US012390071B2

(12) United States Patent
Amaral et al.

(10) **Patent No.: US 12,390,071 B2**
(45) **Date of Patent: Aug. 19, 2025**

(54) **EVACUATION STATION WITH DEBRIS SEPARATION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 323 days.

(21) Appl. No.: **18/076,718**

(22) Filed: **Dec. 7, 2022**

(65) **Prior Publication Data**

US 2024/0188780 A1 Jun. 13, 2024

(51) **Int. Cl.**
A47L 9/28 (2006.01)
A47L 9/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A47L 9/2873*** (2013.01); ***A47L 9/0063*** (2013.01); *A47L 2201/024* (2013.01)

(58) **Field of Classification Search**
CPC ... A47L 9/10; A47L 9/106; A47L 9/14; A47L 9/149; A47L 9/1683; A47L 9/2873; A47L 9/0063; A47L 2201/00; A47L 2201/02; A47L 2201/024
See application file for complete search history.

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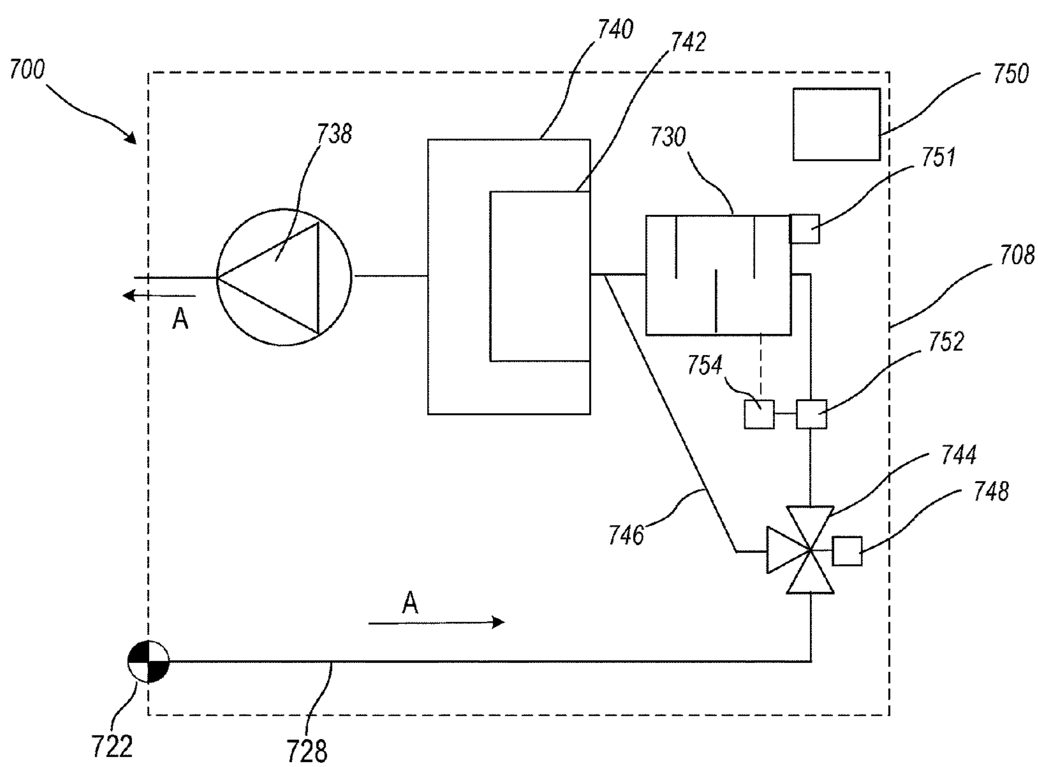
(57) **ABSTRACT**

A docking station for a mobile cleaning robot can include a base configured to receive at least a portion of the mobile cleaning robot thereon, where the base can include a debris port. The docking station can include a canister connected to the base and located at least partially above the base. The canister can include a debris bin to receive debris from the mobile cleaning robot. The canister can include a debris duct connected to the debris port and to the debris bin. The canister can include a debris collector connected to the debris duct upstream of the debris bin, where the debris collector can collect debris from a debris airstream of the debris duct.

18 Claims, 13 Drawing Sheets



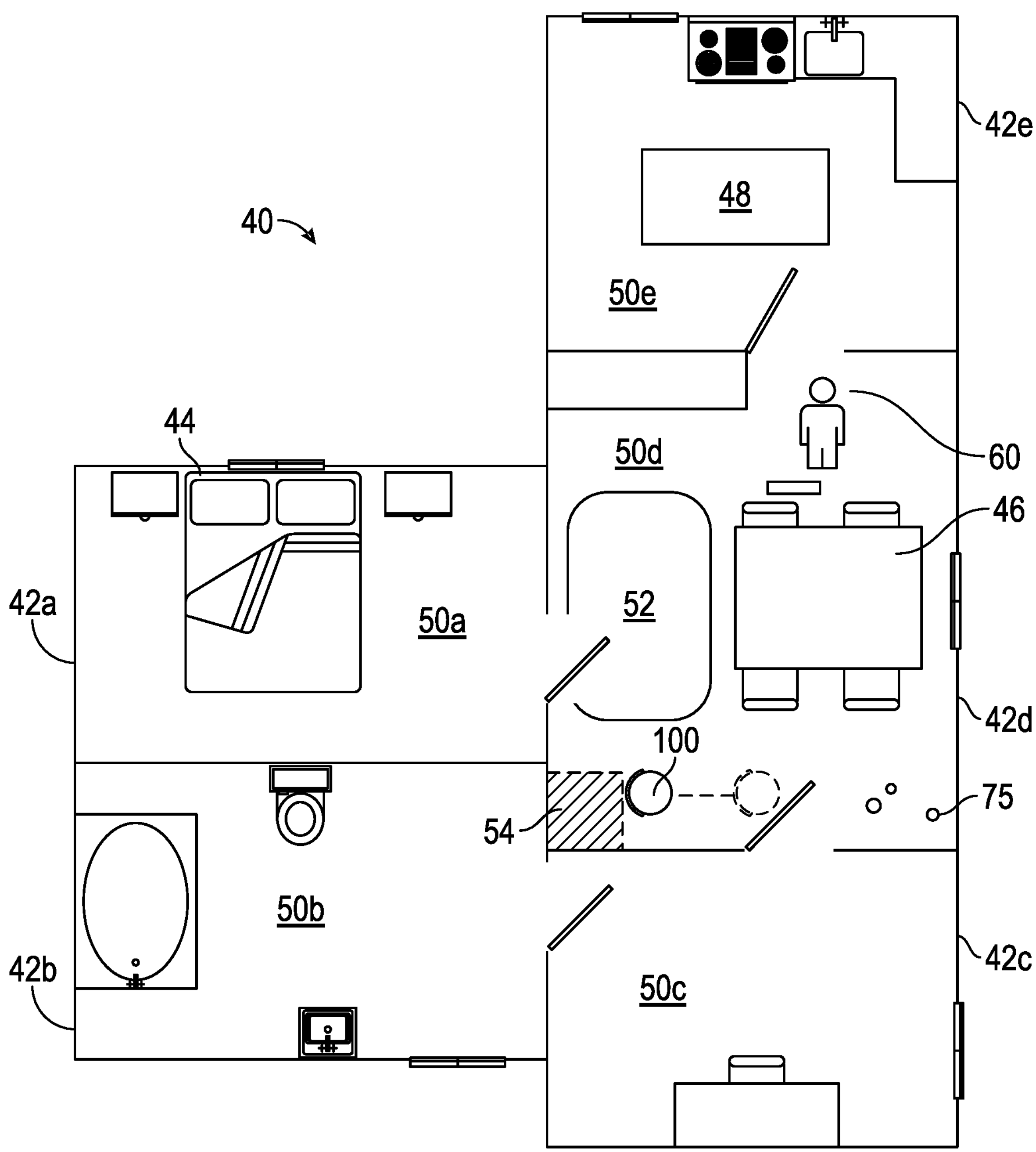


FIG. 1

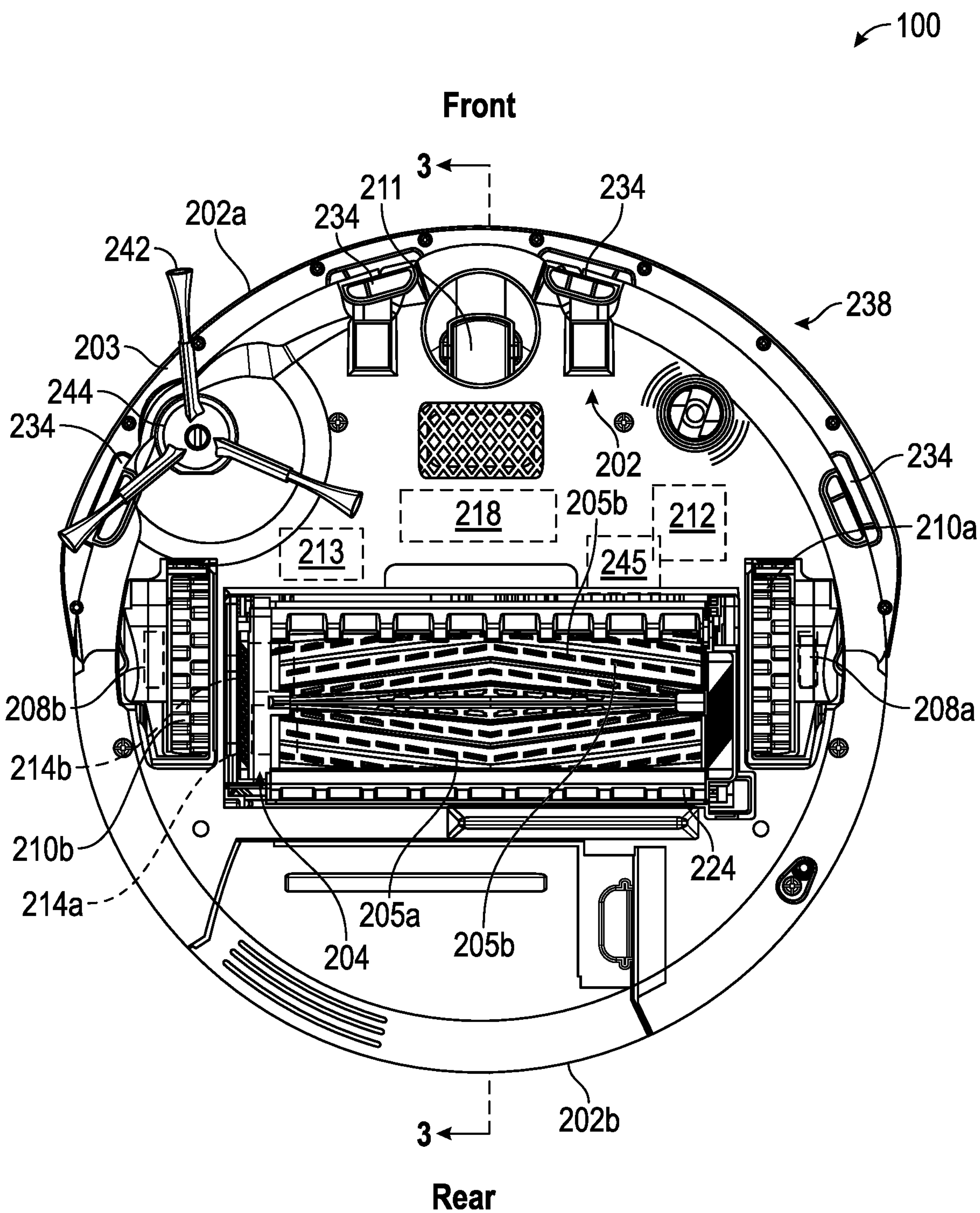

100
Front
3
211
234
234
202a
242
238
203
244
234
202
234
218
205b
212
210a
213
245
208b
208a
214b
210b
224
214a
205a
204
205b
202b
3
Rear

FIG. 2A

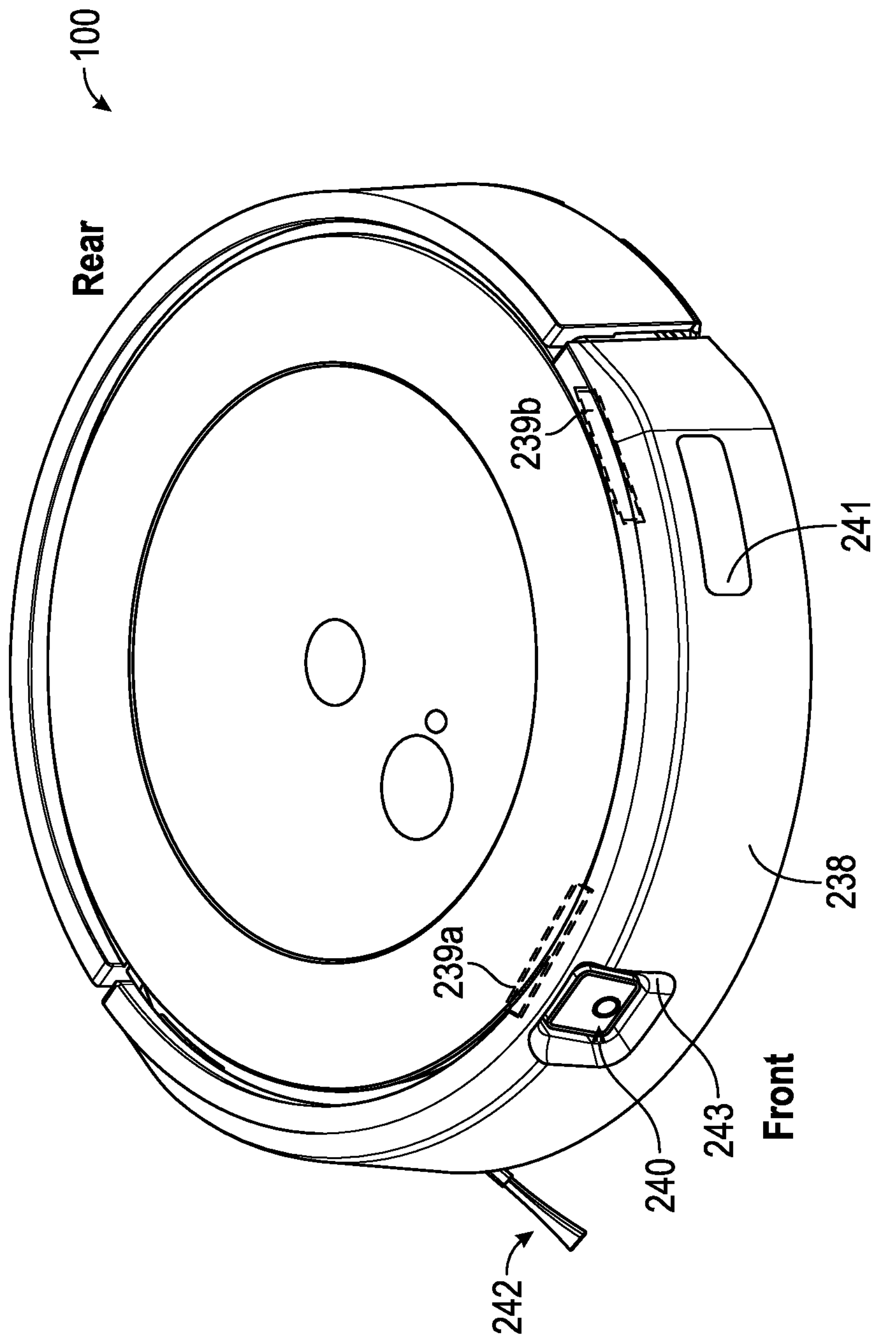


FIG. 2B

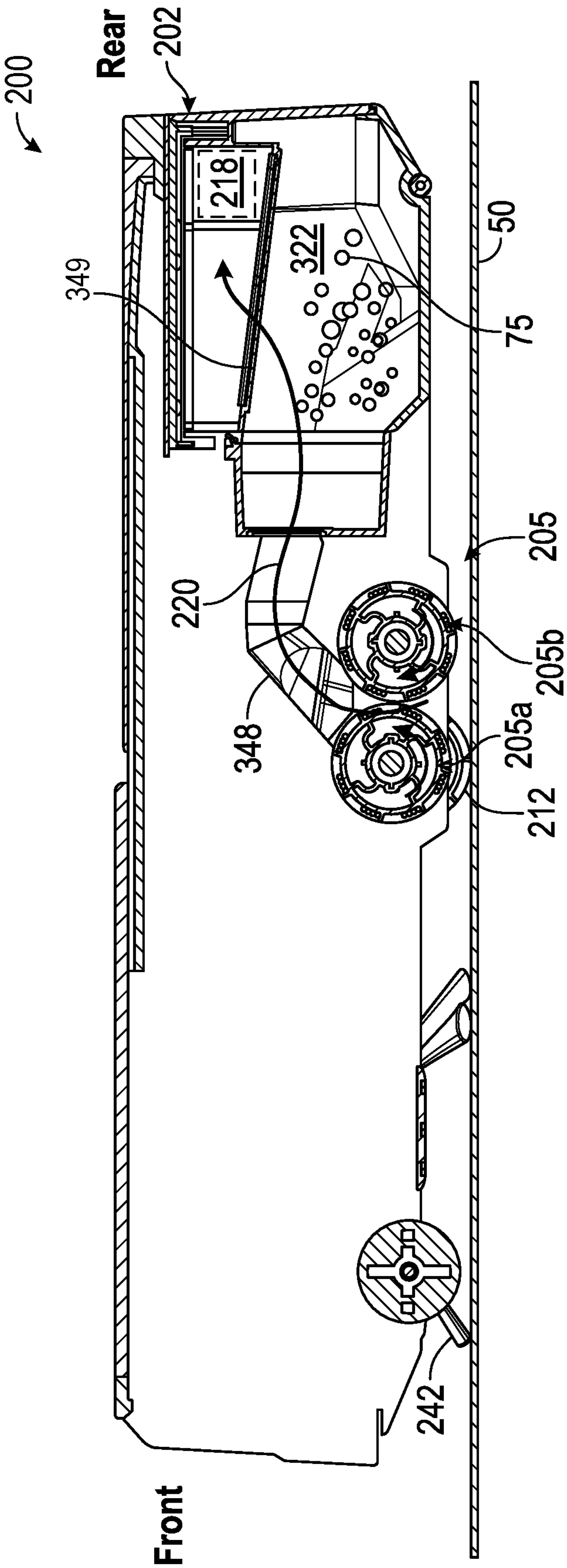

200
Rear
202
218
349
322
75
50
205
220
205b
348
205a
212
242
Front

FIG. 3

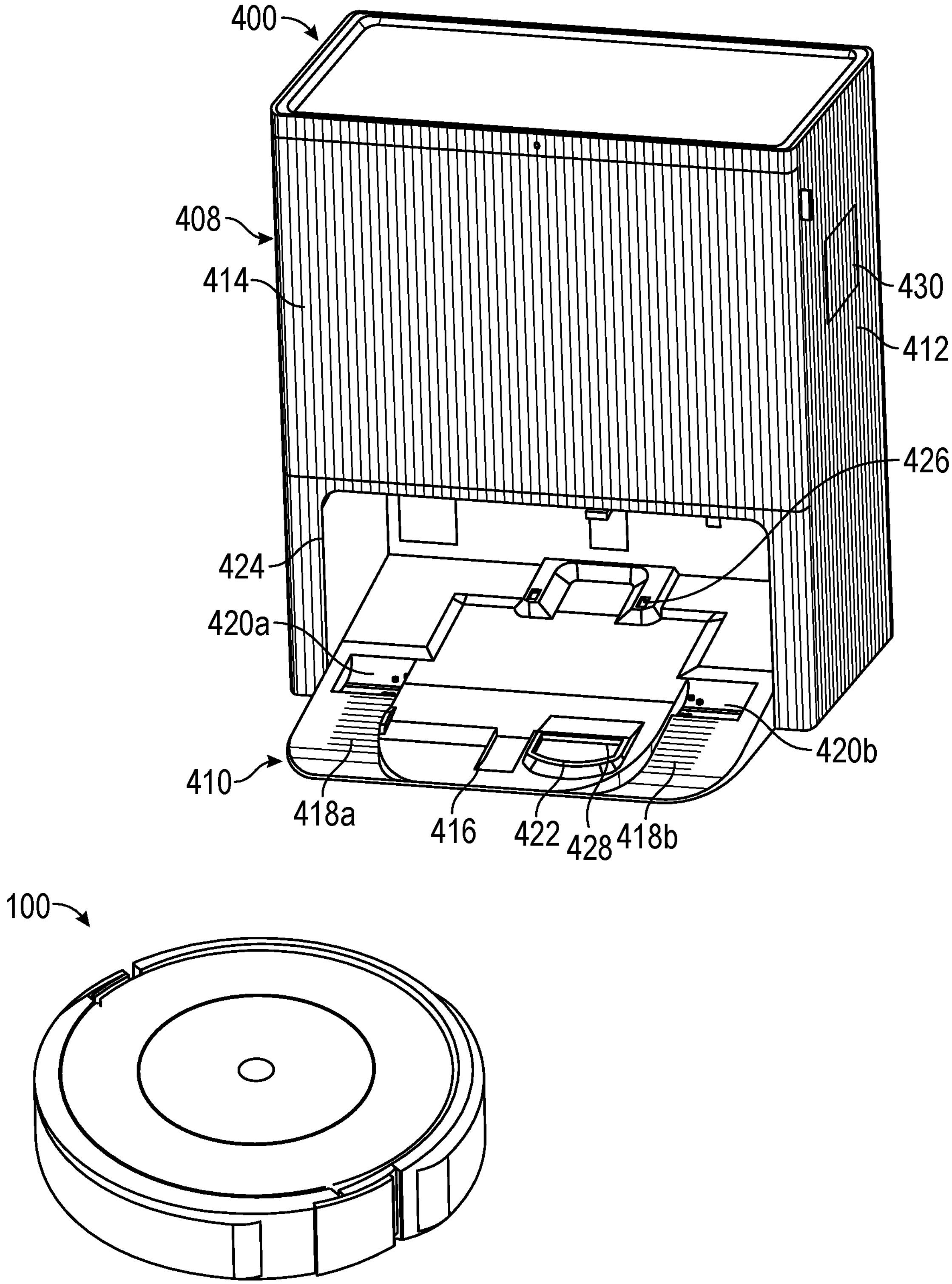

400
408
414
430
412
426
424
420a
420b
410
418a
416
422
428
418b
100

FIG. 4

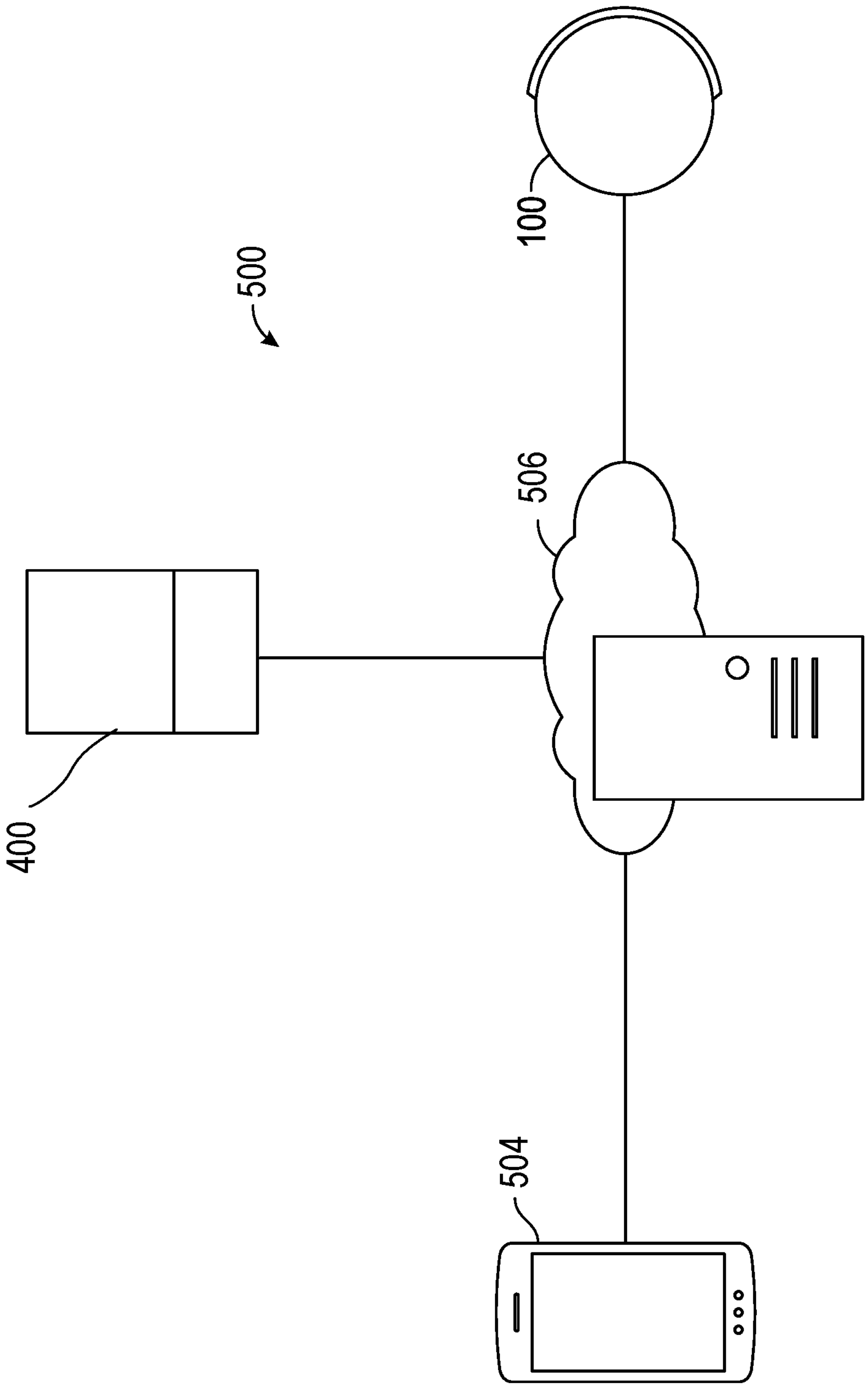


FIG. 5

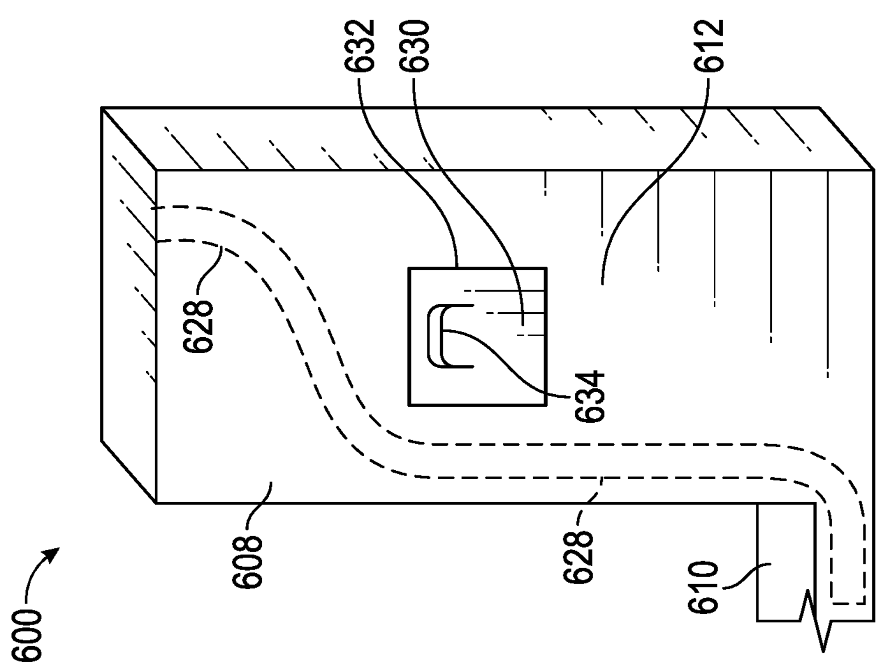


FIG. 6A

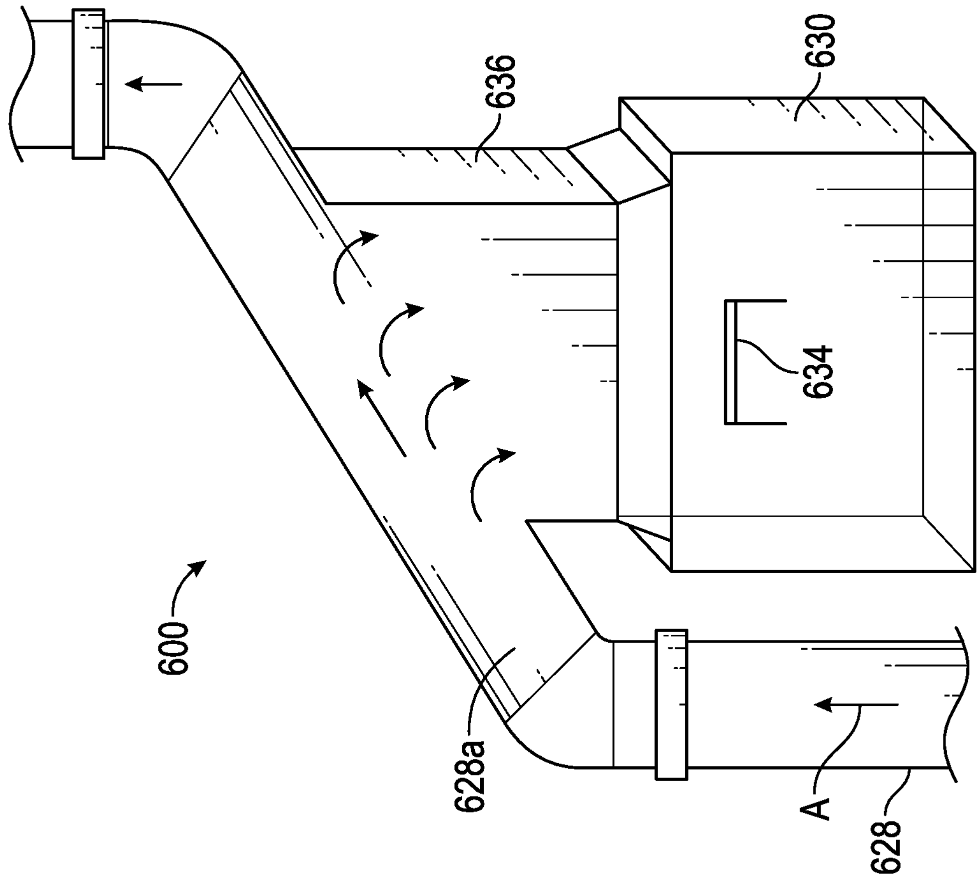


FIG. 6B

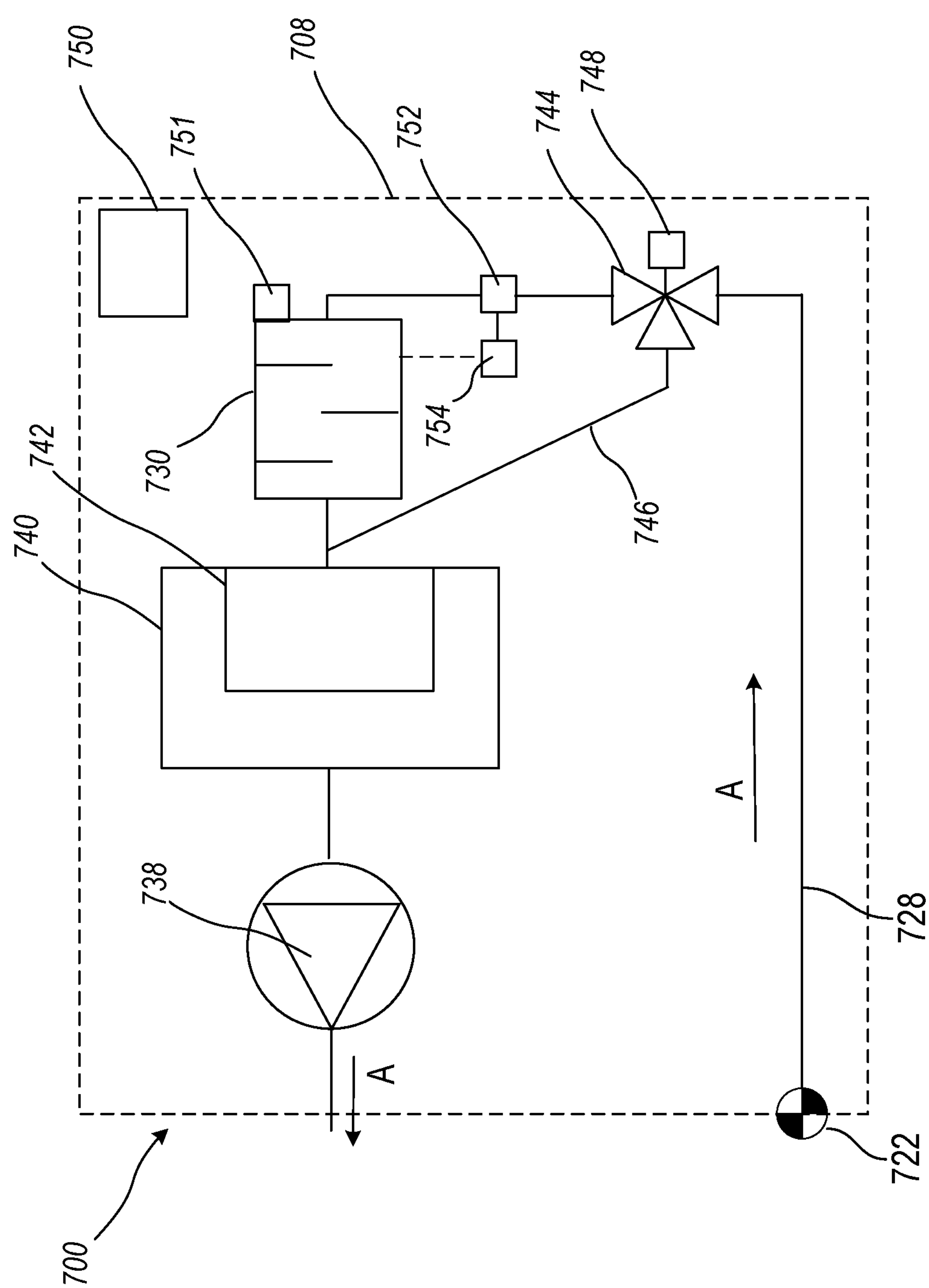


FIG. 7

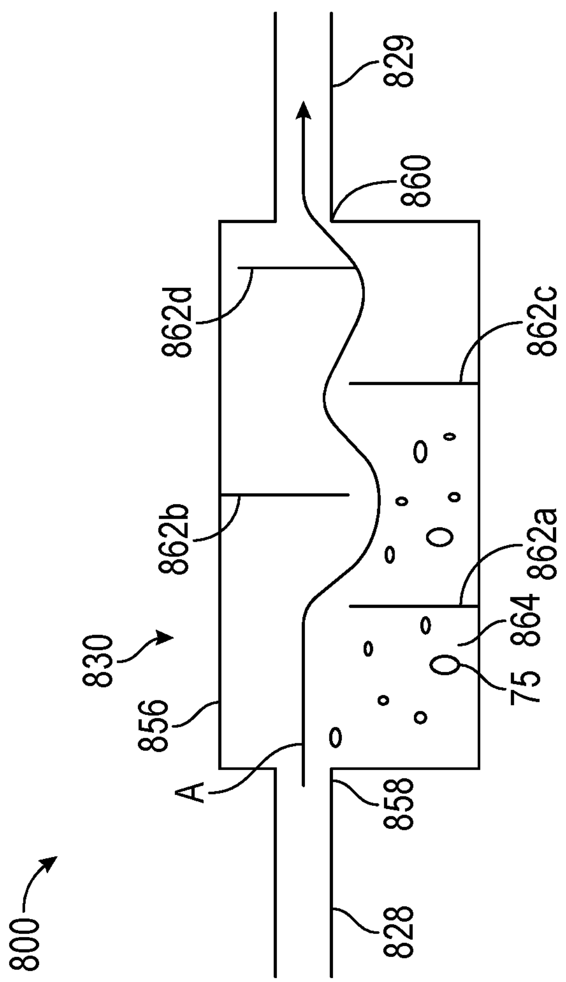


FIG. 8

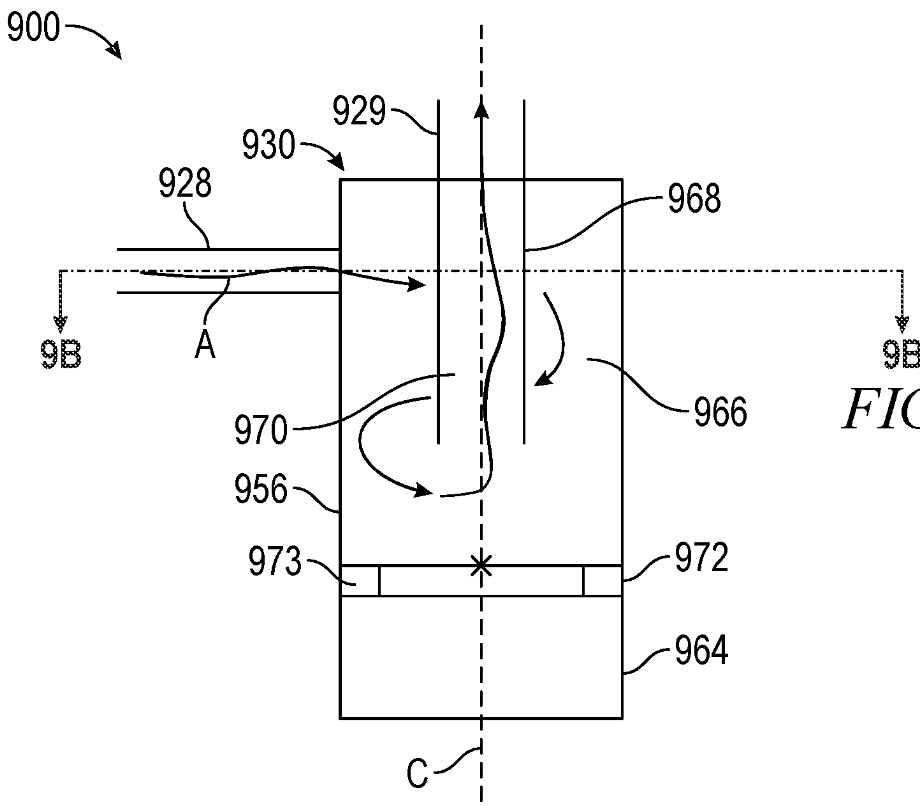

900
929
930
928
968
9B
A
9B
970
966
956
973
972
964
C

FIG. 9A

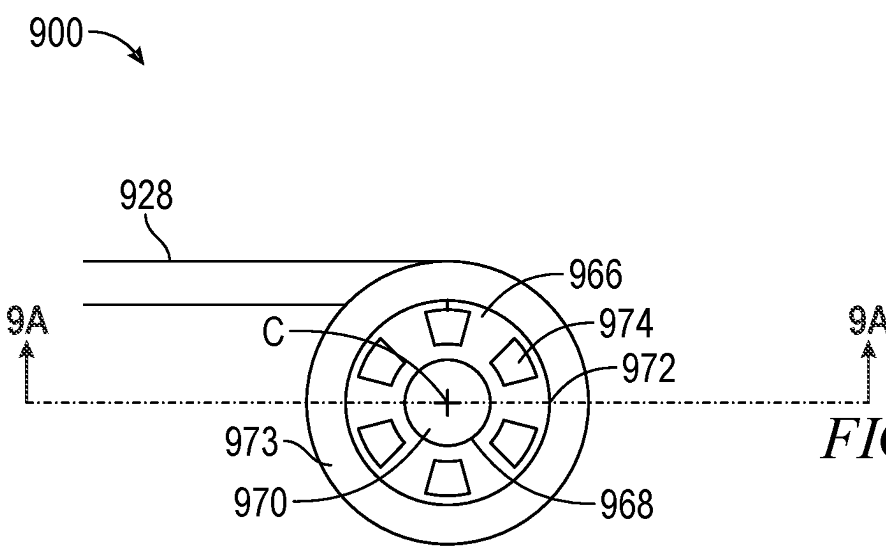

900
928
966
9A
974
9A
C
972
973
970
968

FIG. 9B

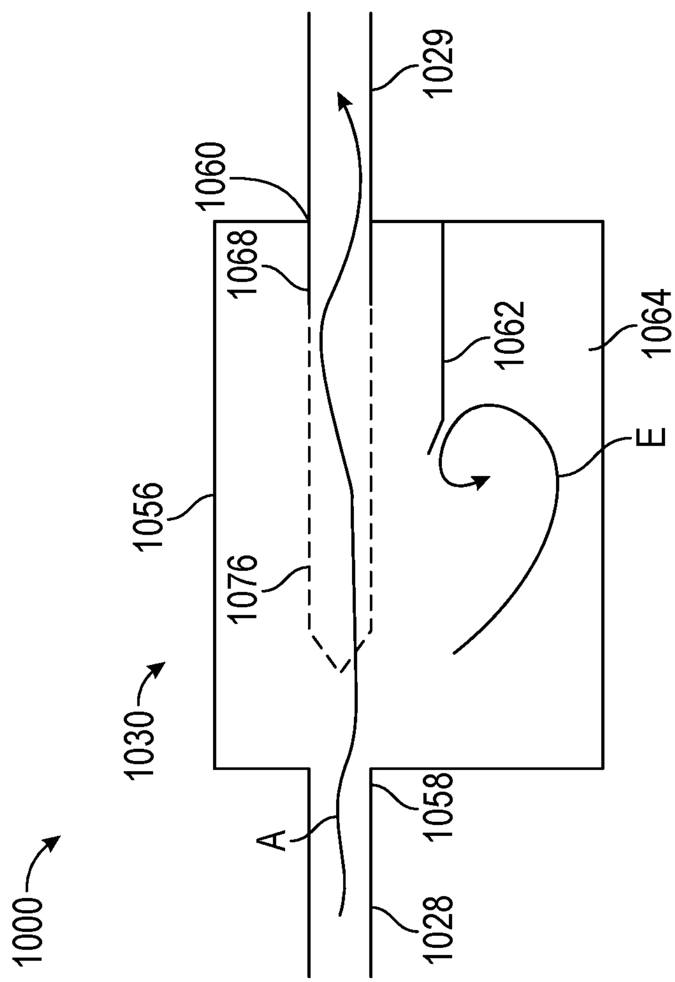


FIG. 10

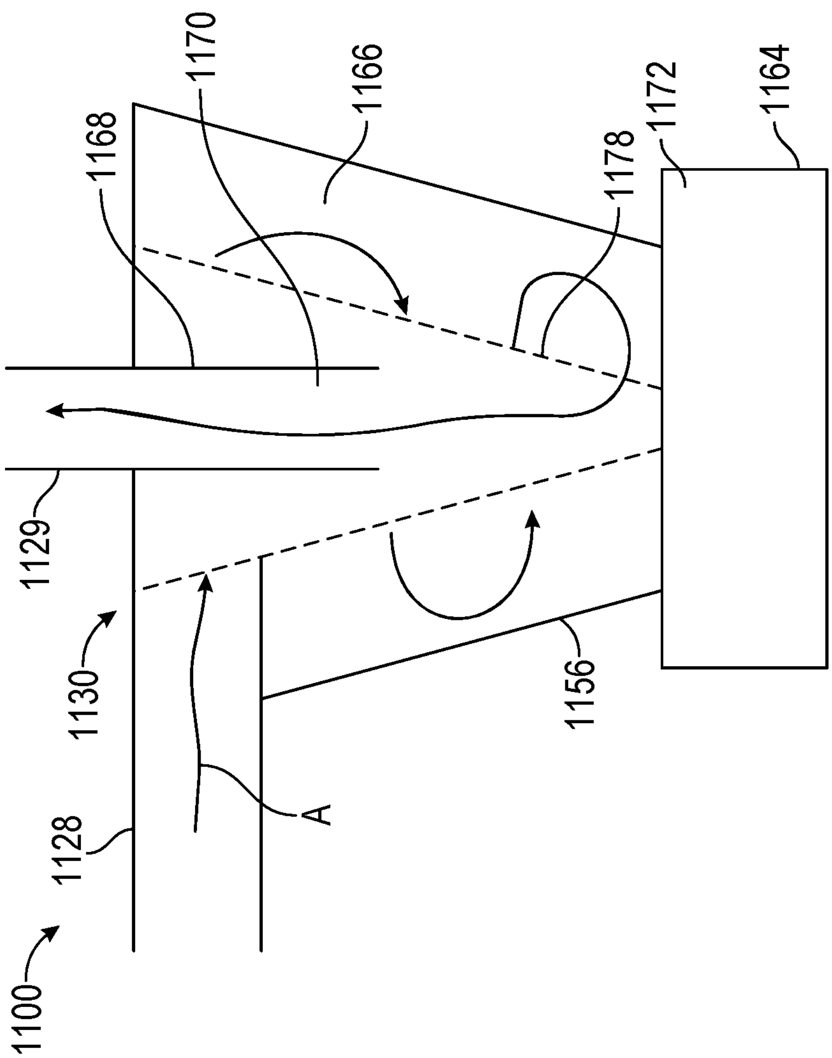


FIG. 11

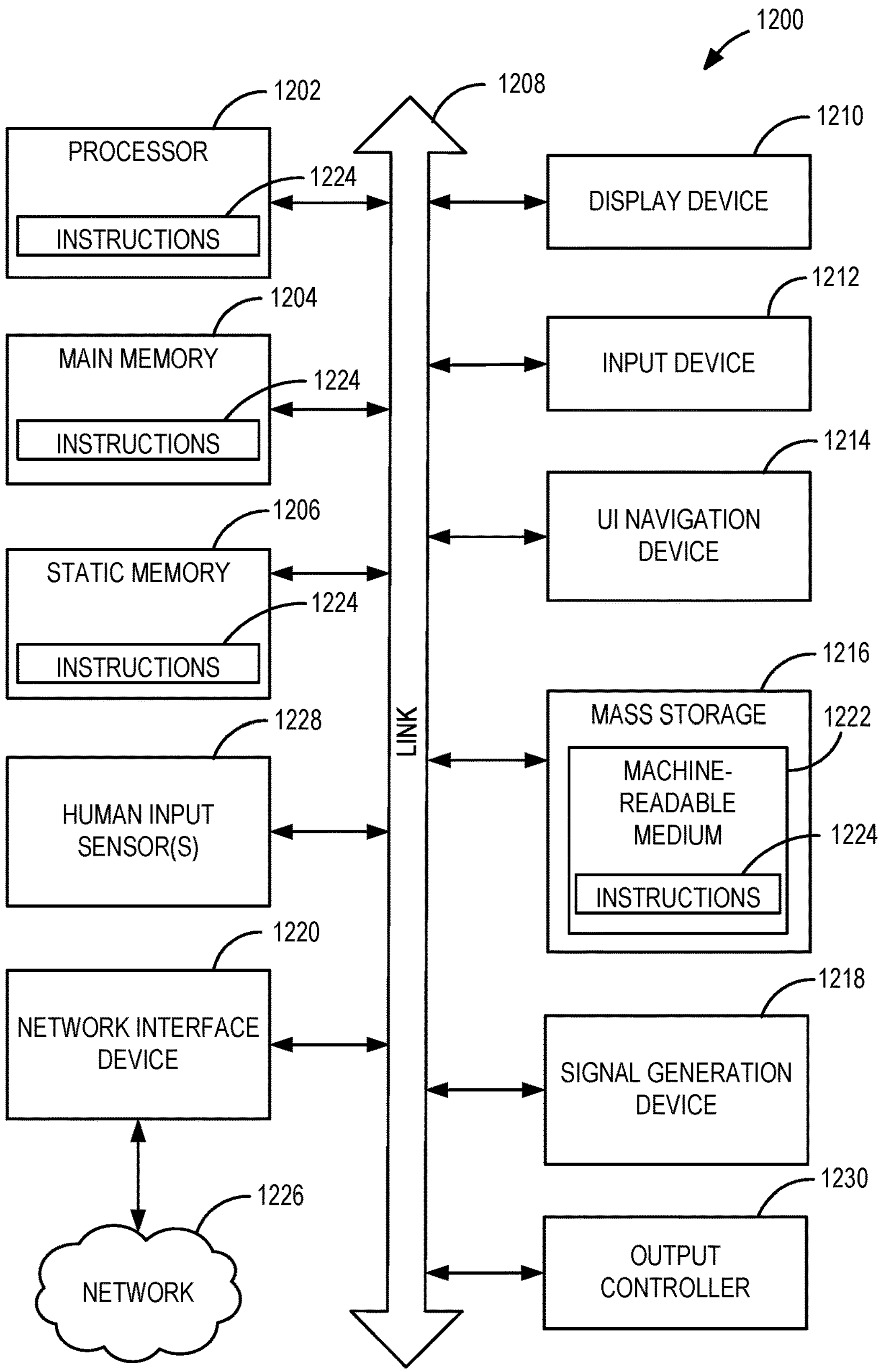

1200
1202
PROCESSOR
INSTRUCTIONS
1224
1204
MAIN MEMORY
INSTRUCTIONS
1224
1206
STATIC MEMORY
INSTRUCTIONS
1224
1228
HUMAN INPUT SENSOR(S)
1220
NETWORK INTERFACE DEVICE
1226
NETWORK
1208
LINK
1210
DISPLAY DEVICE
1212
INPUT DEVICE
1214
UI NAVIGATION DEVICE
1216
MASS STORAGE
1222
MACHINE-READABLE MEDIUM
1224
INSTRUCTIONS
1218
SIGNAL GENERATION DEVICE
1230
OUTPUT CONTROLLER

FIG. 12

EVACUATION STATION WITH DEBRIS SEPARATION

BACKGROUND

Autonomous mobile robots include autonomous mobile cleaning robots that can autonomously perform cleaning tasks within an environment, such as a home. Many kinds of cleaning robots are autonomous to some degree and in different ways. Some robots can interface with a docking station automatically. The docking station can perform maintenance on the robot such as charging of batteries of the robot and evacuation of debris from a debris bin of the robot.

SUMMARY

Mobile cleaning robots can include a variety of components that require maintenance or interaction between missions or during missions. For example, vacuuming robots that extract debris from an environment may need to empty their debris bins during missions or between missions. However, because of autonomous vacuuming, mobile cleaning robots may ingest items that are not desired to be ingested, such as children's toys, screws, office supplies, or jewelry.

This disclosure helps to support these operations by including a docking station that includes features for separation of large or heavy debris. The docking station can be configured to automatically evacuate debris from the mobile cleaning robot during (or following vacuuming operations). During evacuation, the docking station can collect relatively large or heavy items in a debris collector that can be viewed or accessed by a user, such as for removal of non-debris items that were ingested by the robot (and later evacuated). In this way, the docking station can help users avoid disposing of non-debris items that were ingested by the mobile cleaning robot.

For example, a docking station for a mobile cleaning robot can include a base configured to receive at least a portion of the mobile cleaning robot thereon, where the base can include a debris port. The docking station can include a canister connected to the base and located at least partially above the base. The canister can include a debris bin to receive debris from the mobile cleaning robot. The canister can include a debris duct connected to the debris port and to the debris bin. The canister can include a debris collector connected to the debris duct upstream of the debris bin, where the debris collector can collect debris from a debris airstream of the debris duct.

The above discussion is intended to provide an overview of subject matter of the present patent application. It is not intended to provide an exclusive or exhaustive explanation of the invention. The description below is included to provide further information about the present patent application.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The drawings illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

FIG. **1** illustrates a plan view of a mobile cleaning robot in an environment.

FIG. **2**A illustrates a bottom view of a mobile cleaning robot.

FIG. **2**B illustrates an isometric view of a mobile cleaning robot.

FIG. **3** illustrates a cross-section view across indicators **3-3** of FIG. **2**A of a mobile cleaning robot.

FIG. **4** illustrates an isometric view of a docking station and a mobile cleaning robot.

FIG. **5** illustrates a diagram illustrating an example of a communication network in which a mobile cleaning robot operates and data transmission in the network.

FIG. **6**A illustrates a side view of a docking station for a mobile cleaning robot.

FIG. **6**B illustrates a schematic view of a portion of a docking station for a mobile cleaning robot.

FIG. **7** illustrates a schematic view of a portion docking station for a mobile cleaning robot.

FIG. **8** illustrates a side cross-sectional view of a portion of a docking station for a mobile cleaning robot.

FIG. **9**A illustrates a side cross-sectional view of a portion of a docking station for a mobile cleaning robot.

FIG. **9**B illustrates a top cross-sectional view of a portion of a docking station for a mobile cleaning robot.

FIG. **10** illustrates a side cross-sectional view of a portion of a docking station for a mobile cleaning robot.

FIG. **11** illustrates a side cross-sectional view of a portion of a docking station for a mobile cleaning robot.

FIG. **12** illustrates a block diagram illustrating an example of a machine upon which one or more embodiments may be implemented.

DETAILED DESCRIPTION

FIG. **1** illustrates a plan view of a mobile cleaning robot **100** in an environment **40**, in accordance with at least one example of this disclosure. The environment **40** can be a dwelling, such as a home or an apartment, and can include rooms **42***a*-**42***e*. Obstacles, such as a bed **44**, a table **46**, and an island **48** can be located in one or more of the rooms **42** of the environment. Each of the rooms **42***a*-**42***e* can have a floor surface **50***a*-**50***e*, respectively. Some rooms, such as the room **42***d*, can include a rug, such as a rug **52**. The floor surfaces **50** can be of one or more types of flooring, such as hardwood, ceramic, low-pile carpet, medium-pile carpet, long (or high)-pile carpet, stone, or the like.

The mobile cleaning robot **100** can be operated, such as by a user **60**, to autonomously clean the environment **40** in a room-by-room fashion. In some examples, the robot **100** can clean the floor surface **50***a* of one room, such as the room **42***a*, before moving to the next room, such as the room **42***d*, to clean the surface of the room **42***d*. Different rooms can have different types of floor surfaces. For example, the room **42***e* (which can be a kitchen) can have a hard floor surface, such as wood or ceramic tile, and the room **42***a* (which can be a bedroom) can have a carpet surface, such as a medium pile carpet. Other rooms, such as the room **42***d* (which can be a dining room) can include multiple surfaces where the rug **52** is located within the room **42***d*.

During cleaning or traveling operations, the robot **100** can use data collected from various sensors and calculations (such as odometry and obstacle detection) to develop a map of the environment **40**. Once the map is created, the user **60** can define rooms or zones (such as the rooms **42**) within the map. The map can be presentable to the user **60** on a user interface, such as a mobile device, where the user **60** can direct or change cleaning preferences.

During operation, the robot **100** can detect surface types within each of the rooms **42**, which can be stored in the robot or another device. The robot **100** can update the map (or data related thereto) such as to include or account for surface types of the floor surfaces **50***a*-**50***e* of each of the respective rooms **42** of the environment. In some examples, the map can be updated to show the different surface types such as within each of the rooms **42**.

In some examples, the user **60** can define a behavior control zone **54** using, for example, the methods and systems described herein. In response to the user **60** defining the behavior control zone **54**, the robot **100** can move toward the behavior control zone **54** to confirm the selection. After confirmation, autonomous operation of the robot **100** can be initiated. In autonomous operation, the robot **100** can initiate a behavior in response to being in or near the behavior control zone **54**. For example, the user **60** can define an area of the environment **40** that is prone to becoming dirty to be the behavior control zone **54**. In response, the robot **100** can initiate a focused cleaning behavior in which the robot **100** performs a focused cleaning of a portion of the floor surface **50***d* in the behavior control zone **54**.

Components of the Robot

FIG. **2**A illustrates a bottom view of the mobile cleaning robot **100**. FIG. **2**B illustrates a bottom view of the mobile cleaning robot **100**. FIG. **3** illustrates a cross-section view across indicators **3**-**3** of FIG. **2**A of the mobile cleaning robot **100**. FIG. **3** also shows orientation indicators Front and Rear. FIGS. **2A**-**3** are discussed together below.

The cleaning robot **100** can be an autonomous cleaning robot that can autonomously traverse the floor surface **50** while ingesting the debris **75** from different parts of the floor surface **50**. As shown in FIGS. **2**A and **3**, the robot **100** can include a body **202** movable across the floor surface **50**. The body **202** can include multiple connected structures to which movable components of the cleaning robot **100** are mounted. The connected structures can include, for example, an outer housing to cover internal components of the cleaning robot **100**, a chassis or frame to which the drive wheels **210***a* and **210***b* and the cleaning rollers **205***a* and **205***b* (of a cleaning assembly **204**) are mounted, and a bumper **238**. The bumper **238** can be removably secured to the body **202** and can be movable relative to **202** while mounted thereto. In some examples, the bumper **238** form part of the body **202**.

As shown in FIG. **2**A, the body **202** includes a front portion **202***a* that has a substantially semicircular shape and a rear portion **202***b* that has a substantially semicircular shape. These portions can have other shapes in other examples. As shown in FIG. **2**A, the robot **100** can include a drive system including actuators **208***a* and **208***b*, which can be, for example, motors. The actuators **208***a* and **208***b* can be mounted in the body **202** and can be operably connected to the drive wheels **210***a* and **210***b*, which can be rotatably mounted to the body **202** to support the body **202** above the floor surface **50**. The actuators **208***a* and **208***b*, when driven, can rotate the drive wheels **210***a* and **210***b* to enable the robot **100** to autonomously move across the floor surface **50**.

The controller (or processor) **212** can be located within the housing and can be a programmable controller, such as a single or multi-board computer, a direct digital controller (DDC), a programmable logic controller (PLC), or the like. In other examples the controller **212** can be any computing device, such as a handheld computer, for example, a smart phone, a tablet, a laptop, a desktop computer, or any other computing device including a processor, memory, and communication capabilities. The memory **213** can be one or more types of memory, such as volatile or non-volatile memory, read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. The memory **213** can be located within the body **200**, connected to the controller **212** and accessible by the controller **212**.

The controller **212** can operate the actuators **208***a* and **208***b* to autonomously navigate the robot **100** about the floor surface **50** during a cleaning operation. The actuators **208***a* and **208***b* can be operable to drive the robot **100** in a forward drive direction, in a backwards direction, or to turn the robot **100**. The robot **100** can include a caster wheel **211** that can support the body **202** above the floor surface **50**. The caster wheel **211** can support the front portion **202***a* of the body **202** above the floor surface **50**, and the drive wheels **210***a* and **210***b* can support the rear portion **202***b* of the body **202** above the floor surface **50**.

As shown in FIG. **3**, a vacuum assembly **218** can be located at least partially within the body **202** of the robot **100**, e.g., in the rear portion **202***b* of the body **202**. The controller **212** can operate the vacuum assembly **218** to generate an airflow that flows through the air gap near the cleaning rollers **205**, through the body **202**, and out of the body **202**. The vacuum assembly **218** can include, for example, an impeller that generates the airflow when rotated. The airflow and the cleaning rollers **205**, when rotated, can cooperate to ingest debris **75** into a suction duct **348** of the robot **100**. The suction duct **348** can extend down to or near a bottom portion of the body **202** and can be at least partially defined by the cleaning assembly **204**.

The suction duct **348** can be connected to the cleaning head **204** or cleaning assembly and can be connected to a cleaning bin **322**. The cleaning bin **322** can be mounted in the body **202** and can contain the debris **75** ingested by the robot **100**. A filter **349** can be located in the body **202**, which can help to separate the debris **75** from the airflow before the airflow **220** enters the vacuum assembly **218** and is exhausted out of the body **202**. In this regard, the debris **75** can be captured in both the cleaning bin **322** and the filter before the airflow **220** is exhausted from the body **202**.

The cleaning rollers **205***a* and **205***b* can operably connected to one or more actuators **214***a* and **214***b*, e.g., motors, respectively. The cleaning head **204** and the cleaning rollers **205***a* and **205***b* can be positioned forward of the cleaning bin **322**. The cleaning rollers **205***a* and **205***b* can be mounted to a housing **224** of the cleaning head **204** and mounted, e.g., indirectly or directly, to the body **202** of the robot **100**. In particular, the cleaning rollers **205***a* and **205***b* can be mounted to an underside of the body **202** so that the cleaning rollers **205***a* and **205***b* engage debris **75** on the floor surface **50** during the cleaning operation when the underside faces the floor surface **50**.

The housing **224** of the cleaning head **204** can be mounted to the body **202** of the robot **100**. In this regard, the cleaning rollers **205***a* and **205***b* can also be mounted to the body **202** of the robot **100**, such as indirectly mounted to the body **202** through the housing **224**. Alternatively, or additionally, the cleaning head **204** can be a removable assembly of the robot **100** where the housing **224** (with the cleaning rollers **205***a* and **205***b* mounted therein) is removably mounted to the body **202** of the robot **100**.

A side brush **242** can be connected to an underside of the robot **100** and can be connected to a motor **244** operable to rotate the side brush **242** with respect to the body **202** of the robot **100**. The side brush **242** can be configured to engage debris to move the debris toward the cleaning assembly **205** or away from edges of the environment **40**. The motor **244** configured to drive the side brush **242** can be in communication with the controller **212**. The brush **242** can be a side brush laterally offset from a center of the robot **100** such that the brush **242** can extend beyond an outer perimeter of the body **202** of the robot **100**. Similarly, the brush **242** can also be forwardly offset of a center of the robot **100** such that the brush **242** also extends beyond the bumper **238** or an outer periphery of the body **202**.

The robot **100** can further include a sensor system with one or more electrical sensors. The sensor system can generate one or more signals indicative of a current location of the robot **100**, and can generate one or more signals indicative of locations of the robot **100** as the robot **100** travels along the floor surface **50**.

For example, cliff sensors **234** (shown in FIG. 2A) can be located along a bottom portion of the body **200**. The cliff sensors **234** can include an optical sensor that can be configured to detect a presence or absence of an object below the optical sensor, such as the floor surface **50**. The cliff sensors **234** can be connected to the controller **212**.

The bump sensors **239***a* and **239***b* (the bump sensors **239**) can be connected to the body **202** and can be engageable or configured to interact with the bumper **238**. The bump sensors **239** can include break beam sensors, Hall Effect sensors, capacitive sensors, switches, or other sensors that can detect contact between the robot **100** (e.g., the bumper **238**) and objects in the environment **40**. The bump sensors **239** can be in communication with the controller **212**.

An image capture device **240** can be connected to the body **202** and can extend at least partially through the bumper **238** of the robot **100**, such as through an opening **243** of the bumper **238**. The image capture device **240** can be a camera, such as a front-facing camera, configured to generate a signal based on imagery of the environment **40** of the robot **100**. The image capture device **240** can transmit the image capture signal to the controller **212** for use for navigation and cleaning routines.

Obstacle following sensors **241** (shown in FIG. 2B) can include an optical sensor facing outward or downward from the bumper **238** that can be configured to detect the presence or the absence of an object adjacent to a side of the body **202**. The obstacle following sensor **241** can emit an optical beam horizontally in a direction perpendicular (or nearly perpendicular) to the forward drive direction of the robot **100**. The optical emitter can emit an optical beam outward from the robot **100**, e.g., outward in a horizontal direction, and the optical detector detects a reflection of the optical beam that reflects off an object near the robot **100**. The robot **100**, e.g., using the controller **212**, can determine a time of flight of the optical beam and thereby determine a distance between the optical detector and the object, and hence a distance between the robot **100** and the object.

The robot **100** can also optionally include one or more dirt sensors **245** connected to the body **202** and in communication with the controller **212**. The dirt sensors **245** can be a microphone, piezoelectric sensor, optical sensor, or the like, and can be located in or near a flow path of debris, such as near an opening of the cleaning rollers **205** or in one or more ducts within the body **202**. This can allow the dirt sensor(s) **245** to detect how much dirt is being ingested by the vacuum assembly **218** (e.g., via the extractor **204**) at any time during a cleaning mission. Because the robot **100** can be aware of its location, the robot **100** can keep a log or record of which areas or rooms of the map are dirtier or where more dirt is collected. This information can be used in several ways, as discussed further below.

Operation of the Robot

In operation of some examples, the robot **100** can be propelled in a forward drive direction or a rearward drive direction. The robot **100** can also be propelled such that the robot **100** turns in place or turns while moving in the forward drive direction or the rearward drive direction.

When the controller **212** causes the robot **100** to perform a mission, the controller **212** can operate the motors **208** to drive the drive wheels **210** and propel the robot **100** along the floor surface **50**. In addition, the controller **212** can operate the motors **214** to cause the rollers **205***a* and **205***b* to rotate, can operate the motor **244** to cause the brush **242** to rotate, or can operate the motor of the vacuum system **218** to generate airflow. The controller **212** can also execute software stored on the memory **213** to cause the robot **100** to perform various navigational and cleaning behaviors by operating the various motors or components of the robot **100**.

The various sensors of the robot **100** can be used to help the robot navigate and clean within the environment **40**. For example, the cliff sensors **234** can detect obstacles such as drop-offs and cliffs below portions of the robot **100** where the cliff sensors **234** are disposed. The cliff sensors **234** can transmit signals to the controller **212** so that the controller **212** can redirect the robot **100** based on signals from the cliff sensors **234**.

In some examples, a bump sensor **239***a* can be used to detect movement of the bumper **238** in one or more directions of the robot **100**. For example, a bump sensor **239***b* can be used to detect movement of the bumper **238** from front to rear or along one or more sides of the robot **100**. The bump sensors **239** can transmit signals to the controller **212** so that the controller **212** can redirect the robot **100** based on signals from the bump sensors **239**.

In some examples, the obstacle following sensors **241** can detect detectable objects, including obstacles such as furniture, walls, persons, and other objects in the environment of the robot **100**. In some implementations, the sensor system can include an obstacle following sensor along a side surface, and the obstacle following sensor can detect the presence or the absence an object adjacent to the side surface. The one or more obstacle following sensors **241** can also serve as obstacle detection sensors, similar to proximity sensors.

The robot **100** can also include sensors for tracking a distance travelled by the robot **100**. For example, the sensor system can include encoders associated with the motors **208** for the drive wheels **210**, and the encoders can track a distance that the robot **100** has travelled. In some implementations, the sensor can include an optical sensor facing downward toward a floor surface. The optical sensor can be positioned to direct light through a bottom surface of the robot **100** toward the floor surface **50**. The optical sensor can detect reflections of the light and can detect a distance travelled by the robot **100** based on changes in floor features as the robot **100** travels along the floor surface **50**.

The image capture device **240** can be configured to generate a signal based on imagery of the environment **40** of the robot **100** as the robot **100** moves about the floor surface **50**. The image capture device **240** can transmit such a signal to the controller **212**. The image capture device **240** can capture images of wall surfaces of the environment so that features corresponding to objects on the wall surfaces can be used for localization.

The controller **212** can use data collected by the sensors of the sensor system to control navigational behaviors of the robot **100** during the mission. For example, the controller

212 can use the sensor data collected by obstacle detection sensors of the robot **100** (e.g., the cliff sensors **234**, the bump sensors **239**, and the image capture device **240**) to help the robot **100** avoid obstacles when moving within the environment of the robot **100** during a mission.

The sensor data can also be used by the controller **212** for simultaneous localization and mapping (SLAM) techniques in which the controller **212** extracts or interprets features of the environment represented by the sensor data and constructs a map of the floor surface **50** of the environment. The sensor data collected by the image capture device **240** can be used for techniques such as vision-based SLAM (VSLAM) in which the controller **212** can extract visual features corresponding to objects in the environment **40** and can construct the map using these visual features. As the controller **212** directs the robot **100** about the floor surface **50** during the mission, the controller **212** can use SLAM techniques to determine a location of the robot **100** within the map by detecting features represented in collected sensor data and comparing the features to previously stored features. The map formed from the sensor data can indicate locations of traversable and non-traversable space within the environment. For example, locations of obstacles can be indicated on the map as non-traversable space, and locations of open floor space can be indicated on the map as traversable space.

The sensor data collected by any of the sensors can be stored in the memory **213**. In addition, other data generated for the SLAM techniques, including mapping data forming the map, can be stored in the memory **213**. These data produced during the mission can include persistent data that are produced during the mission and that are usable during further missions. In addition to storing the software for causing the robot **100** to perform its behaviors, the memory **213** can store data resulting from processing of the sensor data for access by the controller **212**. For example, the map can be a map that is usable and updateable by the controller **212** of the robot **100** from one mission to another mission to navigate the robot **100** about the floor surface **50**.

The persistent data, including the persistent map, helps to enable the robot **100** to efficiently clean the floor surface **50**. For example, the map enables the controller **212** to direct the robot **100** toward open floor space and to avoid non-traversable space. In addition, for subsequent missions, the controller **212** can use the map to optimize paths taken during the missions to help plan navigation of the robot **100** through the environment **40**.

Docking Station Example

FIG. **4** illustrates an isometric view of a docking station **100** for a mobile cleaning robot **100**. The mobile cleaning robot can be a vacuuming robot, a mopping robot, or a combination thereof (two-in-one) mobile cleaning robot configured to perform mopping and cleaning operations in an environment.

The docking station **400** can include a canister **408** and a base **410**. The canister **408** can include an outer wall **412** and a door **414** and the canister **408** can be connected to the base **410**. The base **410** can include a platform **416** including tracks **418***a* and **418***b* including respective wheel wells **420***a* and **420***b*. The platform **416** can also include a vacuum port **422**.

The components of the docking station **400** can be rigid or semi-rigid components made of materials such as one or more of metals, plastics, foams, elastomers, ceramics, composites, combinations thereof, or the like. Materials of some components are discussed in further detail below. The mobile robot **100** can be a mobile cleaning robot including wheels, extractor, a debris bin, a controller, and various sensors, and can be consistent with the robot **100** described above. The robot **100** can be configured to perform autonomous cleaning missions or routines within an environment.

The base **410** can be a ramped member including the platform **416** and the tracks **418***a* and **418***b*, where the base **410** can be configured to receive the mobile cleaning robot **100** thereon for maintenance, such as charging and emptying debris from the mobile cleaning robot. The tracks **418** can be configured to receive wheels of the robot **100** to guide the robot **100** onto the base **410** for charging and debris evacuation using contacts **426**. The contacts **426** can be (or can be part of) an electrical power interface configured to provide electrical power to the mobile cleaning robot **100**. The platform **416** and the tracks **418** can be sloped toward the front portion to help allow the mobile robot **100** to dock on the station **400**.

The docking station **400** can also include a docking port **424** configured to at least partially receive the mobile cleaning robot **100** therein. When the robot **100** is positioned on the base **410**, such as when wheels of the robot **100** are in wheel wells **420**, the vacuum port **422** can be aligned with a vacuum outlet of the robot **100**. The vacuum port **422** can extend through the base **410** and can connect to the vacuum inlet of the canister **408**. The vacuum port **422** can be connected to a debris duct **428** that can extend through the base **410** and into the canister **408** such as to carry debris into a debris bin.

For example, the mobile cleaning robot **100** can move into the docking port **424** by traversing over the tracks **418***a* and **418***b* until drive wheels of the mobile cleaning robot **402** rest in the wheel wells **420**, which can align the vacuum port **422** with a debris port of the robot and can align charging contacts **426** of the dock with contacts of the mobile cleaning robot **402**, along with other features of the mobile cleaning robot **100** and the docking station **400**.

The canister **408** can be an upper portion of the docking station **400** connected to a rear portion of the base **410** and can extend upward therefrom, such that the canister **408** can be located at least partially above the base **410**. The outer wall **412** of the canister **408** can have a shape of a substantially rectangular hollow prism with rounded corners where the outer wall **412** can define a front portion of the canister **408** that is open. The outer wall **112** can at least partially enclose the debris bin and a fan compartment.

The door **414** can be connected to the outer wall **412** (such as by hinges or other fasteners), such as at a side portion of the door **414**. The door **414** can be releasably securable to the outer wall **412**, such as at a side portion of the door **414** and the outer wall **412** (such as via a friction/interference fit, latch, or the like). Removal of the door **414** or opening of the door **414** (e.g., from a front portion of the canister **408**) can provide access to a debris bin, a debris collector **430**, or a fan compartment.

As discussed in further detail below, the docking station **400** can include the debris collector **430** connected to the debris duct **428** upstream of a debris bin, the debris collector **430** can be configured to collect debris from a debris airstream of the debris duct **428**. As shown in FIG. **4**, the debris collector **430** can be user-accessible through a side wall **432** of the outer wall **412** of the canister **408**, allowing a user to retrieve items ingested by the robot **100** and evacuated into the debris collector **430**, helping to prevent unwanted disposal of items. Optionally, a portion of the debris collector **430** can be transparent, allowing a user to view items therein from outside the docking station **400**.

Network Examples

FIG. **5** is a diagram illustrating by way of example and not limitation a communication network **500** that enables networking between the mobile robot **100** and one or more other devices, such as a mobile device **504**, a cloud computing system **506**, or the docking station **400**. Using the communication network **510**, the robot **100**, the mobile device **504**, the docking station **400**, and the cloud computing system **506** can communicate with one another to transmit and receive data from one another. In some examples, the robot **100**, the docking station **400**, or both the robot **100** and the docking station **400** communicate with the mobile device **504** through the cloud computing system **506**. Alternatively, or additionally, the robot **100**, the docking station **400**, or both the robot **100** and the docking station **400** communicate directly with the mobile device **504**. Various types and combinations of wireless networks (e.g., Bluetooth, radio frequency, optical based, etc.) and network architectures (e.g., mesh networks) can be employed by the communication network **510**.

In some examples, the mobile device **504** can be a remote device that can be linked to the cloud computing system **506** and can enable a user to provide inputs. The mobile device **504** can include user input elements such as, for example, one or more of a touchscreen display, buttons, a microphone, a mouse, a keyboard, or other devices that respond to inputs provided by the user. The mobile device **504** can also include immersive media (e.g., virtual reality) with which the user can interact to provide input. The mobile device **504**, in these examples, can be a virtual reality headset or a head-mounted display.

The user can provide inputs corresponding to commands for the mobile robot **100**. In such cases, the mobile device **504** can transmit a signal to the cloud computing system **506** to cause the cloud computing system **506** to transmit a command signal to the mobile robot **100**. In some implementations, the mobile device **504** can present augmented reality images. In some implementations, the mobile device **504** can be a smart phone, a laptop computer, a tablet computing device, or other mobile device.

According to some examples discussed herein, the mobile device **504** can include a user interface configured to display a map of the robot environment. A robot path, such as that identified by a coverage planner, can also be displayed on the map. The interface can receive a user instruction to modify the environment map, such as by adding, removing, or otherwise modifying a keep-out zone in the environment; adding, removing, or otherwise modifying a focused cleaning zone in the environment (such as an area that requires repeated cleaning); restricting a robot traversal direction or traversal pattern in a portion of the environment; or adding or changing a cleaning rank, among others.

In some examples, the communication network **510** can include additional nodes. For example, nodes of the communication network **510** can include additional robots. Also, nodes of the communication network **510** can include network-connected devices that can generate information about the environment **40**. Such a network-connected device can include one or more sensors, such as an acoustic sensor, an image capture system, or other sensor generating signals, to detect characteristics of the environment **40** from which features can be extracted. Network-connected devices can also include home cameras, smart sensors, or the like.

In the communication network **510**, the wireless links can utilize various communication schemes, protocols, etc., such as, for example, Bluetooth classes, Wi-Fi, Bluetooth-low-energy, also known as BLE, 802.15.4, Worldwide Interoperability for Microwave Access (WiMAX), an infrared channel, satellite band, or the like. In some examples, wireless links can include any cellular network standards used to communicate among mobile devices, including, but not limited to, standards that qualify as 1G, 2G, 3G, 4G, 5G, 6G, or the like. The network standards, if utilized, qualify as, for example, one or more generations of mobile telecommunication standards by fulfilling a specification or standards such as the specifications maintained by International Telecommunication Union. For example, the 4G standards can correspond to the International Mobile Telecommunications Advanced (IMT-Advanced) specification. Examples of cellular network standards include AMPS, GSM, GPRS, UMTS, LTE, LTE Advanced, Mobile WiMAX, and WiMAX-Advanced. Cellular network standards can use various channel access methods, e.g., FDMA, TDMA, CDMA, or SDMA.

Debris Separation Examples

FIG. **6**A illustrates a side view of a docking station **600** for a mobile cleaning robot. FIG. **6**B illustrates a schematic view of a portion of the docking station **600** for a mobile cleaning robot. The docking station **600** can be similar to the docking station **400** discussed above; FIGS. **6**A and **6**B show additional details of a debris collector. Any of the systems discussed above or below can be modified to include the features of the docking station **600**.

FIG. **6**A shows that the docking station **600** can include a debris duct **628** extending from a base **610** and into a canister **608**, such as to connect to a debris bin and evacuation fan (blower) downstream of a debris collector **630**. As shown in FIG. **6**A, the debris duct **628** can extend through the base and into the canister **608** where the debris duct **628** can connect to the debris collector **630**, such as for collection of large debris from the debris duct **628** before the items are collected by the debris bin.

As also shown in FIG. **6**A, the debris collector **630** can include or can define a drawer **632** extending at least partially into the canister **608** through an outer wall **612** thereof. The drawer **632** can include a handle **634** that can be user-operable to remove (or partially remove) the drawer **632** from the canister **608** such as to allow a user to collect relatively large debris items separated into or collected by the debris collector **630**. The drawer **632** can optionally be translatable or slidable with respect to the outer wall **612**, such as for removal of the debris collector **630**. Optionally, the debris collector **630** can be connected to the outer wall **612** via a hinge and can rotate with respect to the outer wall **612**. Optionally, the drawer **632** can include a transparent or translucent portion at the outer wall **612** to allow a user to view contents of the debris collector **630** when the drawer **632** is installed within the canister **608**. The drawer **632** can include a seal engageable with the outer wall **612** (or another portion of the docking station **600**) to form a seal between the drawer **632** and the canister **608** when the drawer **632** is inserted into the canister **608**.

FIG. **6**B shows the debris collector **630** connected to the debris duct **628**. More specifically, FIG. **6**B shows that the debris duct **628** can include a debris collection duct **636** connected to the debris duct **628** and connected to the debris collector **630**. The debris collection duct **636** can be connected to the debris duct **628** at an angled portion **628*a*** of the debris duct **628**.

In operation, a debris airstream A can be generated by a fan or blower of the docking station **600** and can travel from the robot (e.g., the robot **100**), through the base **610** via the debris duct **628** and into the canister **608**. Because the angled portion **628*a*** is angled with respect to a gravitational force and because the debris collection duct **636** and the debris collector **630** are located directly below an opening formed in the angled portion **628***a*, relatively heavy debris can fall out of the debris airstream A as it passes through the angled portion **628***a*. In this way, relatively large or heavy debris can collect in the debris collector **630** where it can be retrieved by a user via the drawer **632**.

FIG. **7** illustrates a schematic view of a portion docking station **700** for a mobile cleaning robot. The docking station **700** can be similar to the docking stations discussed above; FIG. **7** shows how the debris collection system can be connected. Any of the systems discussed above or below can be modified to include the features of the docking station **700**.

As shown in FIG. **7**, a debris duct **728** can begin at an opening or port **722** in the docking station **700**, such as in a base (e.g., the base **410**). The duct **728** can extend through the docking station **700** and can end at a discharge downstream of a blower or debris exhaust fan **738**. The debris exhaust fan **738** can include a motor and can be configured to operate to draw an air stream A from the opening **722** (out of the robot **100**) and through the various components of the docking station **700** before exhausting the air stream A.

The docking station **700** can also include a debris bin **740** upstream of the blower or debris exhaust fan **738**. The debris bin **740** can include a debris bag **742** that can be configured to collect debris from the airstream A before the airstream is exhausted from the docking station **700**. The debris bag **742** can be user replaceable to dispose of debris collected by the robot **100** and evacuated into the docking station **700**.

A debris collector **730** can be located upstream of the debris bin **740** and the debris bag **742** such that the debris collector **730** can collect large debris items from the air stream A before the items reach the debris bag **742**, helping to limit unwanted items from entering the debris bag **742**. The debris collector **730** can include one or more separation devices, such as a baffle, as discussed in further detail below, to help separate large or heavy debris items from the air stream A ahead of the debris bag **742**.

FIG. **7** also shows that the docking station **700** can include a control device **744**, such as a damper, which can be connected to the debris duct **728** upstream of the debris collector **730**. Optionally, the control device **744** can be located downstream of the debris collector **730**. The control device **744** can also be connected to a bypass duct **746**. The bypass duct can further connect to the debris duct **728** between the debris collector **730** and the debris bin **740** such as to form a bypass flow path for the air stream A around the debris collector **730**. In operation, the control device **744** can be movable between an open position and a bypass position, where, in the open position, the air stream A can be directed to the debris collector **730** and in the bypass position, the air stream A can be directed to an inlet of the debris bag **742**, bypassing the debris collector **730**. Optionally, the debris collector **730** or the docking station **700** can include a visual indicator to indicate to a user when the debris collector **730** is engaged (such as fully seated) or disengaged.

Optionally, the control device **744** can be configured to control an amount of flow through the debris collector **730**. For example, the control device **744** can be manually or automatically adjusted to control an amount of air that flows through the bypass duct **746** and the debris collector **730**, such as to adjust an amount of debris separation performed by the debris collector **730**.

Optionally, the control device **744** can include an actuator **748**. The actuator **748** can be an electrical device in communication with a controller **750**. In such a configuration, the controller **750** can operate the actuator **748** to move the control device **744** between the open position and the bypass position. Optionally, the actuator **748** can be a manually-operated device, such as a mechanical switch, lever, or slider, and the actuator **748** can be configured to allow a user to move the control device **744** between the open position and the bypass position.

Optionally, the docking station **700** can include a control device **752** in addition to or in lieu of the control device **744**. The control device **752** can be movable between an open position and a closed position, where, in the open position, the air stream A can be directed to the debris collector **730** and in the closed position, the air stream A can be directed to the bypass duct **746** and to an inlet of the debris bag **742**, bypassing the debris collector **730**. The control device **752** can include an actuator **754**, which can be a manual actuator that is user operable or can be an electric actuator connected to the controller **750**.

The actuator **754** (or the actuator **748**) can be a mechanical actuator configured to control the control device **752** (or the control device **744**) and can be connected to the debris collector **730**. In an example where the debris collector **730** is removable, removal of the debris collector **730** from a canister **708** can cause the actuator **754** to operate the actuator **754** (or the actuator **748** to operate the control device **744**) to move to a closed or bypass position, such that the air stream A bypasses the debris collector **730** when the debris collector **730** is removed from the docking station **700**. In such an example, re-insertion or insertion of the debris collector **730** into the docking station **700** can cause the actuator **754** to operate the actuator **754** (or the actuator **748** to operate the control device **744**) to move to an open position (or a non-bypass position).

In some examples, the controller **750** of the docking station **700** can be in communication with the robot **100** or with one or more of the components of the docking station **700**, such as the blower or debris exhaust fan **738**, the actuator **748**, or the actuator **754**. Optionally, the controller **750** can be in communication with the actuator **754** or the actuator **748** to operate the control device **752** or the control device **744**, respectively, between an open position and a bypass position, such as based on one or more sensor signals from the docking station **700** or the robot **100**.

For example, the robot **100** can transmit to the controller **750** a debris signal from the one or more dirt sensors **245**, allowing the controller **750** to determine that large debris has been ingested by the robot **100**. Alternatively, the robot **100** can determine that large debris has been ingested by the robot **100** based on the debris signal and the robot **100** can transmit such a determination to the controller **750**. In either case, controller **750** can store such information and can then, upon the next evacuation of the robot **100**, operate the actuator **754** or the actuator **748** to the open position, to allow the large debris to be collected by the debris collector **730**.

Optionally, either the robot **100** or the controller **750** can produce an alert or transmit an alert to the mobile device **504** that a large debris item may have been ingested by the robot **100**. Also, either the robot **100** or the controller **750** can produce an alert or transmit an alert to the mobile device **504** that a large debris item may have been collected from the robot **100** by the docking station **700**.

The docking station **700** can include a sensor **751** connected to the debris collector **730** and optionally located at least partially within the debris collector **730**. The sensor **751** can be an audio sensor (e.g., microphone or Piezoelectric) or visual sensor (e.g., camera) or load sensor (e.g., load cell). The sensor **751** can produce a signal based on activity within the debris collector **730** and can be in communication with the controller **750** such as to transmit the signal thereto. For example, the controller **750** can use the signal from the sensor **751** to determine when an item has been collected within the debris collector **730** and can transmit an alert to a user device upon such a detection. Optionally, the signal from the sensor **751** can be used to determine when the debris collector **730** is fully inserted into the canister **708**. Optionally, the docking station **700** can include a separate sensor for such detection.

FIG. **8** illustrates a side cross-sectional view of a portion docking station **800** for a mobile cleaning robot. The docking station **800** can be similar to the docking stations discussed above; FIG. **8** shows an example debris collection system and how it can operate. Any of the systems discussed above or below can be modified to include the features of the docking station **800**.

The portion docking station **800** can include a debris collector **830** connected to a debris duct **828** at an inlet **858** of a housing **856**. The housing **856** can also connect to a discharge duct **829** at an outlet **860** of the housing **856**. The housing **830** can be configured such that the air stream A flows from the debris duct **828** into the inlet **858**, through the debris **830**, and out the housing **856** to the discharge duct **829**. From the outlet **860**, the air stream can travel through the discharge duct **829** to a debris bin (e.g., the debris bin **740**).

The debris collector **830** can include one or more baffles **862***a*-**862***d*. The baffles **862** can be connected to one or more walls of the debris collector **830** and can be configured to interact with the air stream A, such as to cause the airstream A to follow a non-linear path (e.g., a serpentine path) through the debris collector **830**. The baffles **862** can also be configured to generate Eddy currents (or at least partially recirculating air currents) to help separate debris from the air stream A. The baffles **862** can also form chambers, such as a chamber **864** formed at least in part by the baffle **862***a*. Optionally, one or more of the baffles **862** can include a hole, perforation, or plurality of holes or perforations therein or therethrough, such as to help reduce air pressure drop through the debris collector **830** while still separating large debris from the air stream A.

In operation, as the air stream A enters the inlet **858**, the air stream A can enter the inlet **858** and engage the baffles **862***a*-**862***c* causing large debris **75** to separate from the air stream and collect in the chambers, such as in the chamber **864**. As the air stream A travels through the debris collector **830**, it can engage the baffle **862***d* to further help separate large debris and to help limit large or heavy debris from leaving the debris collector **830**, before discharging through the outlet **860** and entering the discharge duct **829**.

FIG. **9**A illustrates a side cross-sectional view across indicators **9**A-**9**A of FIG. **9**B of a portion docking station **900** for a mobile cleaning robot. FIG. **9**B illustrates a top cross-sectional view across indicators **9**B-**9**B of FIG. **9**A of the portion docking station **900** for a mobile cleaning robot. FIGS. **9**A and **9**B are discussed together below. The docking station **900** can be similar to the docking stations discussed above; FIG. **9** shows an example of a cyclone debris collection system. Any of the systems discussed above or below can be modified to include the features of the docking station **900**.

As shown in FIG. **9**A, the docking station **900** can include a debris collector **930** connected to a debris duct **928**. The debris collector **930** can include a housing **956** defining an outer portion of an outer chamber **966**. The debris collector **930** can also include an outlet tube **968** located at least partially within the housing **956** and in (or near) a center of the outer chamber **966**. The outlet tube **968** can at least partially define a center chamber **970** connected to a discharge duct **929**. The discharge duct **929** can be connected to a debris bin and a debris bag.

As shown in FIG. **9**B, the debris collector **930** can also include a separator **972** connected to the housing **956**, such as transverse or orthogonally to a central axis C of the outlet tube **968**. The separator **972** can be located at a bottom portion of the outer chamber **966** adjacent an inlet of the outlet tube **968**. The separator **972** can define openings **974** therein or therethrough. Optionally, the separator **972** can define a ring **973**. The ring **973** can be open in the middle or can define one or more openings **974**. The openings **974** can be sized and shaped to allow large debris to fall into a chamber **964** such as for retrieval of the large debris from the debris collector **930**. Optionally, the chamber **964** can be separable from the housing **956**.

In operation, the airstream A can enter the debris duct **928** and can travel through the outer chamber **966**, such as in a cyclone, around the outlet tube **968**. As the airstream A passes into the outlet tube **968**, large debris can be separated out and through the separator **972** and into the chamber **964**, while the airstream A can pull smaller debris (such as hair and dust) into the center chamber **970** of the outlet tube **968** and to the discharge duct **929**. In this way, the debris collector **930** can operate as a cyclone separator help to separate and collect relatively large debris from the airstream A.

FIG. **10** illustrates a side cross-sectional view of a portion docking station **1000** for a mobile cleaning robot. The docking station **1000** can be similar to the docking stations discussed above; FIG. **10** shows an example debris collection system including a perforated tube. Any of the systems discussed above or below can be modified to include the features of the docking station **1000**.

The docking station **1000** can include a debris collector **1030** connected to a debris duct **1028** at an inlet **1058** of a housing **1056**. The housing **1056** can also connect to a discharge duct **1029** at an outlet **1060** of the housing **1056**. The housing **1056** can be configured such that the air stream A flows from the debris duct **1028** into the inlet **1058**, through the debris collector **1030**, and out of the housing **1056** to the discharge duct **1029**. From the outlet **1060**, the air stream can travel through the discharge duct **1029** to a debris bin (e.g., the debris bin **740**).

The debris collector **1030** can include one or more baffles **1062**. The baffle **1062** can be connected to one or more walls of the debris collector **1030** and can be configured to interact with the air stream A, such as to generate an Eddy current E (or at least partially recirculating air currents) to help separate debris from the air stream A. The baffle **1062** can also form chambers, such as a chamber **1064** formed at least in part by the baffle **1062**.

The debris collector **1030** can also include an outlet tube **1068** connected to the outlet **1060**. The air stream A can travel from the debris duct **1028** and through the outlet tube **1068** to the outlet **1060**. Optionally, the outlet tube **1068** can include a perforated portion **1076**. The perforated portion **1076** can include one or more holes or bores of one size or of various sizes, such as to allow the air stream A to enter the outlet tube **1068** while limiting large debris from entering the outlet tube **1068**. The quantity and size of the holes of the perforated portion **1076** can be selected or optimized to separate a debris type or size (such as large debris) or to receive a debris type or size (such as dust and hair).

Optionally, the perforated portion **1076** can be a screen or other perforated item. Optionally, the perforated portion **1076** can be removable (such as user-removable) or can be removed or eliminated.

FIG. **11** illustrates a side cross-sectional view of a portion docking station **1100** for a mobile cleaning robot. The docking station **1100** can be similar to the docking stations discussed above; FIG. **11** shows an example cyclone debris collection system including a perforated section. Any of the systems discussed above or below can be modified to include the features of the docking station **1100**.

The portion of the docking station **1100** can include a debris collector **1130** connected to a debris duct **1128**. The debris collector **1130** can include a housing **1156** defining an outer portion of an outer chamber **1166**. The debris collector **1130** can also include an outlet tube **1168** located at least partially within the housing **1156** and in or near a center of the outer chamber **1166**. The outlet tube **1168** can at least partially define a center chamber **1170** connected to a discharge duct **1129**. The discharge duct **1129** can be connected to a debris bin or a debris bag.

The debris collector **1130** can also include a separator **1172** connected to the housing **1156**, such as transverse or orthogonally to an axis of the outlet tube **1168**. The separator **1172** can be located at a bottom portion of the outer chamber **1166** adjacent an inlet of the outlet tube **1168**. The separator **1172** can define openings therein or therethrough that can be sized and shaped to allow large debris to fall into a chamber **1164** such as for retrieval of the large debris from the debris collector **1130**.

The debris collector **1130** can also include perforated portion **1178** at least partially surrounding the outlet tube **1168** and at least partially surrounding an entrance of the outlet tube **1168**. The perforated portion **1178** can include one or more holes or bores of one size or of various sizes, such as to allow the air stream A to enter the outlet tube **1168** while limiting large debris from entering the outlet tube **1168**. The quantity and size of the holes of the perforated portion **1178** can be selected or optimized to separate a debris type or size (such as large debris) or to receive a debris type or size (such as dust and hair). Optionally, the perforated portion **1178** can be a screen or other perforated item.

In operation, the airstream A can enter the debris duct **1128** and can travel through the outer chamber **1166**, such as in a cyclone, around the outlet tube **1168** and around the perforated portion **1178**. As the airstream A passes through the separator perforated portion **1178**, large debris can be separated out of the air stream A and can fall to the chamber **1164**, while the airstream A can pull smaller debris (such as hair and dust) into the center chamber **1170** of the outlet tube **1168** and to the discharge duct **1129**. In this way, the debris collector **1130** can operate as a cyclone separator help to separate and collect relatively large debris from the airstream A.

System Example

FIG. **12** illustrates a block diagram of an example machine **1200** upon which any one or more of the techniques (e.g., methodologies) discussed herein may perform. Examples, as described herein, may include, or may operate by, logic or a number of components, or mechanisms in the machine **1200**. Circuitry (e.g., processing circuitry) is a collection of circuits implemented in tangible entities of the machine **1200** that include hardware (e.g., simple circuits, gates, logic, etc.). Circuitry membership may be flexible over time. Circuitries include members that may, alone or in combination, perform specified operations when operating. In an example, hardware of the circuitry may be immutably designed to carry out a specific operation (e.g., hardwired). In an example, the hardware of the circuitry may include variably connected physical components (e.g., execution units, transistors, simple circuits, etc.) including a machine readable medium physically modified (e.g., magnetically, electrically, moveable placement of invariant massed particles, etc.) to encode instructions of the specific operation. In connecting the physical components, the underlying electrical properties of a hardware constituent are changed, for example, from an insulator to a conductor or vice versa. The instructions enable embedded hardware (e.g., the execution units or a loading mechanism) to create members of the circuitry in hardware via the variable connections to carry out portions of the specific operation when in operation. Accordingly, in an example, the machine readable medium elements are part of the circuitry or are communicatively coupled to the other components of the circuitry when the device is operating. In an example, any of the physical components may be used in more than one member of more than one circuitry. For example, under operation, execution units may be used in a first circuit of a first circuitry at one point in time and reused by a second circuit in the first circuitry, or by a third circuit in a second circuitry at a different time. Additional examples of these components with respect to the machine **1200** follow.

In alternative embodiments, the machine **1200** may operate as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine **1200** may operate in the capacity of a server machine, a client machine, or both in server-client network environments. In an example, the machine **1200** may act as a peer machine in peer-to-peer (P2P) (or other distributed) network environment. The machine **1200** may be a personal computer (PC), a tablet PC, a set-top box (STB), a personal digital assistant (PDA), a mobile telephone, a web appliance, a network router, switch or bridge, or any machine capable of executing instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while only a single machine is illustrated, the term "machine" shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein, such as cloud computing, software as a service (SaaS), other computer cluster configurations.

The machine (e.g., computer system) **1200** may include a hardware processor **1202** (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory **1204**, a static memory (e.g., memory or storage for firmware, microcode, a basic-input-output (BIOS), unified extensible firmware interface (UEFI), etc.) **1206**, and mass storage **1208** (e.g., hard drive, tape drive, flash storage, or other block devices) some or all of which may communicate with each other via an interlink (e.g., bus) **1230**. The machine **1200** may further include a display unit **1210**, an alphanumeric input device **1212** (e.g., a keyboard), and a user interface (UI) navigation device **1214** (e.g., a mouse). In an example, the display unit **1210**, input device **1212** and UI navigation device **1214** may be a touch screen display. The machine **1200** may additionally include a storage device (e.g., drive unit) **1208**, a signal generation device **1218** (e.g., a speaker), a network interface device **1220**, and one or more sensors **1216**, such as a global positioning system (GPS) sensor, compass, accelerometer, or other sensor. The machine **1200** may include an output controller **1228**, such as a serial (e.g., universal serial bus (USB), parallel, or other wired or wireless (e.g., infrared (IR), near field communication (NFC), etc.) connection to communicate or control one or more peripheral devices (e.g., a printer, card reader, etc.).

Registers of the processor **1202**, the main memory **1204**, the static memory **1206**, or the mass storage **1208** may be, or include, a machine readable medium **1222** on which is stored one or more sets of data structures or instructions **1224** (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions **1224** may also reside, completely or at least partially, within any of registers of the processor **1202**, the main memory **1204**, the static memory **1206**, or the mass storage **1208** during execution thereof by the machine **1200**. In an example, one or any combination of the hardware processor **1202**, the main memory **1204**, the static memory **1206**, or the mass storage **1208** may constitute the machine readable media **1222**. While the machine readable medium **1222** is illustrated as a single medium, the term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store the one or more instructions **1224**.

The term "machine readable medium" may include any medium that is capable of storing, encoding, or carrying instructions for execution by the machine **1200** and that cause the machine **1200** to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. Non-limiting machine readable medium examples may include solid-state memories, optical media, magnetic media, and signals (e.g., radio frequency signals, other photon based signals, sound signals, etc.). In an example, a non-transitory machine readable medium comprises a machine readable medium with a plurality of particles having invariant (e.g., rest) mass, and thus are compositions of matter. Accordingly, non-transitory machine-readable media are machine readable media that do not include transitory propagating signals. Specific examples of non-transitory machine readable media may include: non-volatile memory, such as semiconductor memory devices (e.g., Electrically Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM)) and flash memory devices; magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks.

The instructions **1224** may be further transmitted or received over a communications network **1226** using a transmission medium via the network interface device **1220** utilizing any one of a number of transfer protocols (e.g., frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP), hypertext transfer protocol (HTTP), etc.). Example communication networks may include a local area network (LAN), a wide area network (WAN), a packet data network (e.g., the Internet), mobile telephone networks (e.g., cellular networks), Plain Old Telephone (POTS) networks, and wireless data networks (e.g., Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards known as Wi-Fi®, IEEE 802.16 family of standards known as WiMax®), IEEE 802.15.4 family of standards, peer-to-peer (P2P) networks, among others. In an example, the network interface device **1220** may include one or more physical jacks (e.g., Ethernet, coaxial, or phone jacks) or one or more antennas to connect to the communications network **1226**. In an example, the network interface device **1220** may include a plurality of antennas to wirelessly communicate using at least one of single-input multiple-output (SIMO), multiple-input multiple-output (MIMO), or multiple-input single-output (MISO) techniques. The term "transmission medium" shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine **1200**, and includes digital or analog communications signals or other intangible medium to facilitate communication of such software. A transmission medium is a machine readable medium.

Notes And Examples

The following, non-limiting examples, detail certain aspects of the present subject matter to solve the challenges and provide the benefits discussed herein, among others.

Example 1 is a docking station for a mobile cleaning robot, the docking station comprising: a base configured to receive at least a portion of the mobile cleaning robot thereon, the base including a debris port; and a canister connected to the base and located at least partially above the base, the canister comprising: a debris bin to receive debris from the mobile cleaning robot; a debris duct connected to the debris port and to the debris bin; and a debris collector connected to the debris duct upstream of the debris bin, the debris collector configured to collect debris from a debris airstream of the debris duct.

In Example 2, the subject matter of Example 1 optionally includes a damper connected to the debris duct upstream of the debris collector, the damper movable between an open position and a bypass position.

In Example 3, the subject matter of Example 2 optionally includes a damper actuator connected to the canister and operably connected to the damper, the damper actuator user-operable to move the damper between the open position and the bypass position.

In Example 4, the subject matter of Example 3 optionally includes a debris drawer connected to the debris collector and slidably insertable into a collection compartment of the canister between an open position and a closed position.

In Example 5, the subject matter of Example 4 optionally includes wherein removal of the debris drawer moves the actuator to the bypass position.

In Example 6, the subject matter of any one or more of Examples 2-5 optionally include a damper actuator connected to the canister and operably connected to the damper; and a controller in communication with the damper actuator, the controller configured to control the damper actuator to move the damper between an open position and a bypass position.

In Example 7, the subject matter of Example 6 optionally includes wherein the controller is configured to receive a debris signal from a debris senor of the mobile cleaning robot, the controller configured to operate the damper actuator based on the debris signal.

In Example 8, the subject matter of Example 7 optionally includes a bypass duct connected to the debris duct upstream of the damper, the bypass duct connected to the debris bin, the bypass duct configured to receive the debris airstream therethrough when the damper is in the bypass position.

In Example 9, the subject matter of any one or more of Examples 1-8 optionally include a cyclone separator located within the debris collector, the cyclone separator configured to separate debris from the debris airstream.

In Example 10, the subject matter of Example 9 optionally includes a screen connected to the cyclone separator, the screen configured to separate debris from the debris airstream.

In Example 11, the subject matter of any one or more of Examples 1-10 optionally include a screen connected to an outlet of the debris collector, the screen configured to separate debris from the debris airstream.

In Example 12, the subject matter of any one or more of Examples 1-11 optionally include a baffle located within the debris collector, the baffle configured to separate debris from the debris airstream.

In Example 13, the subject matter of Example 12 optionally includes wherein the baffle includes one or more perforations therein or therethrough.

In Example 14, the subject matter of any one or more of Examples 1-13 optionally include wherein the debris bin is configured to capture or collect dust or hair and the debris collector is configured to capture relatively large debris.

Example 15 is a docking station for a mobile cleaning robot, the docking station comprising: a base configured to receive at least a portion of the mobile cleaning robot thereon, the base including debris port; and a canister connected to the base and located at least partially above the base, the canister comprising: a debris bin to receive debris from a debris airstream from the mobile cleaning robot; and a debris collector connected to the debris bin and the debris port, the debris collector configured to collect debris from the debris airstream.

In Example 16, the subject matter of Example 15 optionally includes an evacuation fan connected to the canister and connectable to the mobile cleaning robot to evacuate debris from a debris bin of the mobile cleaning robot to a debris bag of the canister.

In Example 17, the subject matter of any one or more of Examples 15-16 optionally include a damper located upstream of the debris collector, the damper movable between an open position and a bypass position.

In Example 18, the subject matter of Example 17 optionally includes a damper actuator connected to the canister and operably connected to the damper, the damper actuator user-operable to move the damper between the open position and the bypass position.

In Example 19, the subject matter of any one or more of Examples 15-18 optionally include a debris drawer connected to the debris collector and slidably insertable into a collection compartment of the canister between an open position and a closed position.

In Example 20, the subject matter of any one or more of Examples 1-19 optionally include a cyclone separator located within the debris collector, the cyclone separator configured to separate debris from the debris airstream.

In Example 21, the subject matter of Example 20 optionally includes a screen connected to the cyclone separator, the screen configured to separate debris from the debris airstream.

In Example 22, the apparatuses or method of any one or any combination of Examples 1-21 can optionally be configured such that all elements or options recited are available to use or select from.

The above detailed description includes references to the accompanying drawings, which form a part of the detailed description. The drawings show, by way of illustration, specific embodiments in which the invention can be practiced. These embodiments are also referred to herein as "examples." Such examples can include elements in addition to those shown or described. However, the present inventors also contemplate examples in which only those elements shown or described are provided. Moreover, the present inventors also contemplate examples using any combination or permutation of those elements shown or described (or one or more aspects thereof), either with respect to a particular example (or one or more aspects thereof), or with respect to other examples (or one or more aspects thereof) shown or described herein.

In the event of inconsistent usages between this document and any documents so incorporated by reference, the usage in this document controls.

In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the terms "including" and "comprising" are open-ended, that is, a system, device, article, composition, formulation, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

The above description is intended to be illustrative, and not restrictive. For example, the above-described examples (or one or more aspects thereof) may be used in combination with each other. Other embodiments can be used, such as by one of ordinary skill in the art upon reviewing the above description. The Abstract is provided to comply with 37 C.F.R. § 1.72(b), to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. Also, in the above Detailed Description, various features may be grouped together to streamline the disclosure. This should not be interpreted as intending that an unclaimed disclosed feature is essential to any claim. Rather, inventive subject matter may lie in less than all features of a particular disclosed embodiment. Thus, the following claims are hereby incorporated into the Detailed Description as examples or embodiments, with each claim standing on its own as a separate embodiment, and it is contemplated that such embodiments can be combined with each other in various combinations or permutations. The scope of the invention should be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

The invention claimed is:

1. A docking station for a mobile cleaning robot, the docking station comprising:

a base configured to receive at least a portion of the mobile cleaning robot thereon, the base including a debris port;

a canister connected to the base and located at least partially above the base, the canister comprising:

a debris bin to receive debris from the mobile cleaning robot;

a debris duct connected to the debris port and to the debris bin; and

a debris collector connected to the debris duct upstream of the debris bin, the debris collector configured to collect debris from a debris airstream of the debris duct; and a damper connected to the debris duct upstream of the debris collector, the damper movable between an open position and a bypass position.

2. The docking station of claim **1**, further comprising:

a damper actuator connected to the canister and operably connected to the damper, the damper actuator user-operable to move the damper between the open position and the bypass position.

3. The docking station of claim **2**, further comprising:

a debris drawer connected to the debris collector and slidably insertable into a collection compartment of the canister between an open position and a closed position.

4. The docking station of claim **3**, wherein removal of the debris drawer moves the actuator to the bypass position.

5. The docking station of claim **1**, further comprising:

a damper actuator connected to the canister and operably connected to the damper; and

a controller in communication with the damper actuator, the controller configured to control the damper actuator to move the damper between an open position and a bypass position.

6. The docking station of claim **5**, wherein the controller is configured to receive a debris signal from a debris senor of the mobile cleaning robot, the controller configured to operate the damper actuator based on the debris signal.

7. The docking station of claim **6**, further comprising:

a bypass duct connected to the damper, the bypass duct connected to the debris bin, and the bypass duct configured to receive the debris airstream therethrough when the damper is in the bypass position.

8. The docking station of claim **1**, further comprising:

a cyclone separator located within the debris collector, the cyclone separator configured to separate debris from the debris airstream.

9. The docking station of claim **8**, further comprising:

a screen connected to the cyclone separator, the screen configured to separate debris from the debris airstream.

10. The docking station of claim **1**, further comprising:

a screen connected to an outlet of the debris collector, the screen configured to separate debris from the debris airstream.

11. The docking station of claim **1**, further comprising:

a baffle located within the debris collector, the baffle configured to separate debris from the debris airstream.

12. The docking station of claim **11**, wherein the baffle includes one or more perforations therein or therethrough.

13. The docking station of claim **1**, wherein the debris bin is configured to capture or collect dust or hair and the debris collector is configured to capture relatively large debris.

14. A docking station for a mobile cleaning robot, the docking station comprising:

a base configured to receive at least a portion of the mobile cleaning robot thereon, the base including debris port;

a canister connected to the base and located at least partially above the base, the canister comprising:

a debris bin to receive debris from a debris airstream from the mobile cleaning robot; and

a debris collector connected to the debris bin and the debris port, the debris collector configured to collect debris from the debris airstream;

an evacuation fan connected to the canister and connectable to the mobile cleaning robot to evacuate debris from a debris bin of the mobile cleaning robot to a debris bag of the canister; and

a damper located upstream of the debris collector, the damper movable between an open position and a bypass position.

15. The docking station of claim **14**, further comprising:

a damper actuator connected to the canister and operably connected to the damper, the damper actuator user-operable to move the damper between the open position and the bypass position.

16. The docking station of claim **15**, further comprising:

a debris drawer connected to the debris collector and slidably insertable into a collection compartment of the canister between an open position and a closed position.

17. The docking station of claim **14**, further comprising:

a cyclone separator located within the debris collector, the cyclone separator configured to separate debris from the debris airstream.

18. The docking station of claim **17**, further comprising:

a screen connected to the cyclone separator, the screen configured to separate debris from the debris airstream.

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