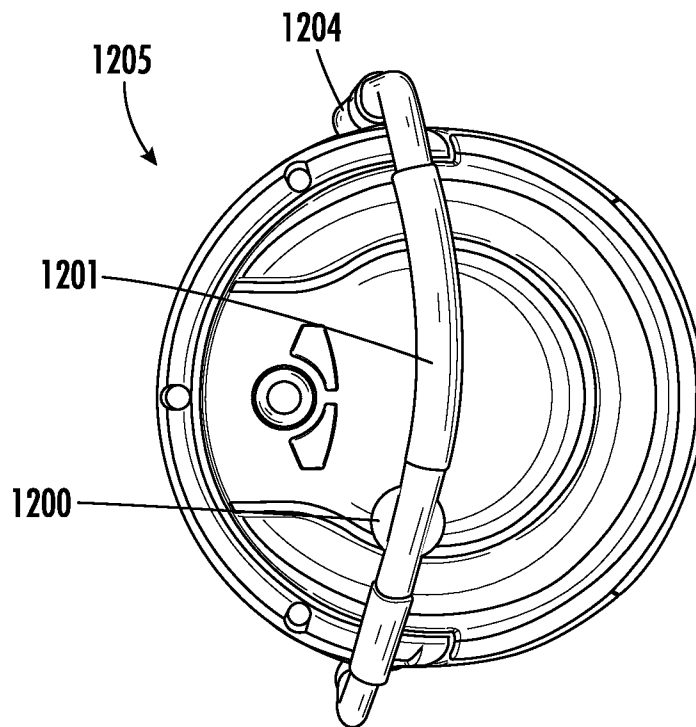
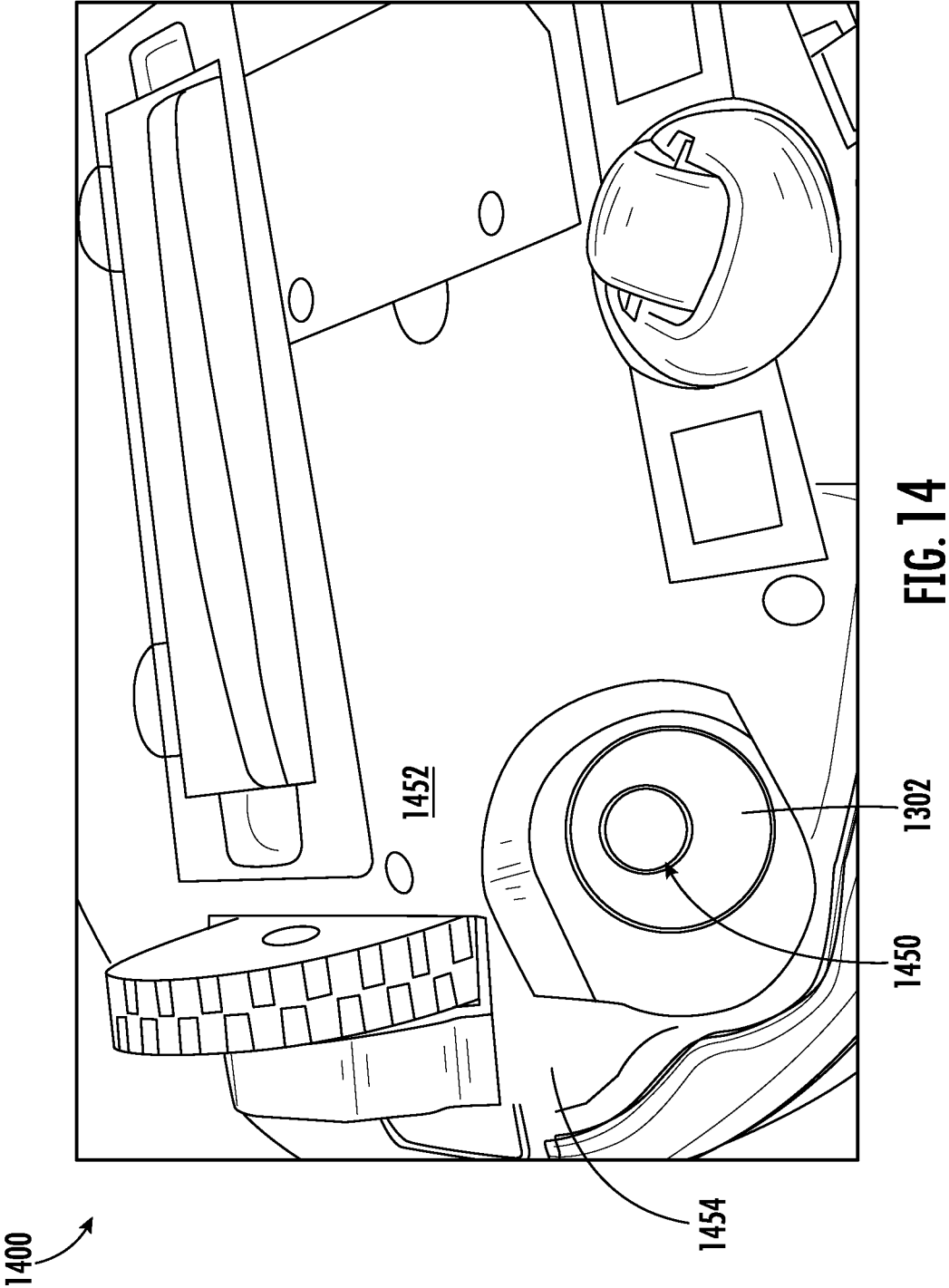


FIG. 13



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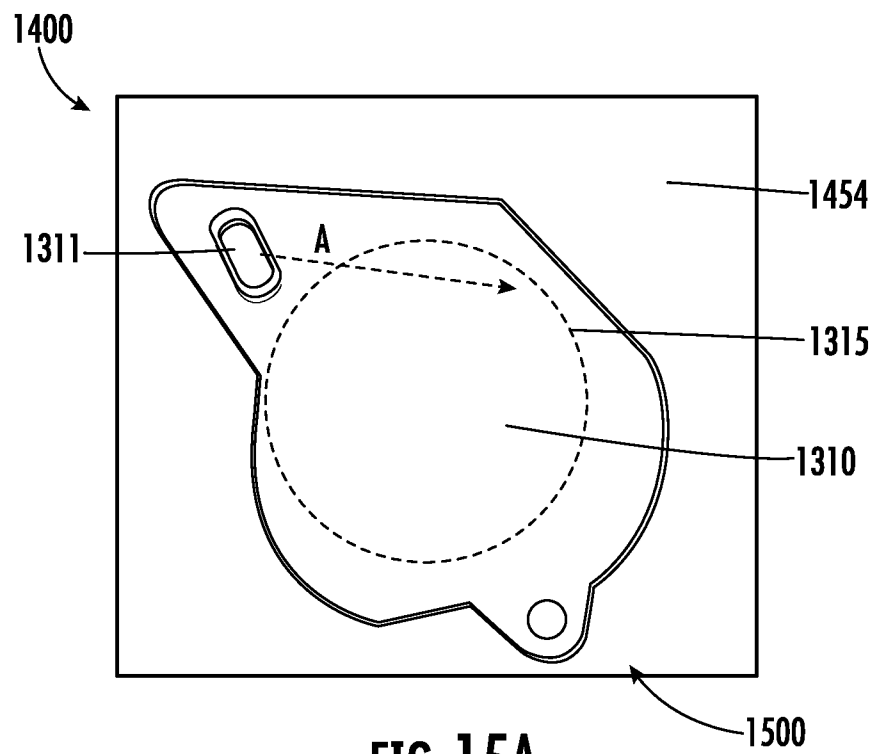


FIG. 15A

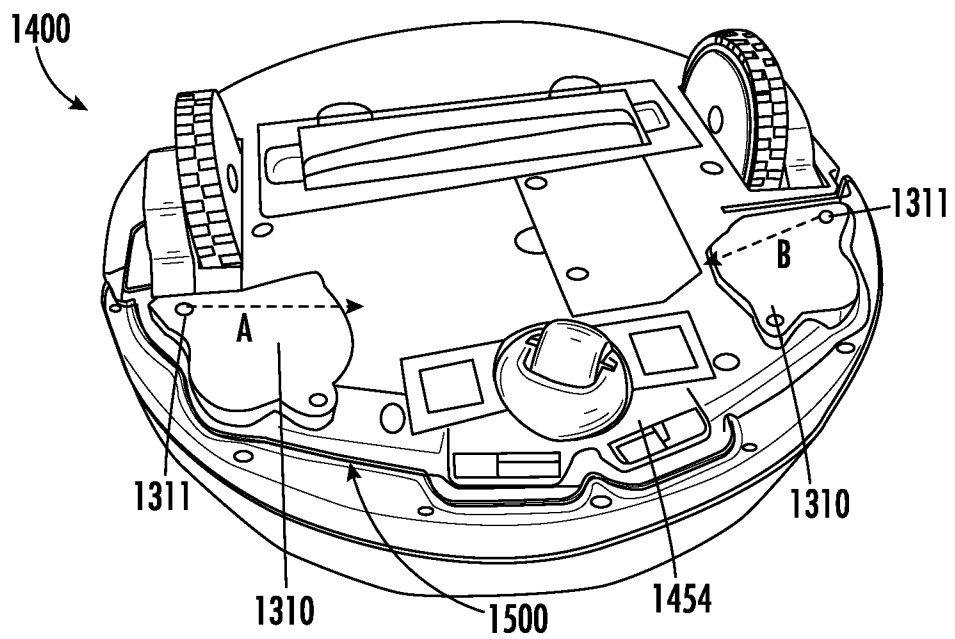


FIG. 15B

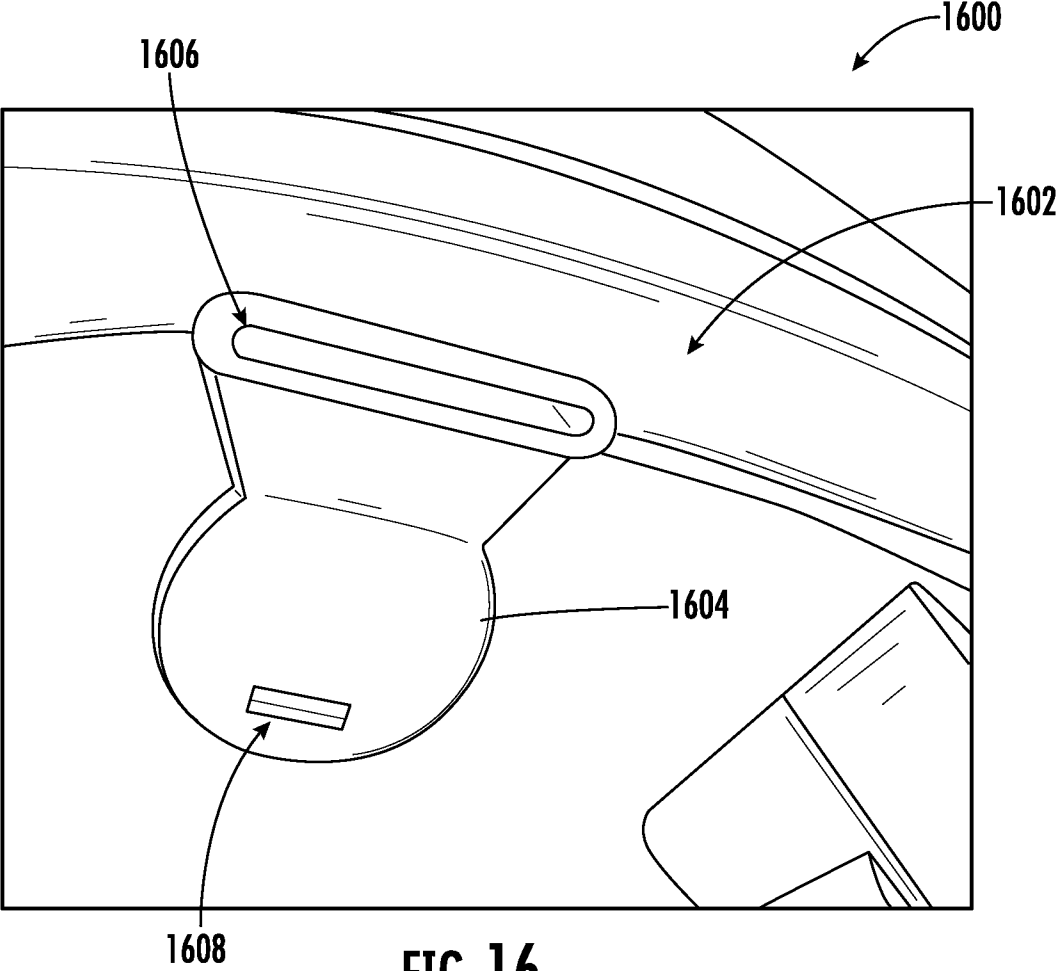


FIG. 16

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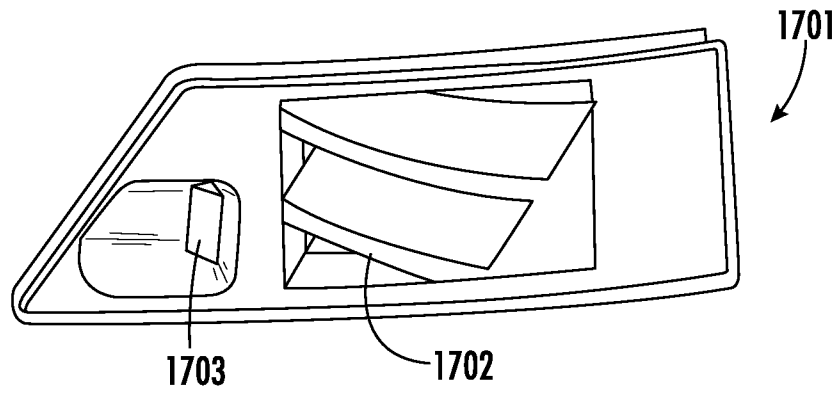


FIG. 17A

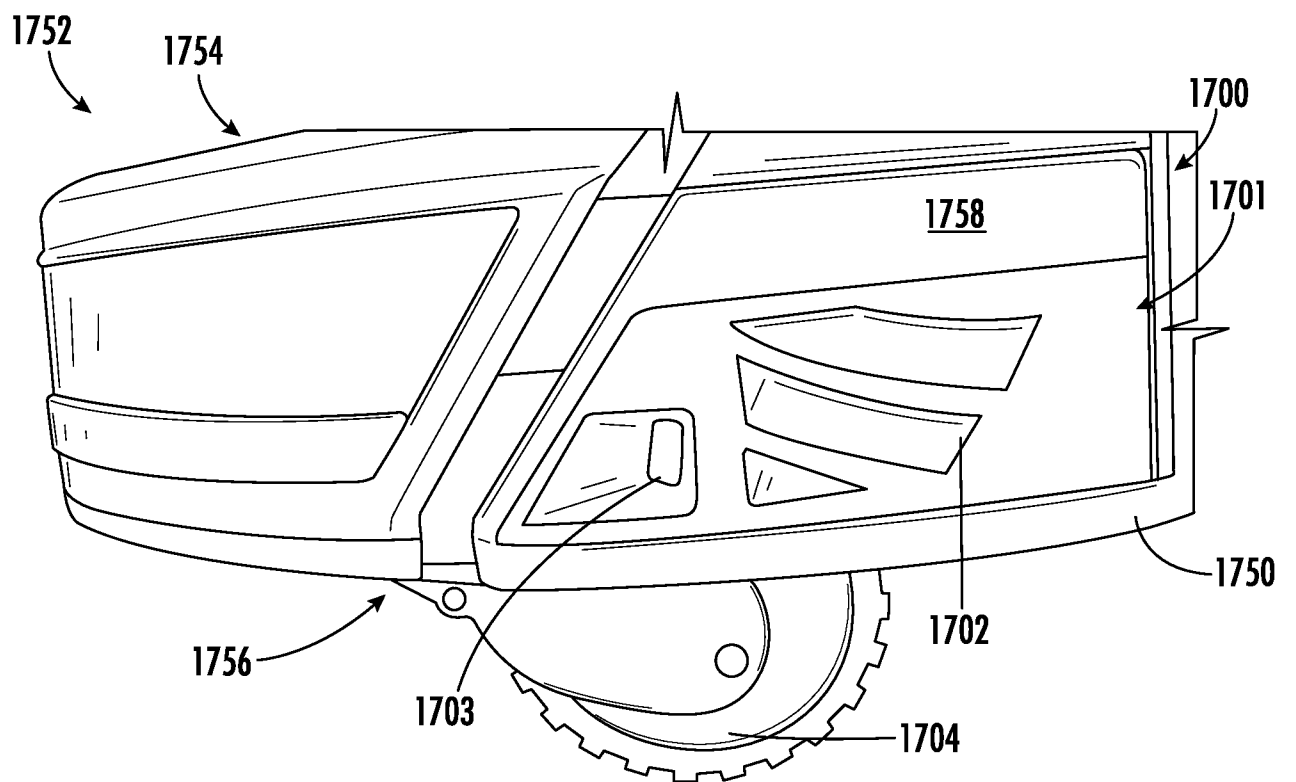


FIG. 17B

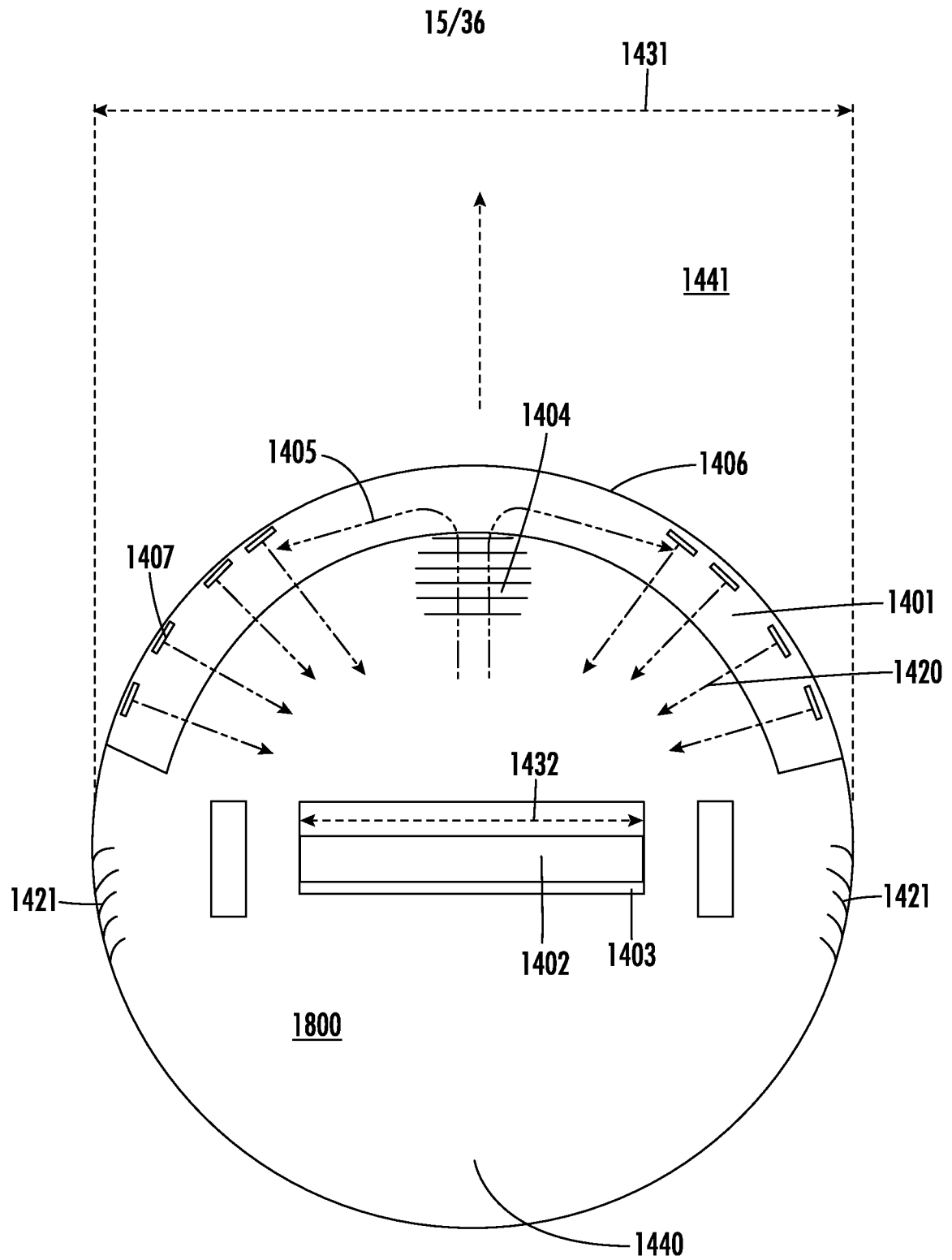


FIG. 18

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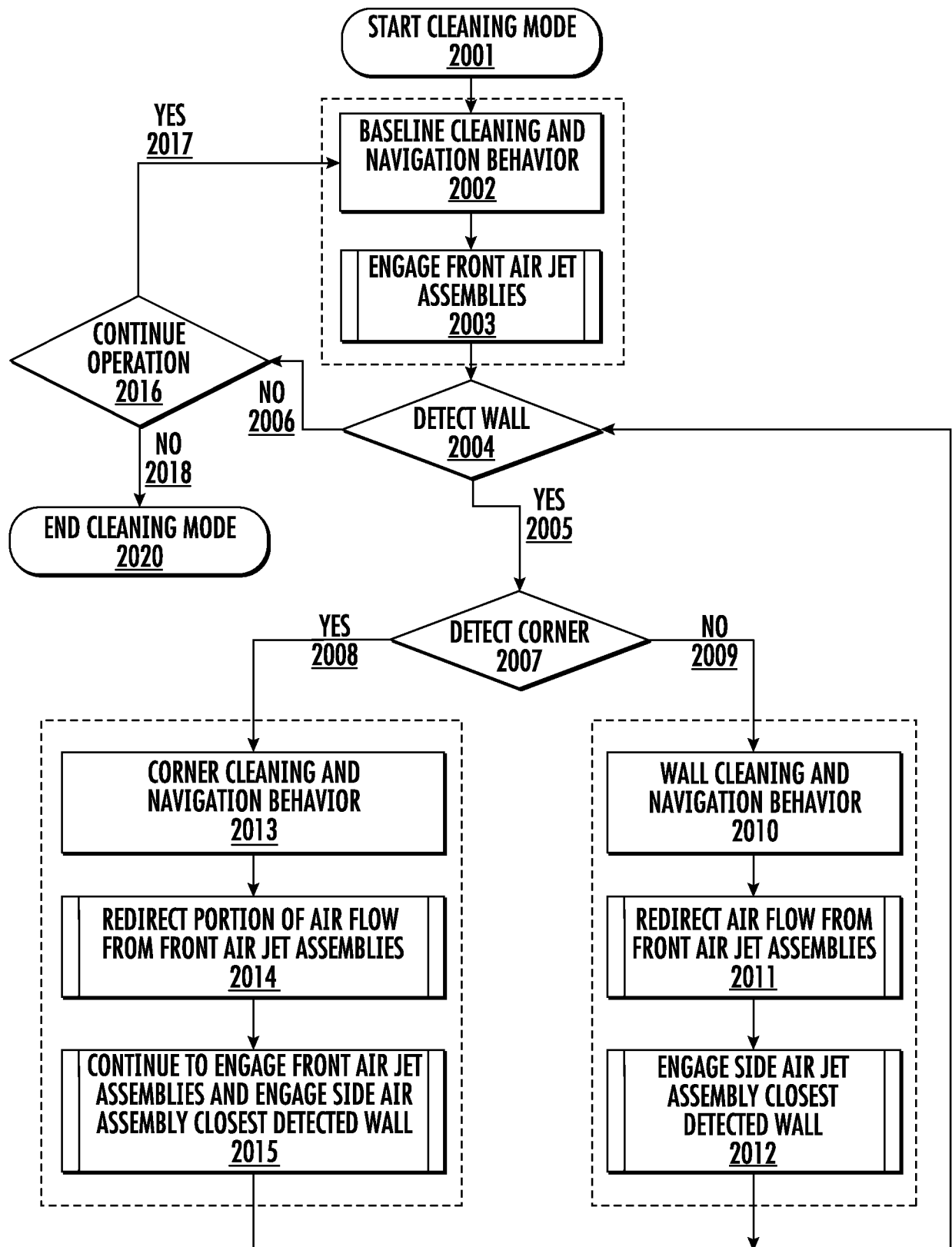


FIG. 19

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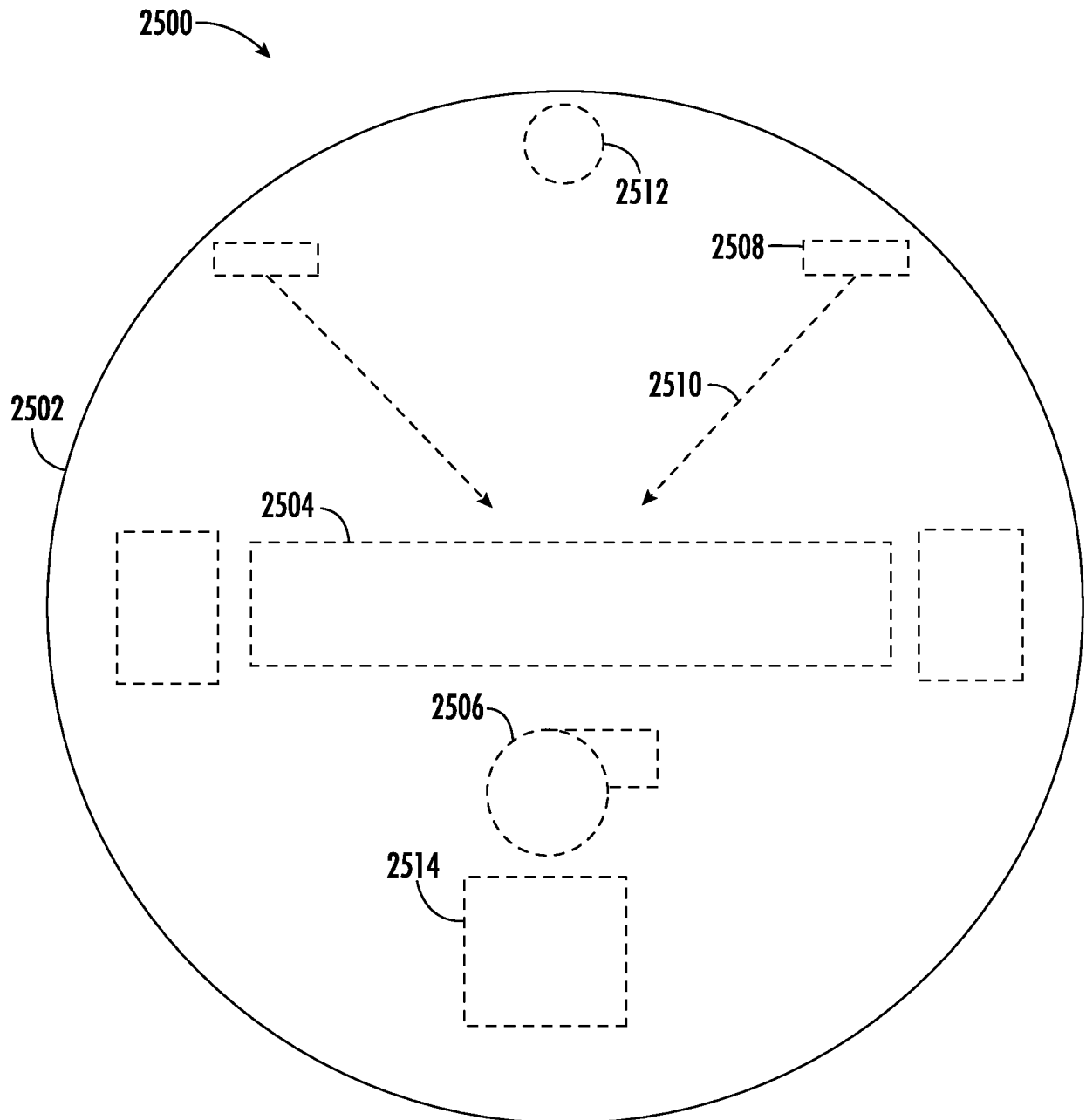


FIG. 20

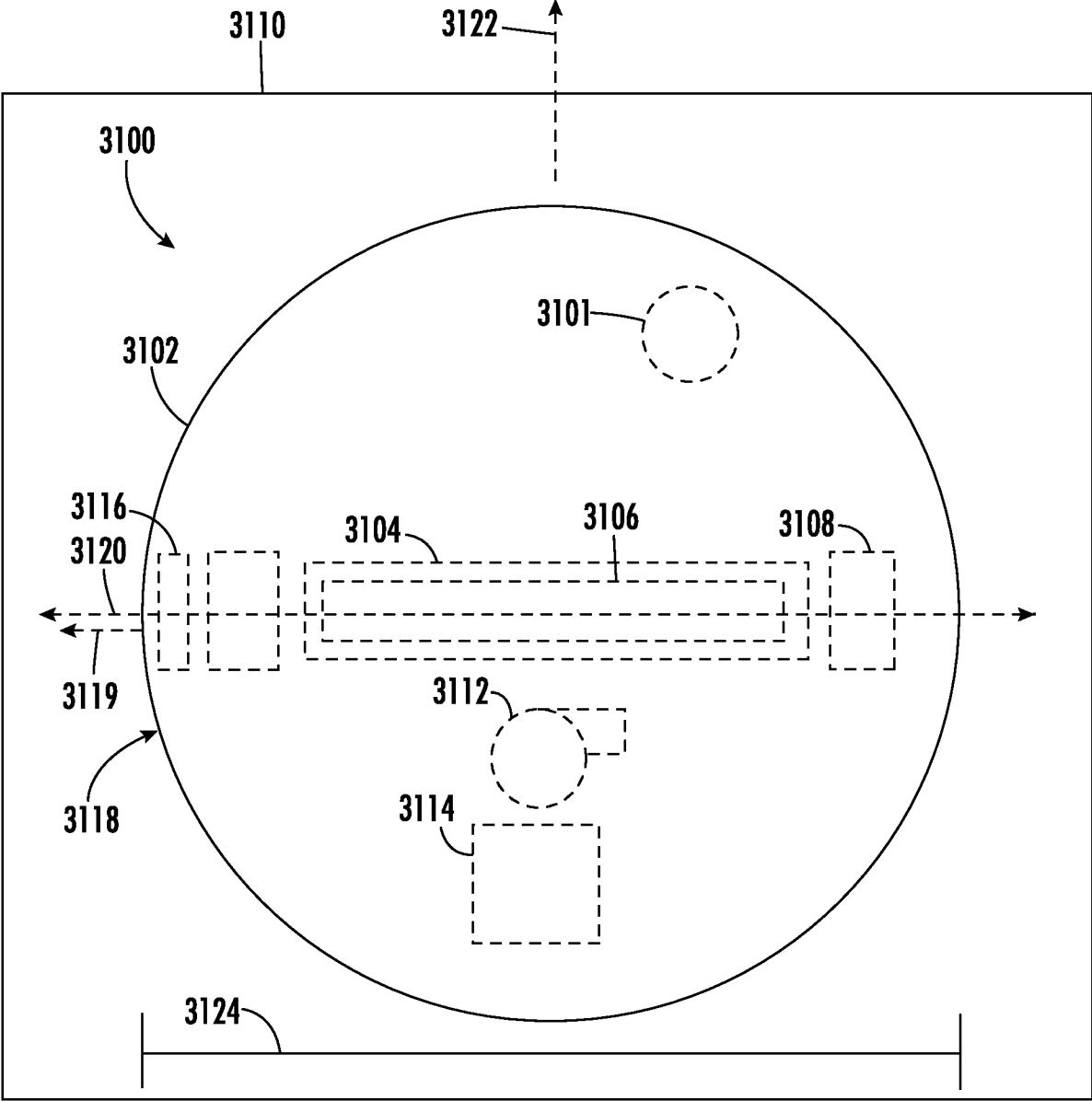


FIG. 21

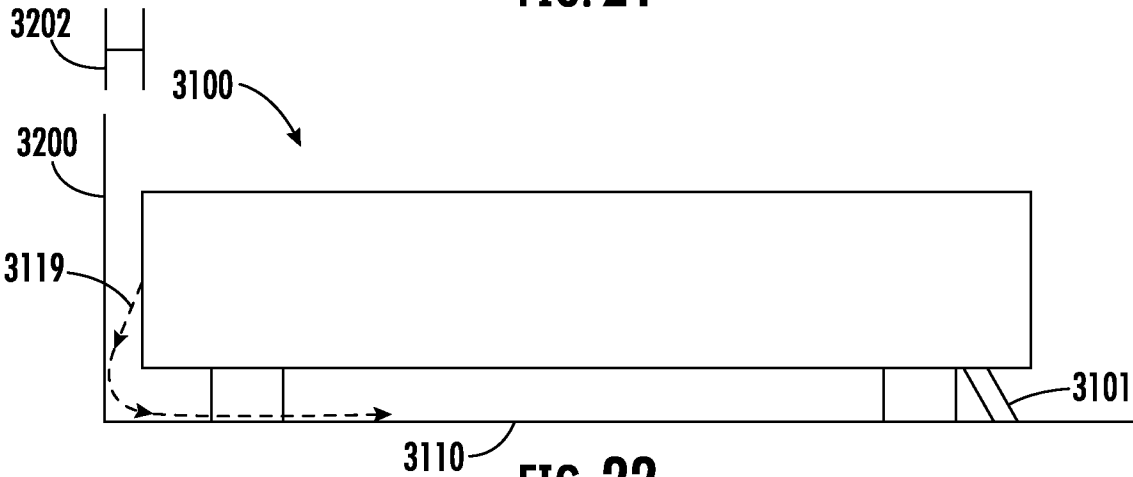
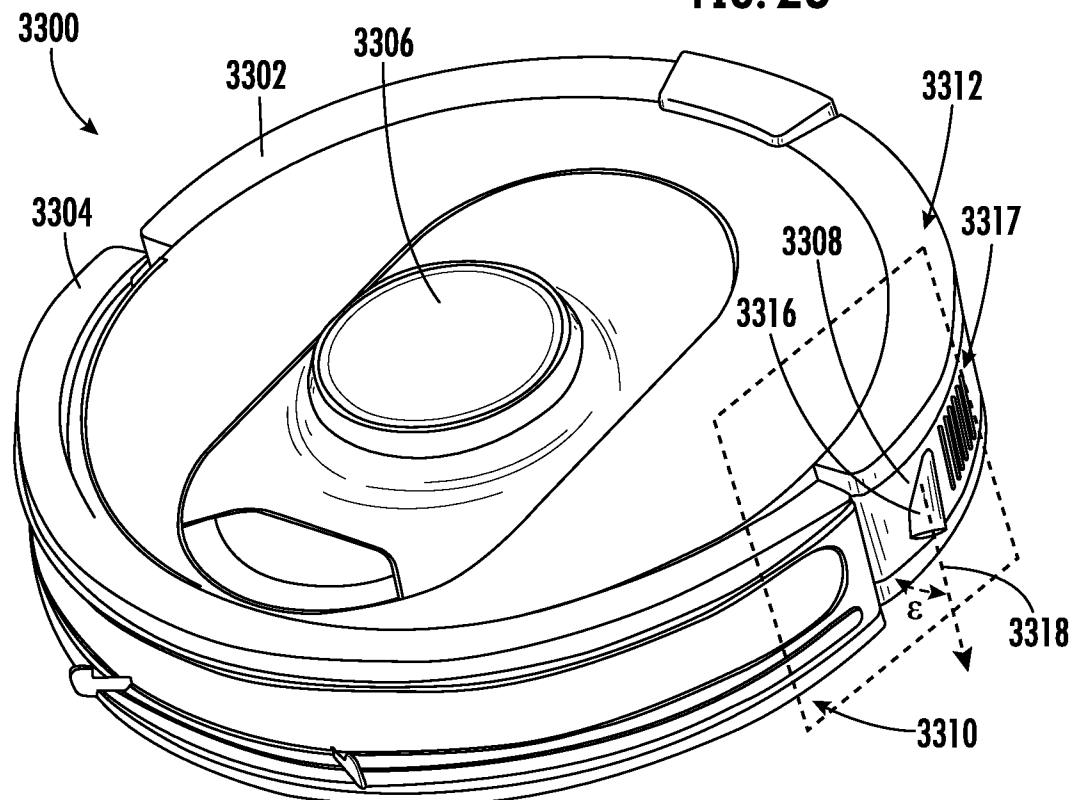
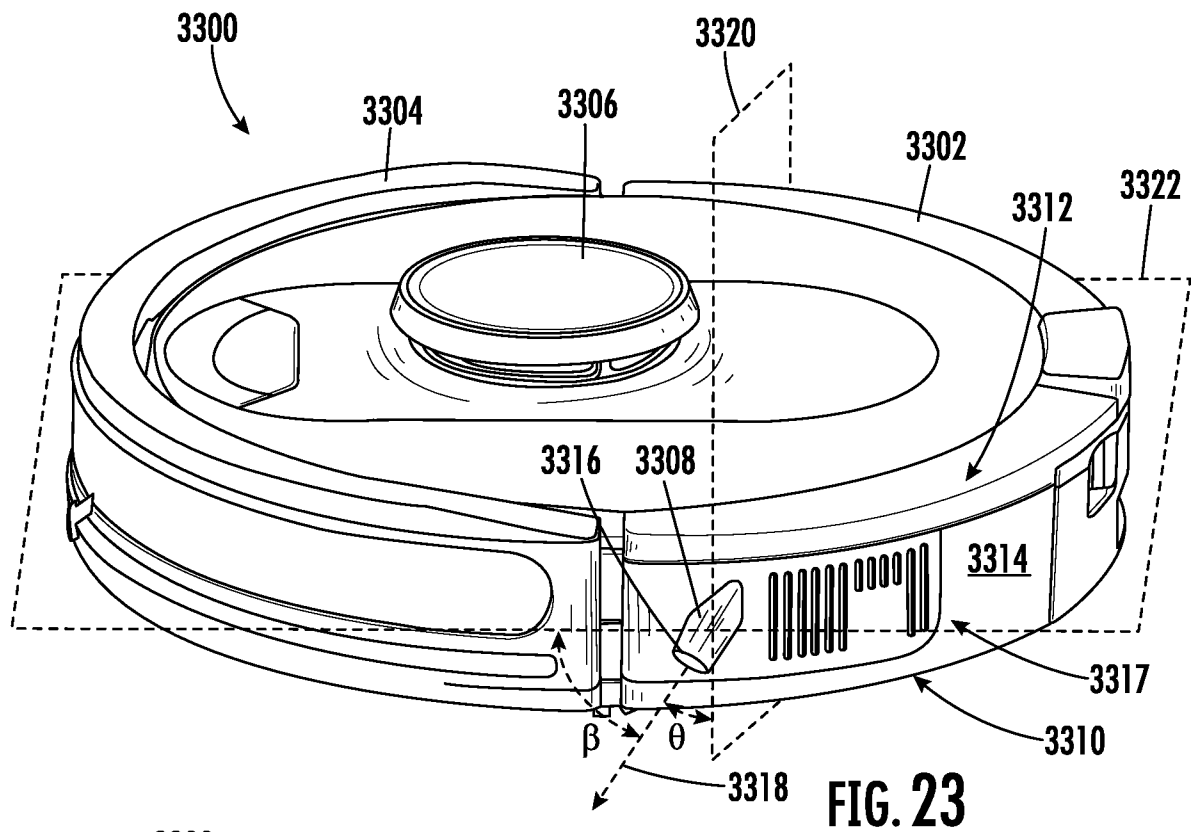


FIG. 22

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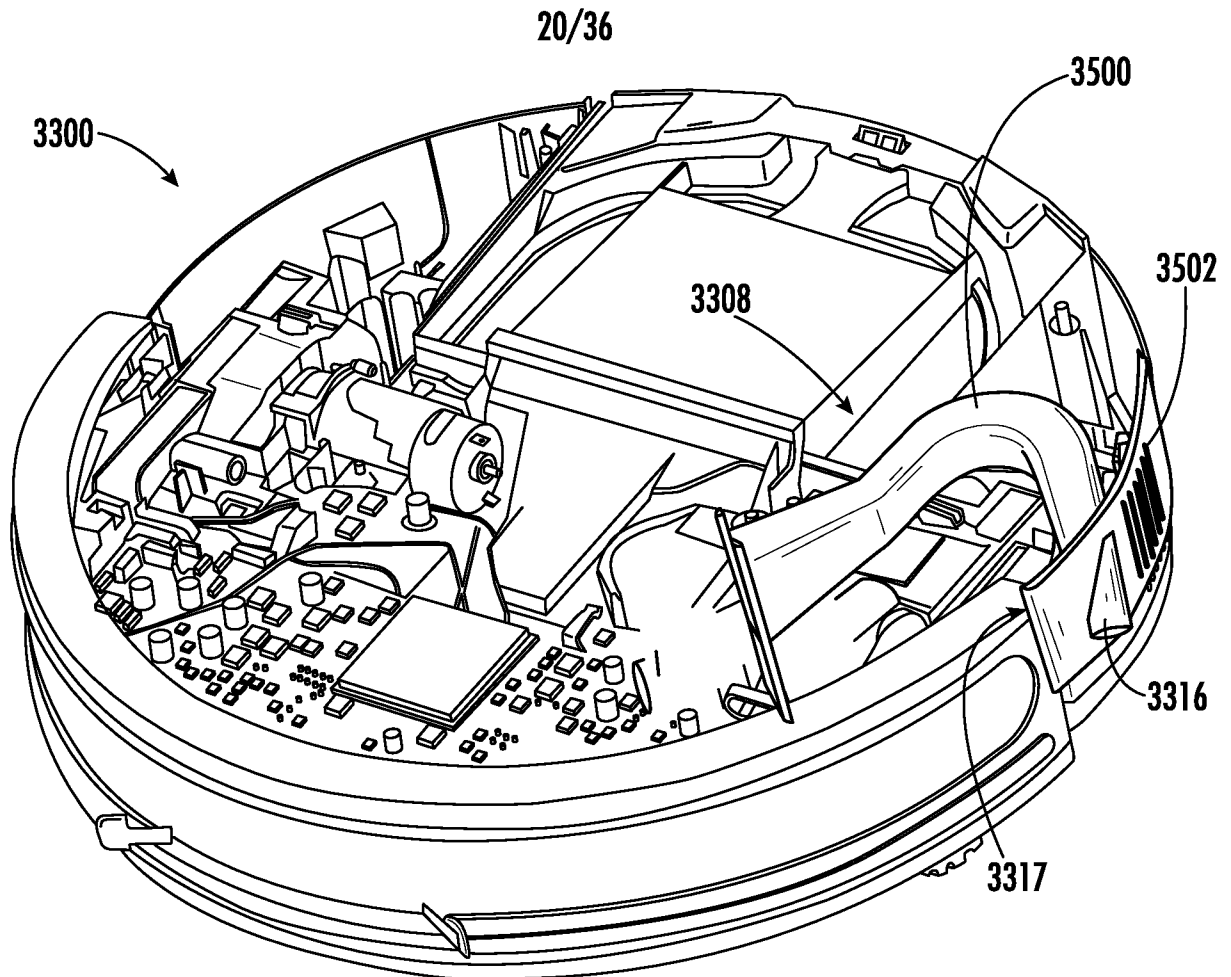


FIG. 25

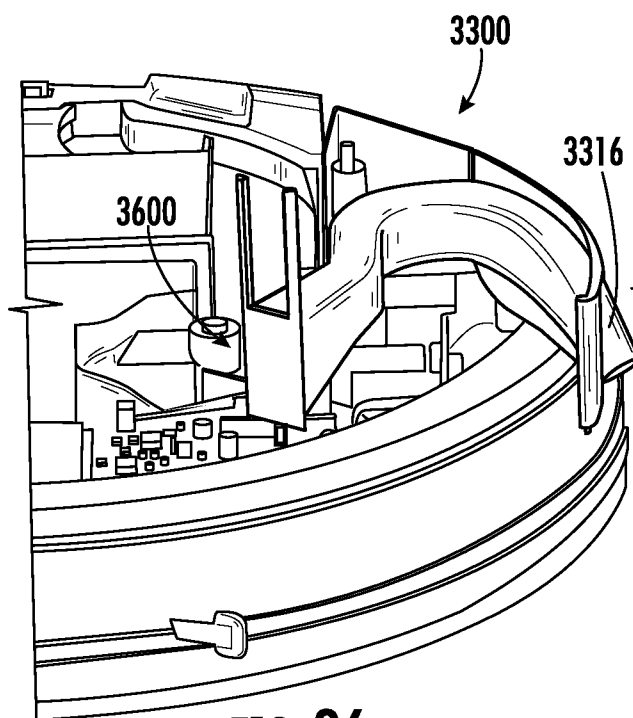


FIG. 26

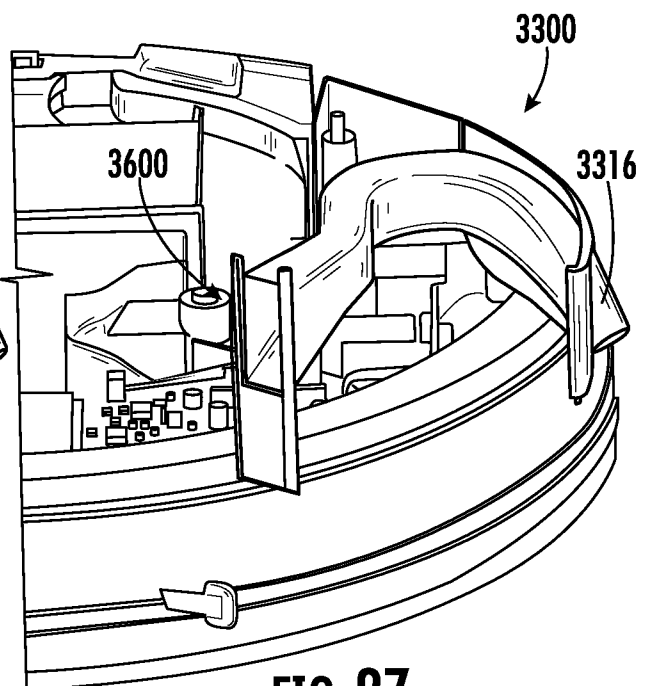


FIG. 27

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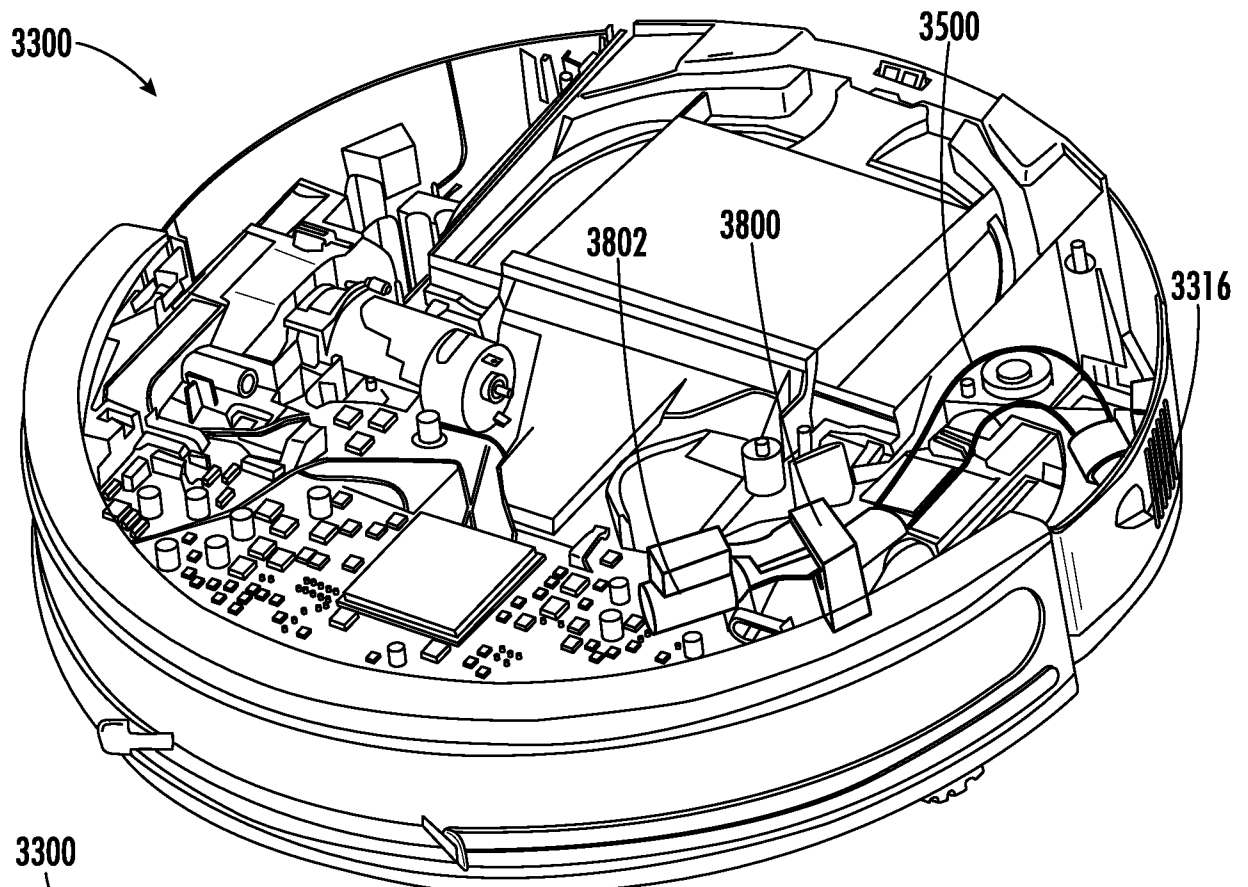


FIG. 28

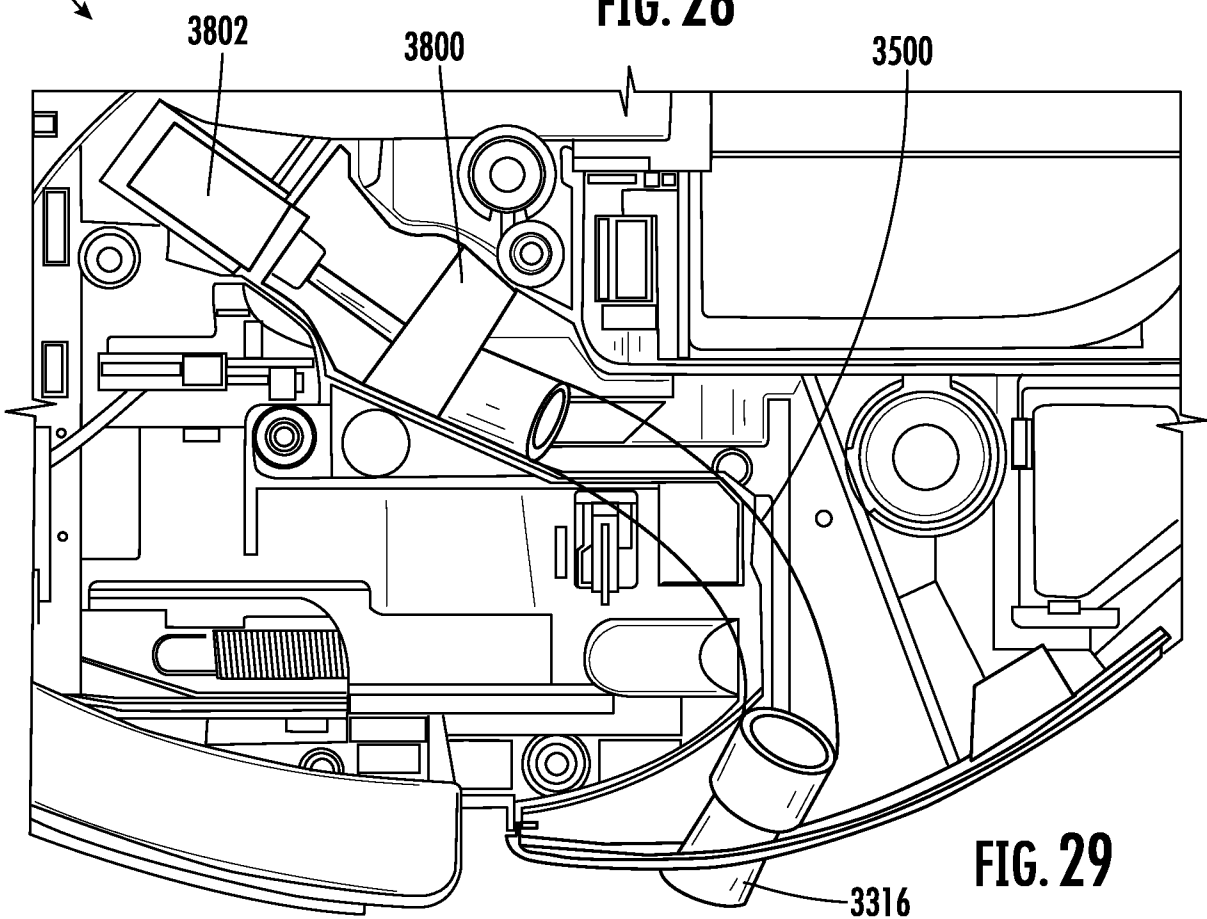


FIG. 29

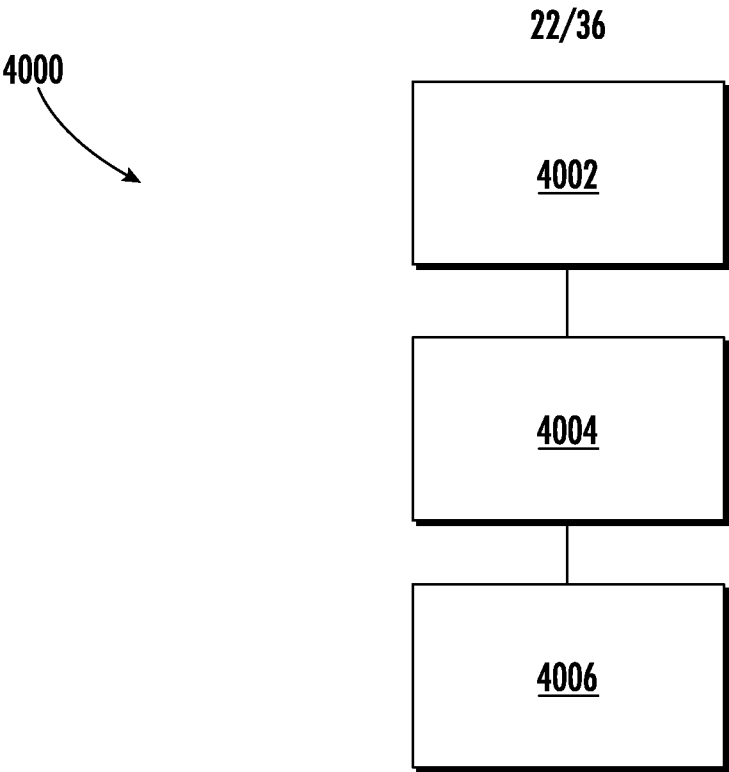


FIG. 30

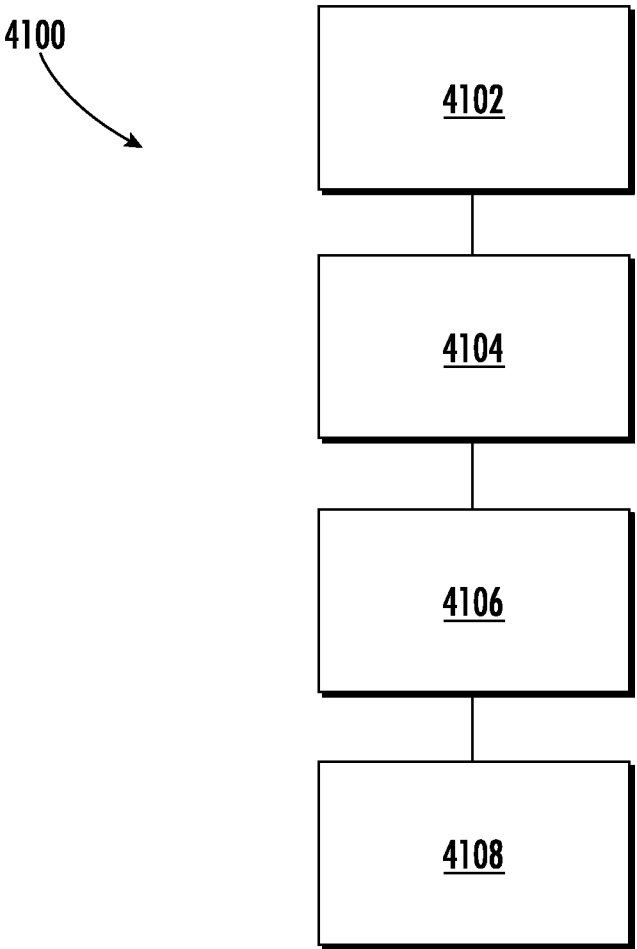


FIG. 31

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4200

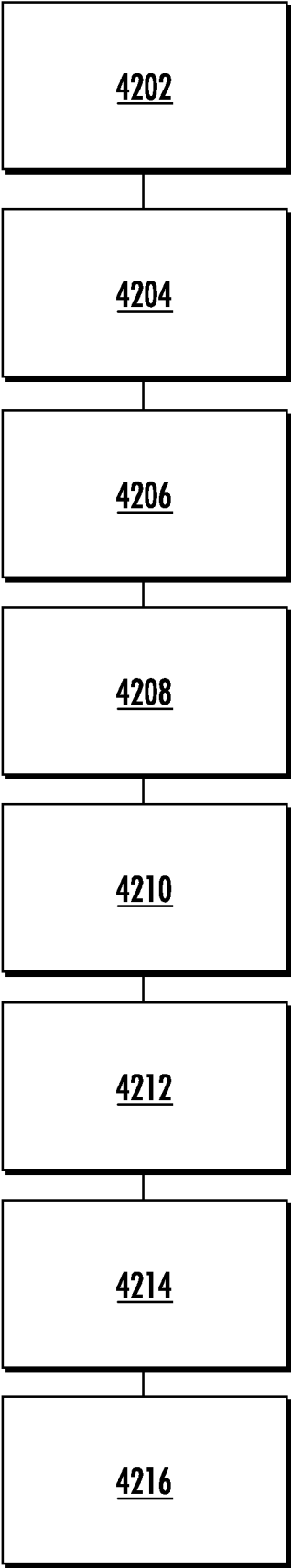


FIG. 32

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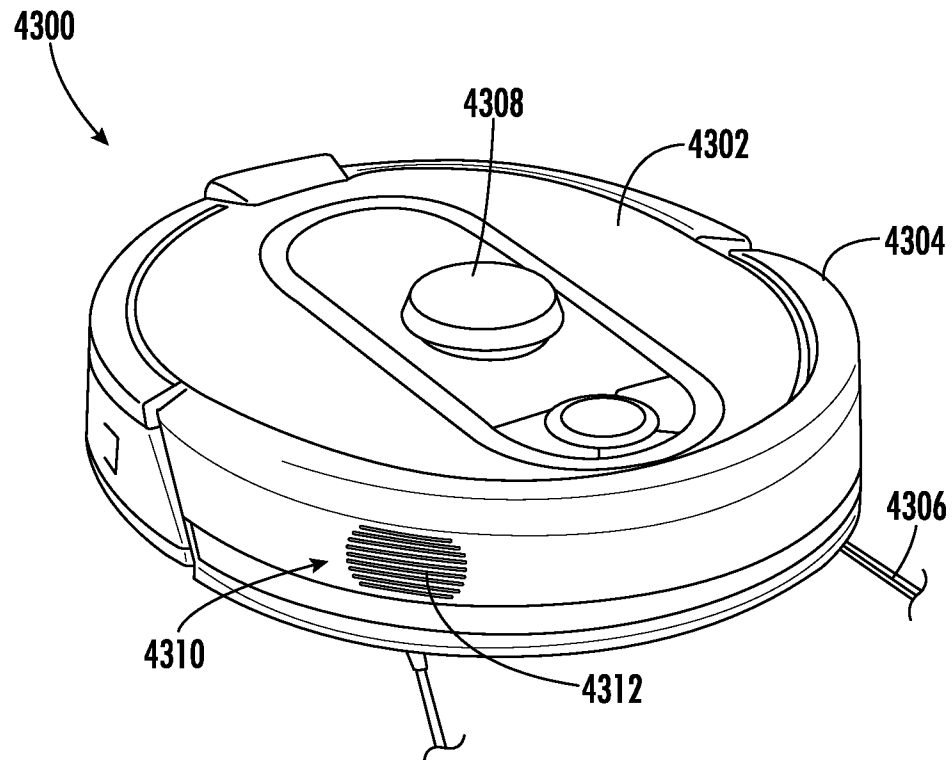


FIG. 33

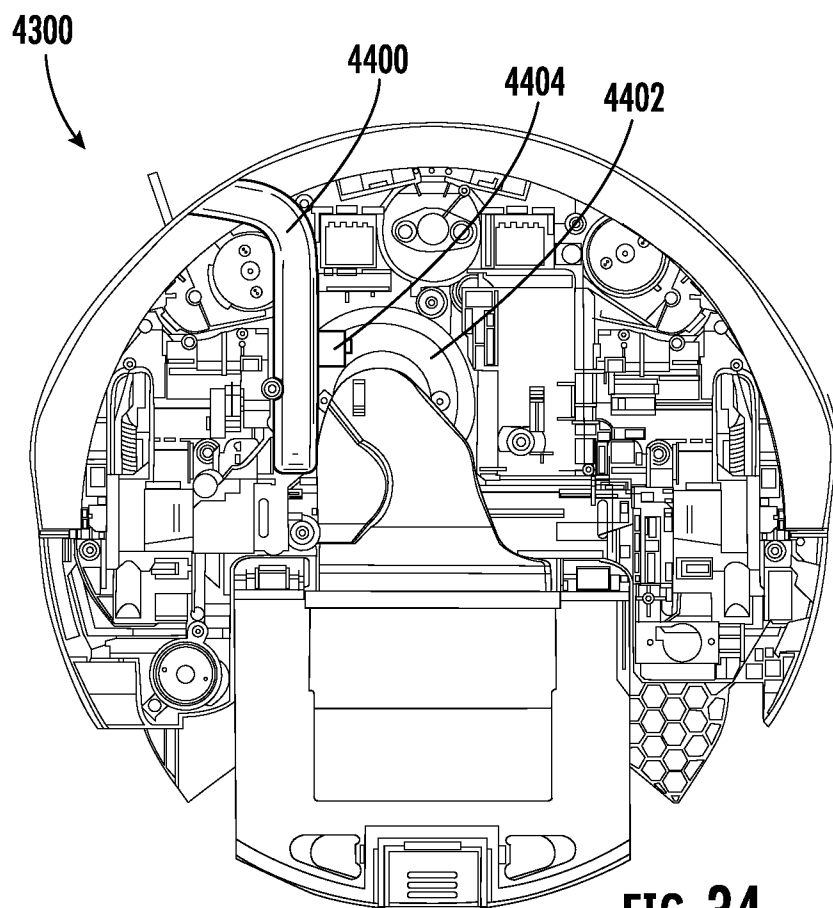


FIG. 34

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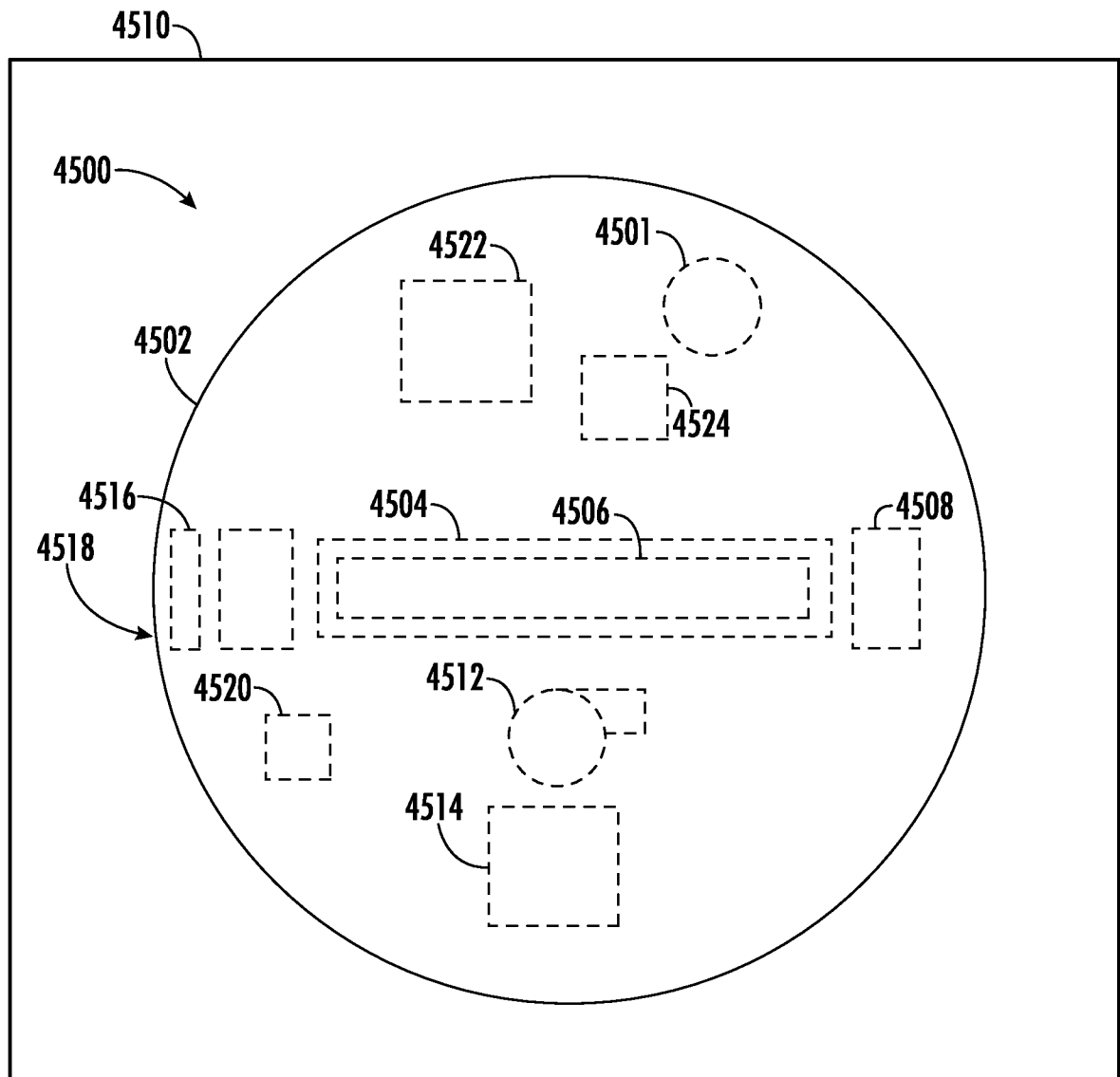


FIG. 35

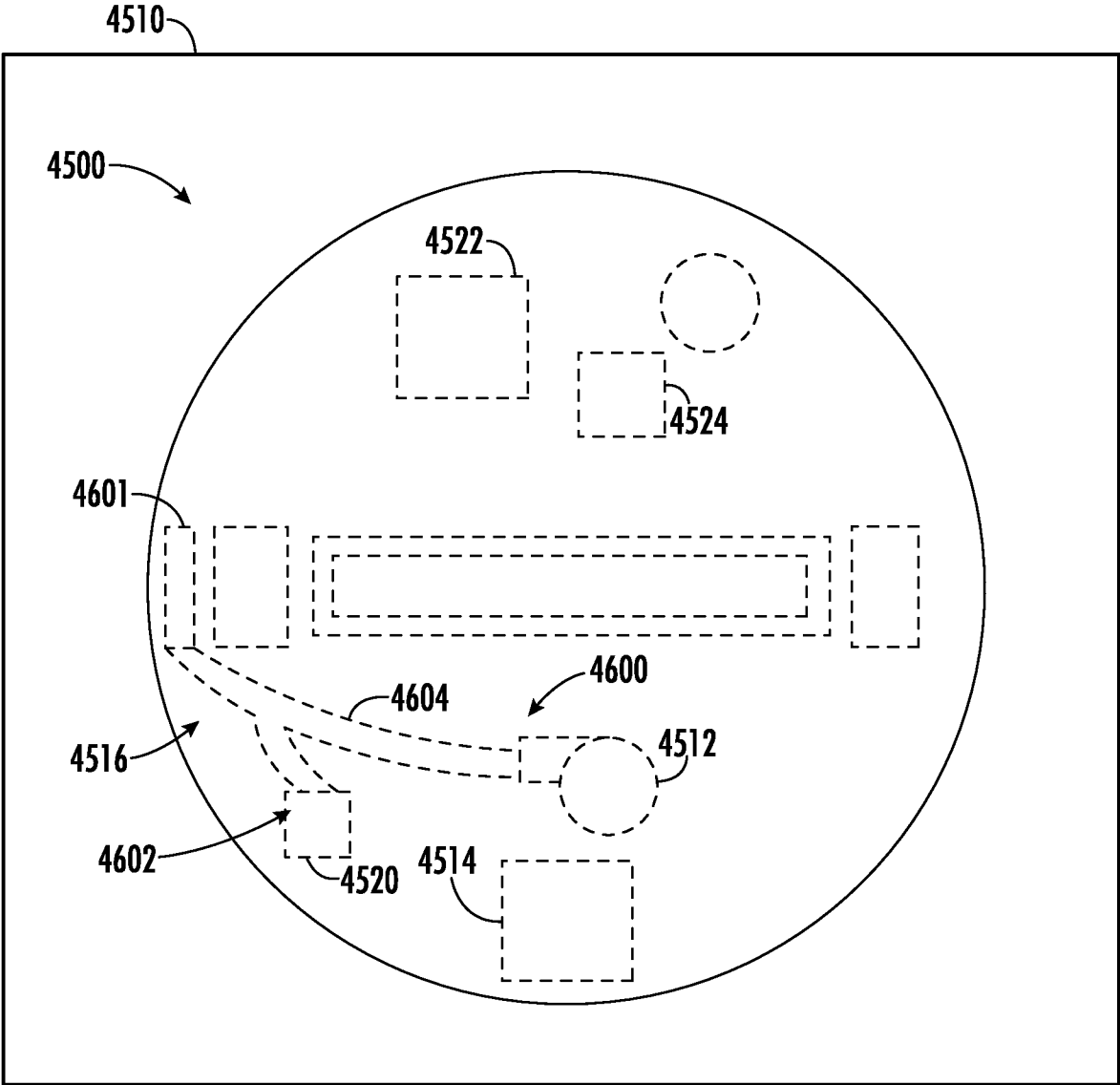


FIG. 36

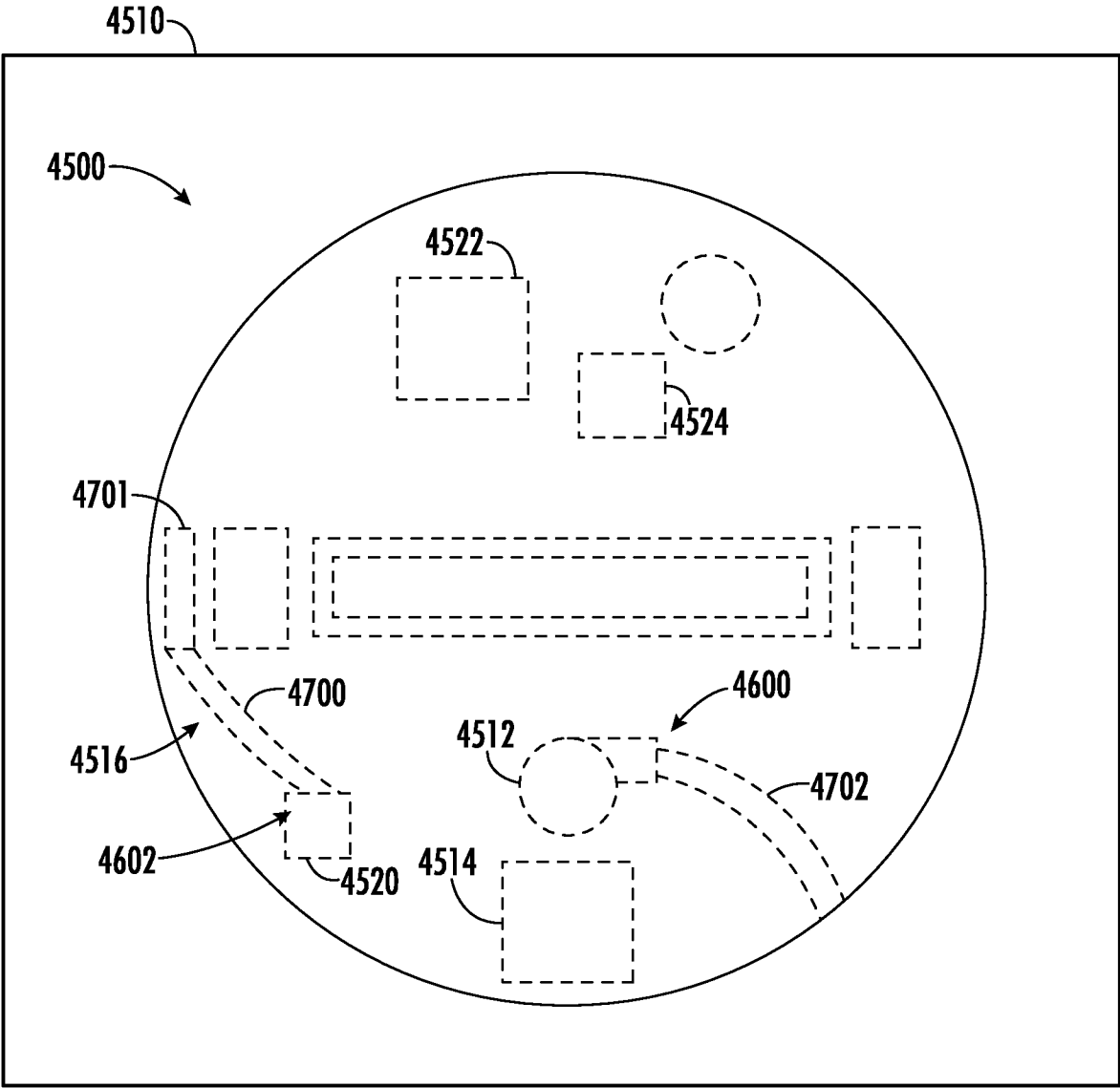


FIG. 37

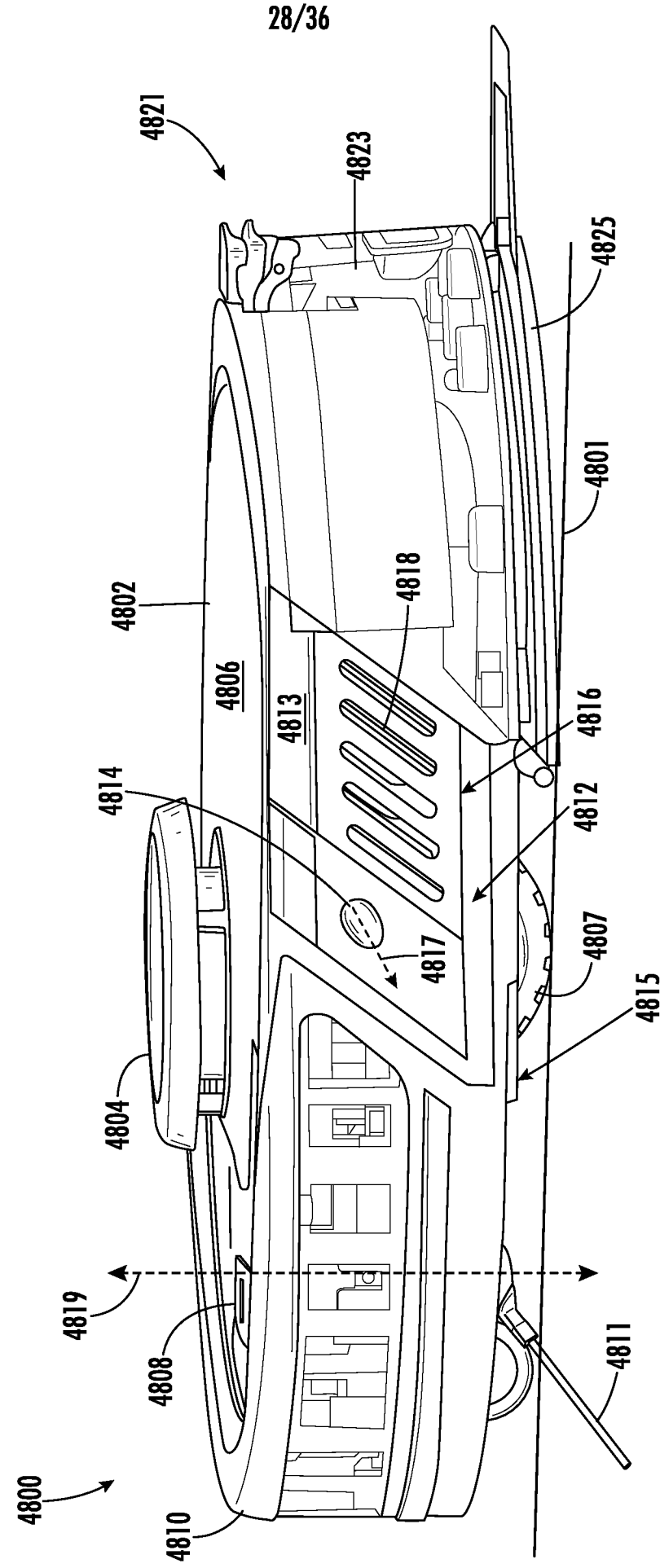


FIG. 38A

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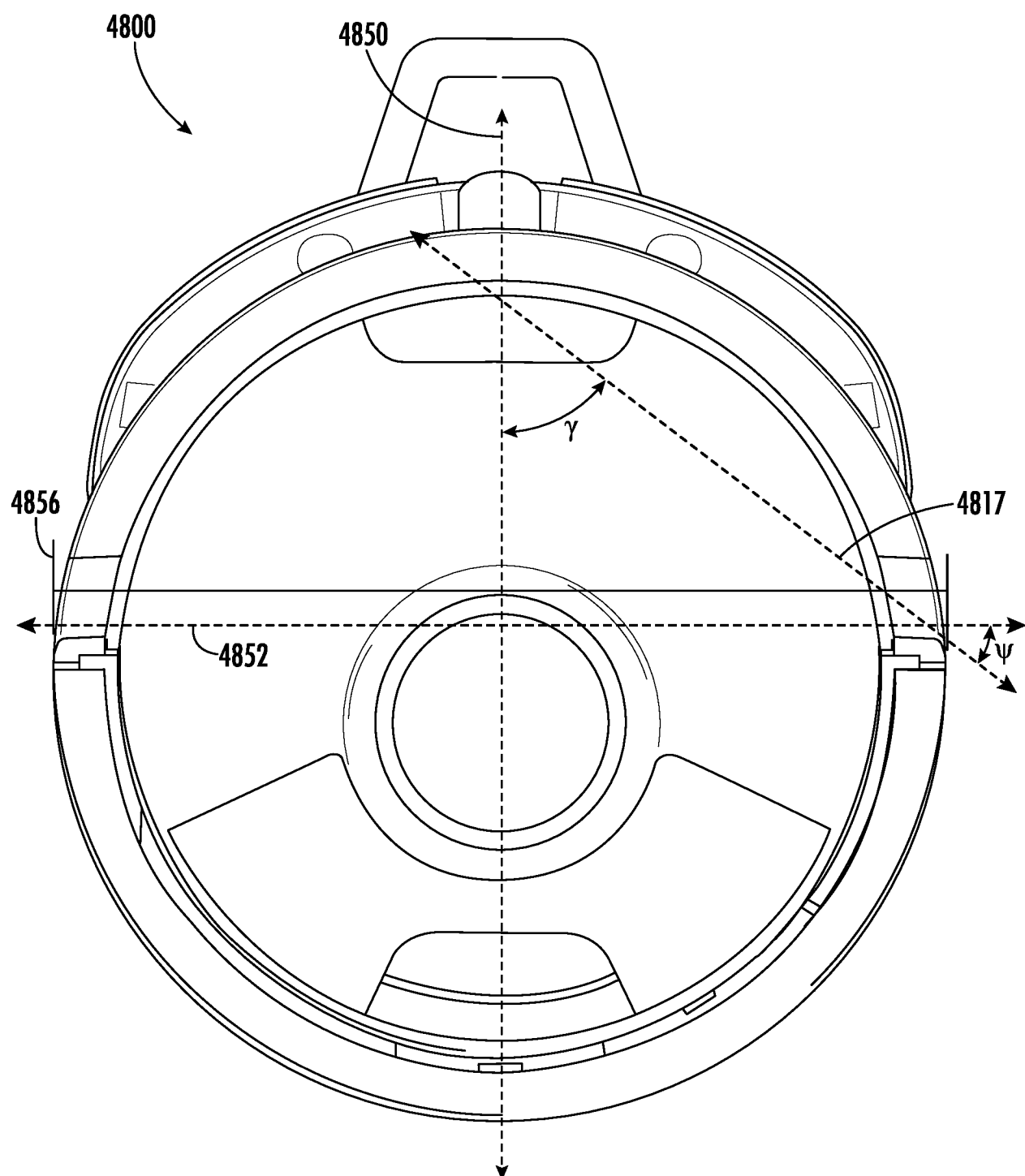


FIG. 38B

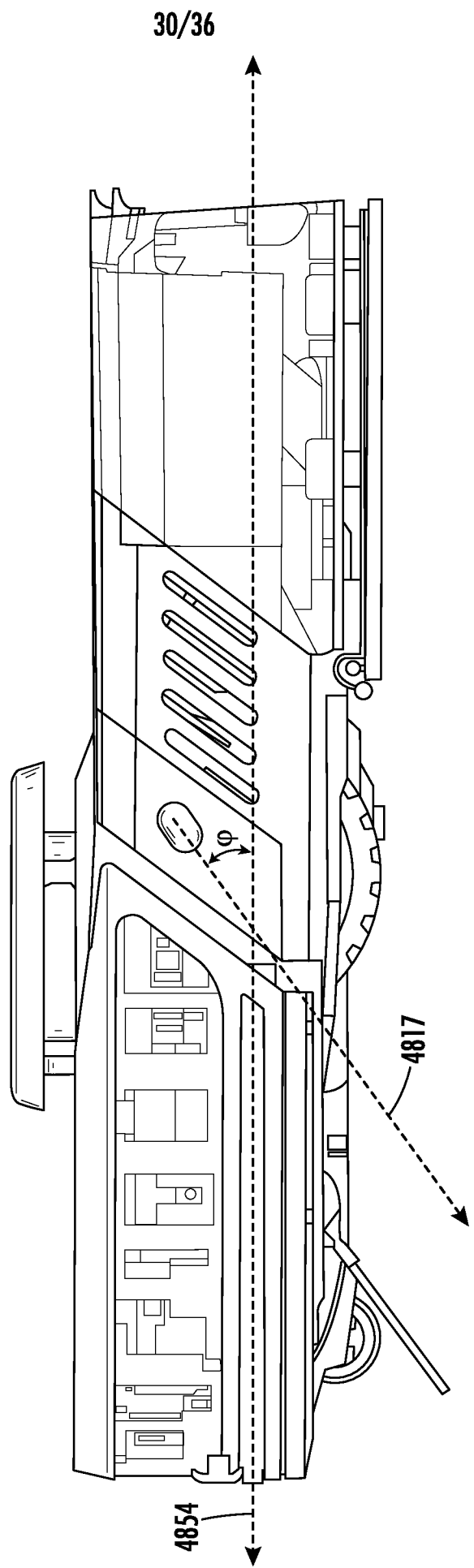


FIG. 38C

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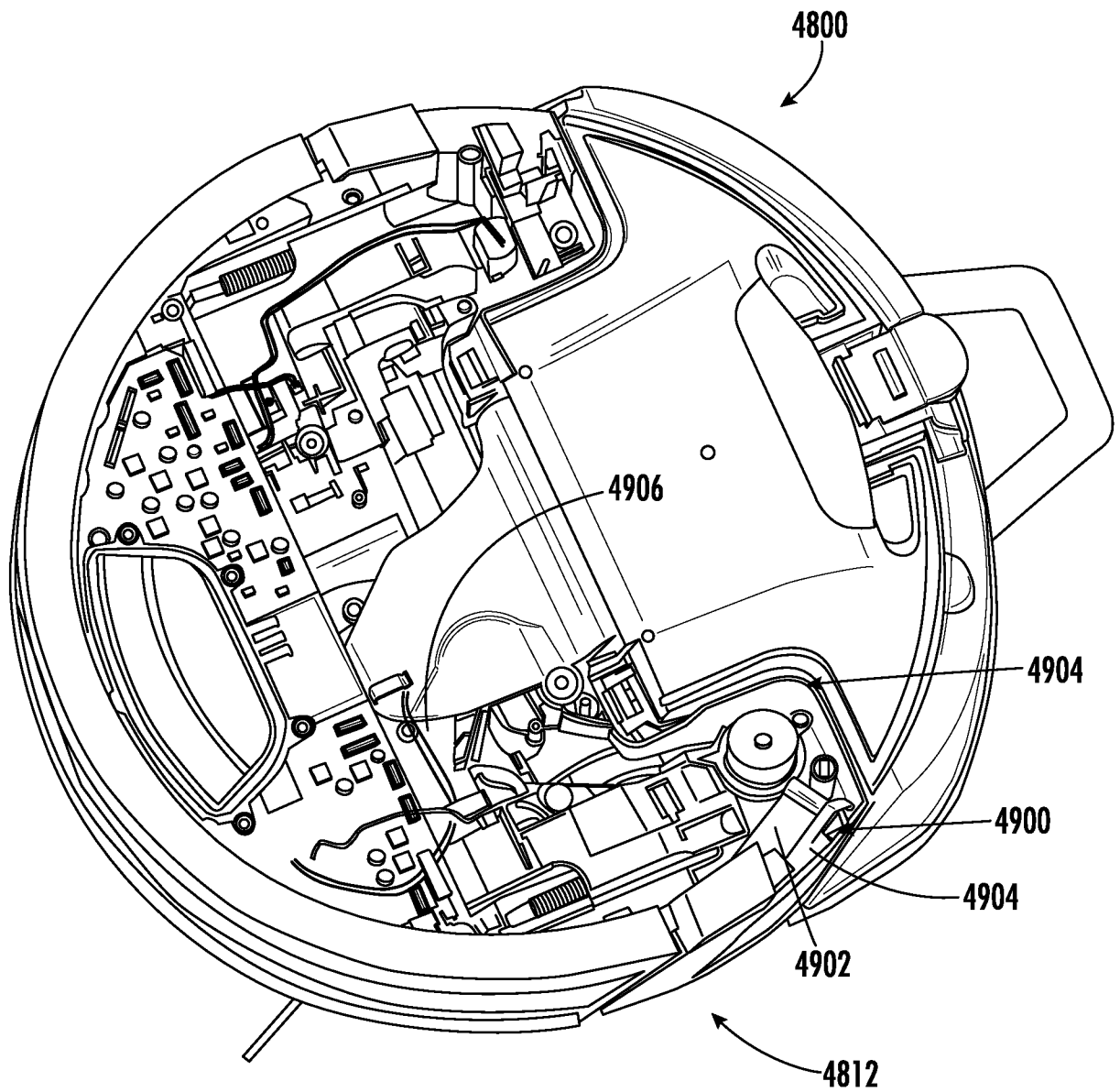


FIG. 39

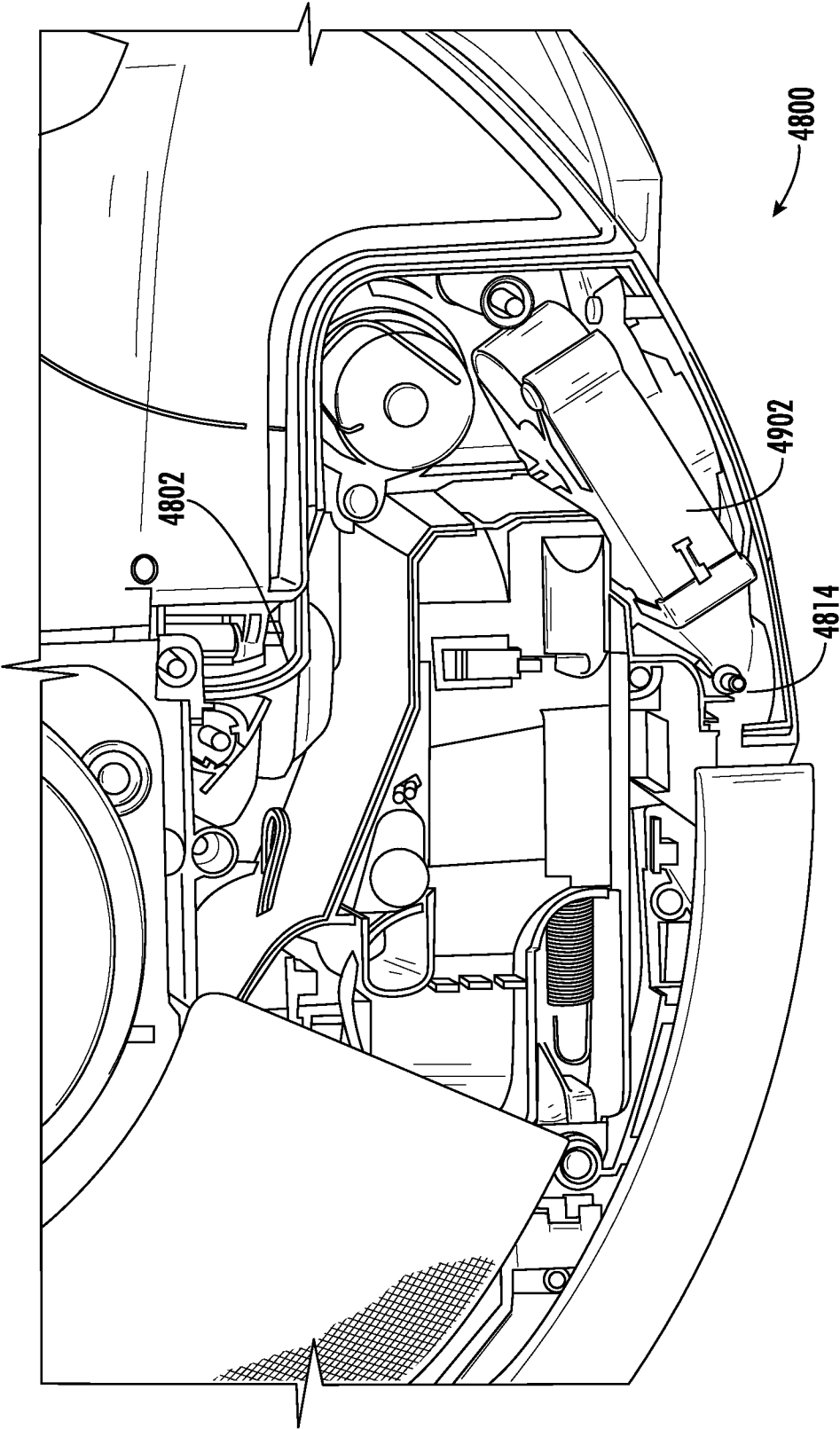


FIG. 40

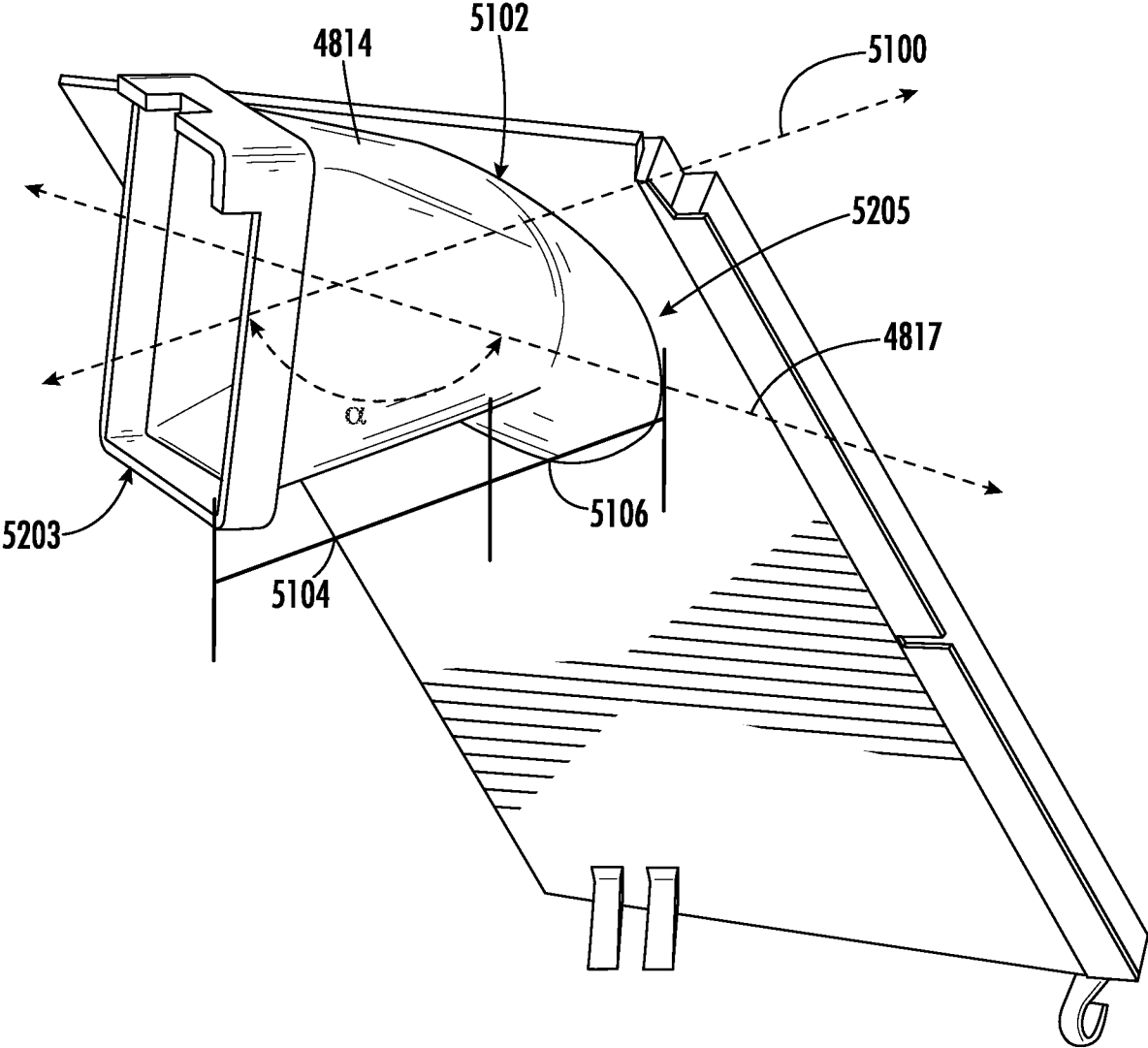


FIG. 41

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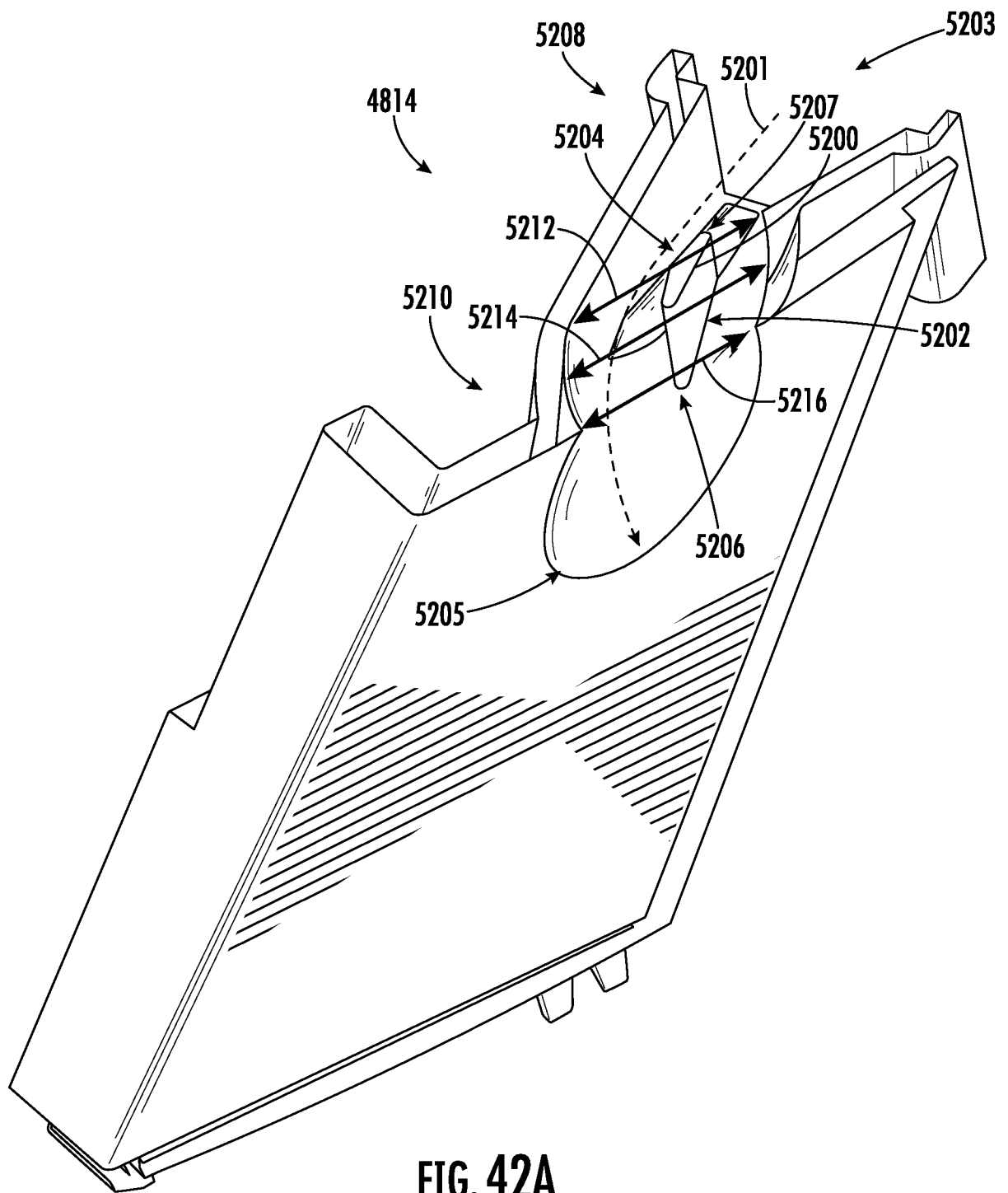


FIG. 42A

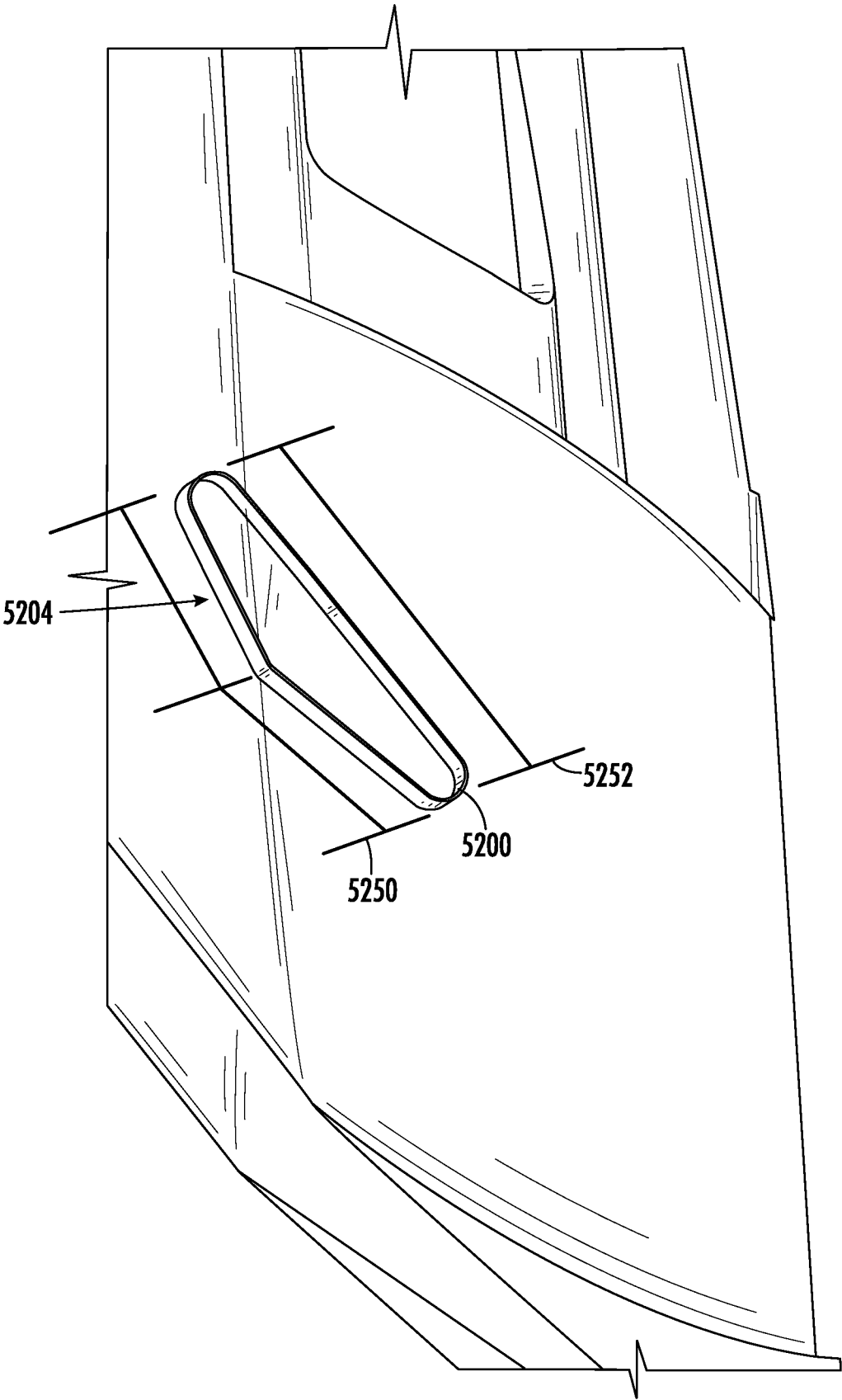


FIG. 42B

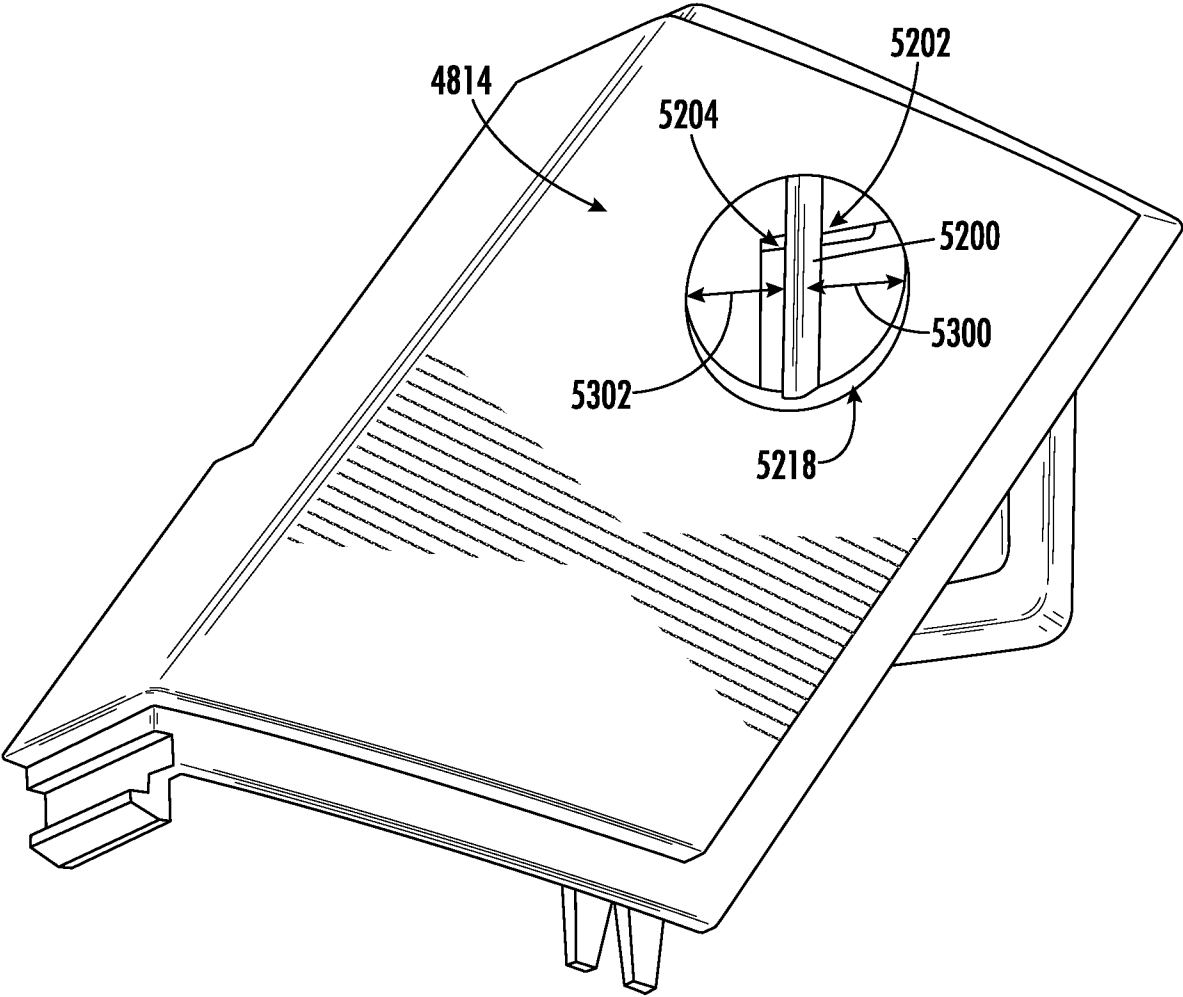


FIG. 43

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/18301

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. A47L 5/14, A47L 9/08 (2023.01)

ADD. A47L 9/02, A47L 11/24, A47L 5/22 (2023.01)

CPC - INV. A47L 5/14, A47L 9/08

ADD. A47L 9/02, A47L 11/24, A47L 5/22, A47L 9/068

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

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

See Search History document

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020/0383547 A1 (SHARKNINJA OPERATING, LLC) 10 December 2020 (10.12.2020), entire document, especially Fig. 1A, 1B, 2A, 3, 32A, 32B, 33A, 33B; para[0091]; para[0181]; para[0180]; para[0103]; para[0093];	1-2, 8, 10, 15
X --- Y	JP 0889448 A (NIPPON YUSOKI CO LTD) 09 April 1996 (09.04.1994), entire document, especially Fig. 1, 2, 3; para[0014]; para[0017]; para[0018]; para[0022];	1, 4-7, 15, 17-20 ----- 11-13
X --- Y	US 2021/0038032 A1 (SHARKNINJA OPERATING LLC) 11 February 2021 (11.02.2021), entire document, especially Fig. 8, 17A, 17B; para[0071]; para[0072]; para[0054]; para[0073]; para[0074]; para[0034]; para[0088];	1, 8-9, 15-16 ----- 3, 8, 11-14
X --- Y	JP 2007029488 A (MATSUSHITA ELECTRIC IND CO LTD) 08 February 2007 (08.02.2007), entire document, especially Fig. 2, 3, 4; para[0017]; para[0018]; para[0021];	1 ----- 3, 8, 14
A	WO 2016/038918 A1 (SHARP KABUSHIKI KAISHA) 17 March 2016 (17.03.2016), entire document	1-20
A	US 2019/0167052 A1 (Samsung Electronics Co., Ltd.) 06 June 2019 (06.06.2019), entire document	1-20
A	US 2003/0192144 A1 (Song et al.) 16 October 2003 (16.10.2003), entire document	1-20
A	US 2010/0088840 A1 (Kim et al.) 15 April 2010 (15.04.2010), entire document	1-20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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"D" document cited by the applicant in the international application

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

07 June 2023 (07.06.2023)

Date of mailing of the international search report

JUN 30 2023

Name and mailing address of the ISA/US

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Authorized officer

Kari Rodriguez

Telephone No. PCT Helpdesk: 571-272-4300