

DESCRIPTION

AUTONOMOUS CLEANER, AUXILIARY BRUSH THEREFOR, AND CLEANER SYSTEM EQUIPPED WITH AUTONOMOUS CLEANER

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TECHNICAL FIELD

The present invention relates to an autonomous cleaner that cleans a floor surface of a region to be cleaned while autonomously travelling, an auxiliary brush therefor, and a cleaner system including the autonomous
10 cleaner.

BACKGROUND ART

A conventional autonomous cleaner includes a body having a suction port for sucking dust on a bottom surface of the body, a main brush disposed in
15 the suction port, and an auxiliary brush provided on the bottom surface of the body (see, for example, PTL 1). The autonomous cleaner collects dust around the body toward a region below the body by rotation of the auxiliary brush and sucks the dust through the suction port. Note that a bristle bundle of the auxiliary brush preferably has a length that reaches a vertex of a corner of a
20 region to be cleaned by the autonomous cleaner.

However, the bristle bundle having this length makes contact with a wall of a room and is markedly warped, for example, while the autonomous cleaner travels along the wall. The warped bristle bundle sometimes flicks dust away when the warped bristle bundle returns to an original state.

25 Meanwhile, if the length of the bristle bundle is determined such that an amount of warpage of the bristle bundle becomes small, the bristle bundle does not reach a corner, and therefore the corner cannot be cleaned.

Citation List

Patent Literature

PTL 1: Unexamined Japanese Patent Publication No. 2010-188205

5 SUMMARY OF THE INVENTION

An auxiliary brush of an autonomous cleaner according to an exemplary embodiment of the present invention is attached to a body constituting the autonomous cleaner so as to be capable of collecting dust to a suction port provided in a bottom surface of the body. The auxiliary brush includes a short
10 bristle bundle that is a bundle of short bristles and a long bristle bundle that is a bundle of bristles longer than the short bristle bundle.

This makes it possible to provide an autonomous cleaner including an auxiliary brush that can efficiently collect dust around a body.

15 BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a plan view of an autonomous cleaner according to the present exemplary embodiment.

FIG. 2 is a bottom view of the autonomous cleaner of FIG. 1.

FIG. 3 is a perspective view of a cleaner system including the
20 autonomous cleaner of FIG. 1.

FIG. 4 is a bottom view of a specific example of the autonomous cleaner of FIG. 1.

FIG. 5 is a cross-sectional view taken along line 5-5 of FIG. 3.

FIG. 6 is a perspective view of a specific example of a trash can unit of
25 FIG. 1.

FIG. 7 is a perspective view of the trash can unit of FIG. 6 whose lid is closed.

FIG. 8 is a perspective view of the trash can unit of FIG. 7 whose lid is opened.

FIG. 9 is a cross-sectional view taken along line 9-9 in FIG. 7.

FIG. 10 is a cross-sectional view of a state where a buckle of FIG. 9 is
5 lifted up.

FIG. 11 is a cross-sectional view of a state where a lid of FIG. 10 is opened.

FIG. 12 is a perspective view of a panel that constitutes a fence of FIG.
3.

FIG. 13 is a perspective view of a state where two panels are connected.
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FIG. 14 is a cross-sectional view taken along line 14-14 of FIG. 13.

FIG. 15 is a cross-sectional view of a state where relative positions of the panels of FIG. 14 have been changed.

FIG. 16 is a cross-sectional view of a state where the fence of FIG. 13 is
15 folded.

FIG. 17 is a sectional view taken along line 17-17 of FIG. 16.

FIG. 18 is a graph showing a first example of a result of detection of floor surface detection sensors.

FIG. 19 is a graph showing a second example of a result of detection of
20 the floor surface detection sensors.

FIG. 20 is a graph showing a third example of a result of detection of the floor surface detection sensors.

FIG. 21A is a plan view showing an example of an operation of a cleaner in a concentrated cleaning operation.

FIG. 21B is a plan view showing an example of an operation of the
25 cleaner in the concentrated cleaning operation.

FIG. 21C is a plan view showing an example of an operation of the

cleaner in the concentrated cleaning operation.

FIG. 22 schematically shows a relationship between an auxiliary brush and a wall and a corner of a region to be cleaned.

FIG. 23A is a plan view showing an example of an operation of the
5 cleaner in first moving control.

FIG. 23B is a plan view showing an example of an operation of the cleaner in the first moving control.

FIG. 23C is a plan view showing an example of an operation of the cleaner in the first moving control.

10 FIG. 24 is a flowchart of a skid determining process.

FIG. 25 is a flowchart of a collision determining process.

FIG. 26 is a flowchart of a step determining process.

FIG. 27 is a flowchart of a wheel fall determining process.

FIG. 28A is a plan view showing an example of an operation of a cleaner
15 in a concentrated cleaning operation according to a modification.

FIG. 28B is a plan view showing an example of an operation of a cleaner in a concentrated cleaning operation according to a modification.

DESCRIPTION OF EMBODIMENT

20 An exemplary embodiment of the present invention is hereinafter described with reference to the drawings. It is to be noted that this exemplary embodiment is not restrictive of the present invention.

(Exemplary embodiment)

A configuration of autonomous cleaner 10 (hereinafter simply referred
25 to as “cleaner 10”) according to the present exemplary embodiment is described below with reference to FIGS. 1 through 4.

FIGS. 1 and 2 schematically show the configuration of cleaner 10. FIG.

3 shows a cleaner system including cleaner 10. FIG. 4 shows an example of a specific form of cleaner 10.

Cleaner 10 according to the present exemplary embodiment is a robot vacuum cleaner that sucks dust on a floor surface in a region to be cleaned while autonomously travelling on the floor surface. The region to be cleaned is, for example, a floor surface of a room.

As shown in FIG. 3, cleaner system 1 includes cleaner 10 and fence 90.

Cleaner 10 includes body 20, drive unit 30, cleaning unit 40, trash can unit 50, suction unit 60, control unit 70, power unit 80, and the like. A part of drive unit 30, a part of cleaning unit 40, trash can unit 50, suction unit 60, control unit 70, and power unit 80 are disposed in body 20. That is, body 20 incorporates therein various components constituting cleaner 10.

Drive unit 30 moves body 20 on a floor surface to clean the floor surface. Cleaning unit 40 collects dust around body 20 to a region below body 20 and scrapes the dust up. Trash can unit 50 stores therein dust sucked by suction unit 60. Suction unit 60 sucks dust scraped up by cleaning unit 40 into body 20. Control unit 70 controls operations of drive unit 30, cleaning unit 40, suction unit 60, and the like. Power unit 80 supplies power to drive unit 30, cleaning unit 40, suction unit 60, control unit 70, and the like.

Body 20 has a planar shape of a Reuleaux triangle, a polygon substantially similar to the Reuleaux triangle, or a Reuleaux triangle or a polygon with rounded corners. As body 20 is shaped as described above, body 20 has geometric characteristics that are the same as or similar to those of the Reuleaux triangle.

As shown in FIGS. 1 and 3, cleaner 10 further includes panel cover 21, bumper 22, and the like. Panel cover 21 covers an operation panel (not shown) on an upper part of body 20. Panel cover 21 is attached on the upper part of

body 20 to be opened and closed relative to body 20. Bumper 22 absorbs impact applied to body 20. Bumper 22 is provided in a front part of body 20 to be displaced relative to body 20.

As shown in FIGS. 2 and 4, cleaner 10 further includes caster 23.

5 Caster 23 supports a rear part of body 20. Caster 23 is rotated according to an operation of drive unit 30.

Body 20 includes suction port 20B on bottom surface 20A. Suction port 20B sucks dust below body 20 into body 20.

Cleaning unit 40 includes a first brush drive motor, a second brush
10 drive motor, a first power transmission unit, a second power transmission unit (these are not shown), main brush 41, auxiliary brush 100, and the like. The first and second brush drive motors and the first and second power transmission units are disposed in body 20. The first power transmission unit is coupled to main brush 41 and transmits torque of the first brush drive motor
15 to main brush 41. The second power transmission unit is coupled to auxiliary brush 100 and transmits torque of the second brush drive motor to auxiliary brush 100. The first and second power transmission units are constituted, for example, by a gear or the like and transmit power to main brush 41 and auxiliary brush 100.

20 Main brush 41 scrapes up dust below body 20, for example, dust on a floor surface. For example, main brush 41 includes a core having a rotational axis and brush bristles around an outer periphery of the core, and is disposed at suction port 20B. Main brush 41 is driven by the first power transmission unit to rotate in a direction of scraping up dust from downward to upward on a rear
25 side of the rotational axis.

Auxiliary brush 100 collects dust around body 20 to a region below suction port 20B. Cleaner 10 includes, for example, paired auxiliary brushes

100. Paired auxiliary brushes 100 are provided on left and right side parts of a front part of bottom surface 20A of body 20, respectively. Auxiliary brushes 100 are driven by the second power transmission unit to rotate in a direction of collecting dust from front of body 20 toward suction port 20B.

5 A drive system for moving cleaner 10 is constituted by an opposed two-wheel system. Cleaner 10 thus includes paired drive units 30. Each drive unit 30 includes a wheel drive motor (not shown), drive wheel 31, housing 32, and the like. The wheel drive motor, which is coupled to a shaft of drive wheel 31, is disposed in housing 32, and transmits torque to drive wheel 31.
10 Drive wheel 31 includes a wheel coupled to the shaft and a tire attached to an outer periphery of the wheel. The tire has a tread pattern for enabling the tire to stably run on an unstable surface such as a carpet.

 Trash can unit 50 is disposed on a front side of suction unit 60 in a front-rear direction of body 20. When body 20 is planarly viewed, paired drive
15 units 30 are disposed to sandwich trash can unit 50 in a width direction perpendicular to the front-rear direction of body 20. Body 20 and trash can unit 50 are configured in a manner such that a user can freely select a state where trash can unit 50 is attached to body 20 and a state where trash can unit 50 is removed from body 20.

20 Suction unit 60 includes an electric fan (not shown) and is disposed between trash can unit 50 and power unit 80 in the front-rear direction of body 20. The electric fan sucks air into trash can unit 50. When the electric fan is driven, dust scraped up by main brush 41 is moved into trash can unit 50.

 Control unit 70 is disposed on power unit 80 in body 20, and is
25 electrically connected to power unit 80. For example, control unit 70 includes a semiconductor integrated circuit such as a central processing unit (CPU) and a storage unit. For example, the storage unit is constituted by a non-volatile

semiconductor storage element such as a flash memory. The storage unit stores therein various programs executed by control unit 70 and parameters.

Cleaner 10 according to the present exemplary embodiment further includes a plurality of sensors, as shown in FIGS. 1 to 4. The sensors include, 5 for example, obstacle detection sensor 71, a plurality of distance measuring sensors 72, collision detection sensor 73, a plurality of floor surface detection sensors 74, dust sensor 75, first rotation speed sensor 76, second rotation speed sensor 77, and wheel fall detection sensor 78. These sensors are electrically connected to control unit 70 and power unit 80 and output detection signals to 10 control unit 70.

Obstacle detection sensor 71 detects a distance to an obstacle present ahead of body 20. Obstacle detection sensor 71 is constituted by, for example, an ultrasonic sensor including a transmitter and a receiver. Each of distance measuring sensors 72 detects a distance between an object present around body 15 20 and body 20. Each of distance measuring sensors 72 is constituted by, for example, an infrared sensor including a transmitter and a receiver. Collision detection sensor 73 detects collision between body 20 and an object present around body 20. Collision detection sensor 73 is constituted by, for example, a contact displacement sensor including a switch that is switched on when 20 bumper 22 is pressed into body 20. Each of floor surface detection sensors 74 detects a distance to a floor surface. Each of floor surface detection sensors 74 is constituted by, for example, an infrared sensor including a transmitter and a receiver. Dust sensor 75 detects an amount of dust flowing in a path within trash can unit 50. Dust sensor 75 is constituted by, for example, an infrared 25 sensor including a transmitter and a receiver.

Floor surface detection sensors 74 according to the present exemplary embodiment are, for example, first to fifth floor surface detection sensors 74.

First floor surface detection sensor 74 is provided ahead of main brush 41 in the front-rear direction of body 20. Second floor surface detection sensor 74 is provided between right auxiliary brush 100 and right drive unit 30 in the front-rear direction of body 20. Third floor surface detection sensor 74 is
5 provided between left auxiliary brush 100 and left drive unit 30 in the front-rear direction of body 20. Fourth floor surface detection sensor 74 is provided behind right drive unit 30, right auxiliary brush 100, and main brush 41 in the front-rear direction of body 20. Fifth floor surface detection sensor 74 is provided behind left drive unit 30, left auxiliary brush 100, and main
10 brush 41 in the front-rear direction of body 20.

Control unit 70 determines whether an object that hinders travelling of cleaner 10 is present within a predetermined range on the front side of body 20, based on a detection signal input from obstacle detection sensor 71. Control unit 70 calculates a distance between an object present around a side part of
15 body 20 and an outline of body 20 based on a detection signal input from distance measuring sensor 72. Control unit 70 determines whether body 20 has collided with an object present around body 20 based on a detection signal input from collision detection sensor 73. Control unit 70 calculates a distance between bottom surface 20A of body 20 and a floor surface based on detection
20 signals input from floor surface detection sensors 74.

First rotation speed sensor 76 detects a rotation speed of drive wheel 31. Second rotation speed sensor 77 detects a rotation speed of caster 23. First rotation speed sensor 76 and second rotation speed sensor 77 are constituted, for example, by a magnetic sensor or the like. Control unit 70 calculates a
25 moving speed of cleaner 10 based on a detection signal supplied from first rotation speed sensor 76.

Wheel fall detection sensor 78 detects whether drive wheel 31 has fallen.

In a first example, wheel fall detection sensor 78 is constituted by a sensor that detects a load of an energizing member that gives force for pressing drive wheel 31 against a floor surface. In a second example, wheel fall detection sensor 78 is constituted by a sensor that detects an amount of displacement of drive
5 wheel 31 relative to body 20 in a height direction of cleaner 10.

Autonomous cleaner 10 and cleaner system 1 including autonomous cleaner 10 according to the present exemplary embodiment are configured as above.

Hereinafter, a specific configuration of auxiliary brush 100 according to
10 the present exemplary embodiment will be described with reference to FIG. 4.

Auxiliary brush 100 includes brush shaft 110, attachment part 120, a pair of bristle holders 130, and a plurality of bristle bundles 140. Body 20 and auxiliary brush 100 are configured in a manner such that a user can freely select a state where auxiliary brush 100 is attached to body 20 and a state
15 where auxiliary brush 100 is removed from body 20.

Brush shaft 110 is, for example, made of a metal such as stainless steel or a resin such as polyacetal (POM). For example, brush shaft 110 is formed in a cylindrical shape. Auxiliary brush 100 is attached on a side of bottom surface 20A of body 20, and is coupled via brush shaft 110 to the second power
20 transmission unit (not shown). In a state where auxiliary brush 100 is coupled to the second power transmission unit, brush shaft 110 is disposed to project downward from bottom surface 20A of body 20. A central axis of brush shaft 110 is disposed along a height direction of body 20.

Attachment part 120 is attached so as to surround brush shaft 110 and
25 rotates integrally with brush shaft 110. Attachment part 120 and the pair of bristle holders 130 are constituted by an integrally formed component made of a resin such as elastomer.

Bristle holders 130 hold the plurality of bristle bundles 140 such that bristle bundles 140 do not fall off. The pair of bristle holders 130 are provided at positions opposed in a radial direction with respect to a central axis of attachment part 120 so as to protrude outward from attachment part 120.

5 That is, one bristle holder 130 and other bristle holder 130 are disposed to as to protrude in opposite directions in the radial direction with respect to the central axis of bristle holders 130.

The plurality of bristle bundles 140 includes a plurality of short bristle bundles 141 and a plurality of long bristle bundles 142. Bristle bundles 140
10 are bundles of a plurality of bristles that are bundled so as to collect dust on a floor surface. For example, 50 bristles constitute each of bristle bundles 140. Bristles are made of, for example, nylon.

Short bristle bundles 141 are bundles of short bristles. Long bristle bundles 142 are bundles of bristles longer than the bristles of short bristle
15 bundles 141. Short bristle bundles 141 and long bristle bundles 142 are held by bristle holders 130 protruding from attachment part 120. Accordingly, a length of bristles is shorter by a length corresponding to bristle holders 130 than a case where short bristle bundles 141 and long bristle bundles 142 are held by attachment part 120, on a condition that positions of front ends of the
20 bristles in these cases are the same. This makes it possible to reduce an amount of warpage caused when short bristle bundles 141 and long bristle bundles 142 make contact with a wall.

Specifically, a distance from a center of rotation of brush shaft 110 to the front ends of short bristle bundles 141 is set to a first predetermined
25 distance, for example, approximately 5 cm. A distance from the center of brush shaft 110 to the front ends of long bristle bundles 142 is set to a second predetermined distance, for example, approximately 7 cm, which is longer than

the first predetermined distance. Note that the first predetermined distance of 5cm and the second predetermined distance of 7 cm are examples and are not limited to these values.

That is, in the present exemplary embodiment, auxiliary brush 100 is
5 constituted by two kinds of bristle bundles having different lengths, i.e., short bristle bundles 141 and long bristle bundles 142. This produces the following effects.

First, in a case where cleaner 10 cleans along a wall in the region to be cleaned, an amount of warpage of short bristle bundles 141 that make contact
10 with the wall is smaller than a case where long bristle bundles 142 make contact with the wall. Accordingly, force (recovering force) recovering from a warped state to an original state of short bristle bundles 141 is smaller. As a result, dust close to the wall is less likely to be flicked far away.

Furthermore, in a case where cleaner 10 cleans along a wall while
15 travelling such that short bristle bundles 141 do not make contact with the wall, short bristle bundles 141 are not warped. Accordingly, dust close to the wall is not flicked far away by short bristle bundles 141. As a result, dust close to the wall can be more efficiently collected to a region below body 20 by auxiliary brush 100.

20 Furthermore, the front ends of long bristle bundles 142 reach a cleaning region that is out of reach of the front ends of short bristle bundles 141. Accordingly, in a case where cleaner 10 cleans a corner of the region to be cleaned, dust close to a vertex of the corner is easily collected by long bristle bundles 142.

25 That is, use of auxiliary brush 100 including two kinds of bristle bundles, i.e., short bristle bundles 141 and long bristle bundles 142 makes it possible to efficiently collect dust both in a case where cleaner 10 cleans the

region to be cleaned while travelling along a wall and a case where cleaner 10 cleans a region close to a vertex of a corner of the region to be cleaned.

Furthermore, bristle holders 130 hold short bristle bundles 141 and long bristle bundles 142 such that a gap is created between short bristle bundle 141 and long bristle bundle 142.

The gap between short bristle bundle 141 and long bristle bundle 142 is set as follows.

When short bristle bundle 141 and long bristle bundle 142 are pressed against a floor surface, the bristles that constitute short bristle bundle 141 and long bristle bundle 142 spread like a fan. In view of this, the gap is set such that short bristle bundle 141 and long bristle bundle 142 that spread like a fan do not overlap each other or such that an amount of overlap between short bristle bundle 141 and long bristle bundle 142 becomes small. Bristle holders 130 hold short bristle bundle 141 and long bristle bundle 142 such that the gap widens from a base (fixed end side) toward a front end (free end side).

Short bristle bundle 141 and long bristle bundle 142 are inclined such that front end portions thereof are closer to a downward side (a floor surface side) than drive wheel 31 (see FIG. 5). Accordingly, when cleaner 10 is placed on a floor surface, short bristle bundle 141 and long bristle bundle 142 are pressed against the floor surface. This causes the bristles that constitute short bristle bundle 141 and long bristle bundle 142 to spread like a fan. In this state, a gap is formed between short bristle bundle 141 and long bristle bundle 142 held by bristle holder 130, as described above. Accordingly, short bristle bundle 141 and long bristle bundle 142 that are pressed against the floor surface are hard to overlap each other. As a result, a contact areas of short bristle bundle 141 and long bristle bundle 142 with the floor surface increases. It is therefore possible to efficiently collect dust.

Furthermore, bristle holder 130 holds short bristle bundle 141 and long bristle bundle 142 such that short bristle bundle 141 rotates so as to be followed by long bristle bundle 142 in a rotation direction of auxiliary brush 100. Accordingly, in a case where cleaner 10 cleans a region close to a wall, short
5 bristle bundle 141 that is less likely to be warped by contact with a wall than long bristle bundle 142 collects dust earlier. This reduces an amount of dust that is present on the floor surface when long bristle bundle 142 returns from a warped state to an original state. As a result, it is less likely that dust is flicked far away (out of the region to be cleaned) by recovering force of long
10 bristle bundle 142 from the warped state.

Auxiliary brush 100 according to the present exemplary embodiment is configured as described above.

Hereinafter, a configuration of trash can unit 50 according to the present exemplary embodiment will be described with reference to FIG. 6 to
15 FIG. 11.

As shown in Fig. 6, trash can unit 50 includes trash can 51 and filter 55. Trash can 51 includes main body 52, lid 53, hinge 54, and the like. Main body 52 and lid 53 are coupled with use of hinge 54 interposed therebetween. Main body 52 accumulates sucked dust. Lid 53 is used to open or close an opening of
20 main body 52 and hold filter 55. Main body 52 has inlet 52A. Inlet 52A is connected to a duct (not shown) disposed in body 20. The duct guides, into trash can 51, dust sucked from suction port 20B into body 20 (see FIG. 5).

Filter 55 includes frame 56 and collector 57. Frame 56 holds collector 57 and guides air that has passed inlet 52A to collector 57. Collector 57
25 collects dust included in the air. Frame 56 and lid 53 are attachable to and detachable from each other.

Frame 56 includes a pair of windows 56A, middle wall 56B, guide 56C,

and the like. Window 56A exposes collector 57 such that air can pass through collector 57. Middle wall 56B serves as a partition between one window 56A and other window 56A. Guide 56C guides air that has passed inlet 52A of main body 52 to collector 57. Guide 56C is a projection on middle wall 56B
5 and has top part 56D and a pair of guide surfaces 56E. Top part 56D is a part of guide 56C that protrudes most from middle wall 56B. Guide surfaces 56E are inclined surfaces that approach middle wall 56B from top part 56D toward the pair of windows 56A.

As shown in FIG. 7, trash can unit 50 further includes buckle 58 and
10 handle 59. Handle 59 is rotatably attached to trash can 51. Handle 59 is held by a user when the user detaches trash can unit 50 from body 20 and when the user carries detached trash can unit 50.

As shown in FIG. 8, main body 52 of trash can unit 50 includes outlet 52B. Lid 53 and filter 55 are connected with use of hinge 54 so as to be
15 rotatable with respect to trash can 51 such that outlet 52B can be opened and closed. Outlet 52B is an opening for discharging dust accumulated in main body 52. Outlet 52B faces downward direction Z rather than horizontal direction X in a state where the user holds handle 59 such that trash can unit 50 is suspended. This makes it easier to discharge dust from trash can 51,
20 thereby making it harder for dust to remain in main body 52.

Buckle 58 of trash can unit 50 is rotatably attached to main body 52, as shown in FIGS. 9 and 10. In a case where buckle 58 is hooked on lid 53, lid 53 and filter 55 are fixed to main body 52, and thus outlet 52B is closed. Meanwhile, when buckle 58 is detached from lid 53, lid 53 is rotated relative to
25 main body 52 and filter 55, and thus outlet 52B is opened.

Gap 58P is formed between a top part of frame 56 of filter 55 and buckle 58 in a state shown in FIG. 9 where lid 53 is fixed to main body 52. Similarly,

gap 58Q is formed between a top part of lid 53 and buckle 58. Gap 58P is larger than gap 58Q in a height direction (a gap from buckle 58). This makes it possible to avoid buckle 58 from being caught by filter 55 when outlet 52B is opened by moving lid 53 rotationally relative to main body 52. Accordingly, lid
5 53 and filter 55 can be quickly moved rotationally to a position where outlet 52B is opened.

Furthermore, buckle 58 can be used in the following form as illustrated in FIG. 11.

Specifically, lid 53 and filter 55 shown in FIG. 10 are separated.
10 Buckle 58 is hooked on frame 56 of filter 55 in a state where only filter 55 is attached to trash can 51. That is, only filter 55 is fixed to trash can 51. According to this form of use, for example, dust accumulated between filter 55 and lid 53 can be easily taken off.

As illustrated in FIG. 5, when trash can unit 50 is attached to body 20,
15 inlet 52A of main body 52 is disposed so as to face not collector 57 (see FIG. 6) but guide 56C and a part surrounding guide 56C of middle wall 56B. Middle wall 56B is inclined such that an upper end is located closer to a rear side of body 20 than a lower end (floor surface side) is. Since middle wall 56B is inclined, guide 56C is also inclined such that an upper end is located closer to a
20 rear side of body 20 than a lower end is.

Accordingly, air that has been sucked from inlet 52A and has passed inlet 52A makes contact with guide 56C and a part surrounding guide 56C of middle wall 56B. The air that makes contact with guide 56C flows while being guided toward the pair of left and right windows 56A (see FIG. 6) by guide
25 surfaces 56E (see FIG. 6).

Furthermore, guide 56C is inclined along middle wall 56B. Accordingly, flow of the air that has made contact with guide 56C includes a

component flowing upward.

The air whose direction of flow has been changed by guide surfaces 56E flows leftward and rightward along middle wall 56B and passes through the pair of windows 56A and collectors 57. The air that has passed through the
5 pair of windows 56A and collectors 57 passes through outlet 52B (see FIG. 8) of trash can unit 50 and is sucked by suction unit 60. The air that has been sucked by suction unit 60 passes through an exhaust path (not shown) provided in body 20 and is discharged to an outside of body 20.

According to trash can unit 50 having the above configuration, the
10 following effects can be obtained.

For example, in a case where middle wall 56B is omitted and collector 57 is provided in a range from one window 56A to other window 56A, dust tends to be accumulated especially in a part of collector 57 that faces inlet 52A of main body 52. Accordingly, even in a case where other parts of collector 57
15 have room for accumulation and collection of dust, inlet 52A is sometimes blocked by dust accumulated in the part of collector 57 that faces inlet 52A of main body 52.

However, the configuration of trash can unit 50 having middle wall 56B according to the present exemplary embodiment lowers a risk of concentrated
20 accumulation of dust.

Furthermore, air is guided toward the pair of windows 56A by guide 56C. This forms smooth flow of air on middle wall 56B. Accordingly, for example, dust is less likely to be accumulated in a part of middle wall 56B that faces inlet 52A. As a result, it is possible to suppress occurrence of blockage of
25 inlet 52A by dust in long-term use.

Furthermore, according to trash can unit 50 according to the present exemplary embodiment, guide 56C is disposed on middle wall 56B so as to be

inclined such that an upper end is located closer to the rear side of body 20 than a lower end is. With this configuration, dust carried to collector 57 is accumulated in an upper part of collector 57. Therefore, resistance against a main air current passing through collector 57 is less likely to increase than a case where dust is accumulated on whole collector 57.

Accordingly, strength of an air current formed by suction unit 60 is less likely to decrease even in a case where a cumulative period of use of cleaner 10 increases. As a result, cleaner 10 that has stable suction performance over a long term is obtained.

Trash can unit 50 according to the present exemplary embodiment is configured as above.

Hereinafter, a configuration of fence 90 according to the present exemplary embodiment will be described with reference to FIG. 3 and FIGS. 12 to FIG. 17.

Fence 90 is a member that is used by a user to determine a range in which cleaner 10 moves. As shown in FIG. 3, for example, fence 90 includes a plurality of panels 91. Panels 91 are, for example, made of a resin such as ABS. The plurality of panels 91 are connectable to each other and separable from each other by the user. That is, fence 90 is constituted by the plurality of panels 91 that are connected to each other, and thus a range in which cleaner 10 moves is set to any range.

Specifically, as illustrated in FIG. 12, each of panels 91 is, for example, constituted by panel body 95 having a flat plate shape, rotary shaft 92, shaft bearing 93, and base 94. Panel body 95 has first end 91A and second end 91B close to respective ends in a longitudinal direction of panel body 95. Base 94 is provided at both ends of rotary shaft 92. When base 94 is placed on a floor surface, panel 91 stands by itself on the floor surface.

A shape of panel body 95 can be freely changed. For example, a shape of panel body 95 in plan view can be changed to a wave shape or an arc shape.

Rotary shaft 92 is provided at first end 91A along a short direction of panel body 95. Shaft bearing 93 is provided at second end 91B along the short
5 direction of panel body 95. As shown in FIG. 12, for example, two shaft bearings 93 are provided along the short direction of panel body 95. Two shaft bearings 93 are provided at an interval wider than a width of first end 91A of panel body 95. Each of shaft bearings 93 includes, for example, a pair of claws 93A. Each of claws 93A has an arc shape so as to support rotary shaft 92 of
10 another panel 91 connected to panel 91. Front ends of the arc shapes of claws 93A are provided at different positions in a height direction (the short direction).

As shown in FIG. 13, rotary shaft 92 of one panel 91 (right panel 91 in FIG. 13) is attached to shaft bearings 93 of another panel 91 (left panel 91 in
15 FIG. 13). That is, rotary shaft 92 of one panel 91 is inserted into shaft bearings 93 of other panel 91.

Specifically, as shown in FIG. 14, gap 93D is formed between the front end of one claw 93A of other panel 91 and the front end of other claw 93A of other panel 91 in plan view of fence 90. Accordingly, rotary shaft 92 of one
20 panel 91 is inserted between the pair of claws 93A through gap 93D.

As shown in FIGS. 14 and 15, shaft bearings 93 are configured to permit movement of rotary shaft 92 relative to shaft bearings 93 within a certain range in a direction normal to a virtual plane (a direction orthogonal to FIG. 14) including first end 91A and second end 91B of panel body 95. Shaft
25 bearings 93 are configured to regulate movement of rotary shaft 92 relative to shaft bearings 93 in a direction parallel with the plane. In this case, shaft bearings 93 may be, for example, configured to permit movement of rotary shaft

92 relative to shaft bearings 93 within a certain range in the direction parallel with the virtual plane.

As shown in FIGS. 16 and 17, fence 90 can be folded by rotating other panel 91 about a connecting part of one panel 91. That is, rotary shaft 92 of one panel 91 is movable in the normal direction relative to shaft bearings 93. Accordingly, when fence 90 is folded, rotary shaft 92 can be moved relative to shaft bearings 93 such that one panel 91 and other panel 91 approach each other. This reduces a gap between panels 91 in a state where fence 90 is folded. As a result, it is possible to increase storability of fence 90.

Fence 90 having, for example, two panels 91 is configured as above. Needless to say, two or more panels 91 may be connected in a manner similar to that described above so as to constitute fence 90 of any size.

Fence 90 according to the present exemplary embodiment is configured as above.

An example of control executed by control unit 70 in cleaner 10 according to the present exemplary embodiment is described below.

Control unit 70 shown in FIG. 2 executes a plurality of types of control for the purpose of cleaning a region to be cleaned. The plurality of types of control include at least first cleaning control, second cleaning control, third cleaning control, first moving control, second moving control, third moving control, and the like.

The first cleaning control first determines a type of floor surface based on detection signals from floor surface detection sensors 74 while cleaner 10 is moving on any path on the floor surface. The first cleaning control then adjusts sucking force of suction unit 60 based on a result of the determination.

The second cleaning control first determines a type of floor surface based on the detection signals from floor surface detection sensors 74 when a

region with a large amount of dust is detected. The second cleaning control then decides a cleaning operation of cleaner 10 for concentrated suction of dust based on a result of the determination.

5 The third cleaning control is control for moving body 20 along a wall toward a corner to suck dust along the wall and at the corner in the region to be cleaned.

The control for adjusting the sucking force in the first cleaning control may be executed in combination with one or more of the second cleaning control, the third cleaning control, and other cleaning control for operating suction unit
10 60.

The first moving control is control for causing cleaner 10 to retreat from the corner in the region to be cleaned without making contact with the wall when cleaner 10 finishes cleaning the corner.

15 The second moving control is control for suspending the process for determining the type of floor surface in a case where rotation and stoppage of drive wheel 31 are repeated in a short period.

The third moving control is control for changing a method for controlling drive wheel 31 such that a travelling inhibiting factor inhibiting travelling of cleaner 10 during travelling of cleaner 10 is overcome upon
20 detection of the travelling inhibiting factor. The travelling inhibiting factor includes, for example, a skid of drive wheel 31, collision of body 20 with an object, presence of a step of the floor surface below body 20, and fall of drive wheel 31.

Control unit 70 controls cleaner 10 in which control unit 70 is mounted
25 based on the above control contents.

Next, the first cleaning control executed by control unit 70 is described in detail with reference to FIGS. 18 through 21C.

FIGS. 18 through 20 show an example of detection signals obtained from floor surface detection sensors 74 during travelling of cleaner 10. The horizontal axis represents a travelling period of cleaner 10, and the vertical axis represents magnitude of the detection signals obtained by floor surface detection sensors 74.

Types of floor surface determined based on the detection signals obtained by floor surface detection sensors 74 are, for example, three types, specifically, a first surface, a second surface, and a third surface. The first surface is, for example, a flat surface having few surface irregularities such as a wood floor surface. The second surface is, for example, a surface, such as a tatami mat surface, having small surface irregularities and having a relatively stable surface shape. The third surface is, for example, a surface, such as a carpet surface, that is provided with a material (e.g., fur) that is easy to deform and tends to have large irregularities.

FIG. 18 shows an example of a result of detection of floor surface detection sensors 74 in a case where cleaner 10 travels on the first surface. The detection signals obtained by floor surface detection sensors 74 exhibit at least the following two characteristics with respect to the travelling period of cleaner 10. A first characteristic is that changes of a wave height and amplitude are smaller than those of the second and third surfaces described later. A second characteristic is that a change of a moving average of the detection signals of cleaner 10 is smaller than that of the second and third surfaces described later.

FIG. 19 shows an example of a result of detection of floor surface detection sensors 74 in a case where cleaner 10 travels on the second surface. The detection signals obtained by floor surface detection sensors 74 exhibit at least the following two characteristics with respect to the travelling period of

cleaner 10. A first characteristic is that changes of a wave height and amplitude are larger than that of the first surface. A second characteristic is that a change of a moving average of the detection signals of cleaner 10 is larger than that of the first surface.

5 FIG. 20 shows an example of a result of detection of floor surface detection sensors 74 in a case where cleaner 10 travels on the third surface. The detection signals obtained by floor surface detection sensors 74 exhibit at least the following two characteristics with respect to the travelling period of cleaner 10. A first characteristic is that changes of a wave height and
10 amplitude are markedly larger than that of the first surface. A second characteristic is that a change of a moving average of the detection signals of cleaner 10 is markedly larger than that of the first surface.

As is clear from FIGS. 18 through 20, detection signals obtained by floor surface detection sensors 74 during travelling of cleaner 10 vary depending on
15 the type of floor surface.

However, there is a correlation between a waveform of detection signals obtained by floor surface detection sensors 74 over the travelling period of cleaner 10 and the type of floor surface. Accordingly, the type of floor surface can be determined based on the detection signals obtained by floor surface
20 detection sensors 74.

That is, for example, it can be determined that the type of floor surface is the first surface in a case where a wave height or amplitude of detection signals representing a predetermined interval in time-series data of the detection signals obtained by floor surface detection sensors 74 is equal to or
25 smaller than a first determination value.

Meanwhile, it can be determined that the type of floor surface is the second surface in a case where a wave height or amplitude of detection signals

representing a predetermined interval in time-series data of the detection signals obtained by floor surface detection sensors 74 is larger than the first determination value and is equal to or smaller than a second determination value.

5 Meanwhile, it can be determined that the type of floor surface is the third surface in a case where a wave height or amplitude of detection signals representing a predetermined interval in time-series data of the detection signals obtained by floor surface detection sensors 74 is larger than the second determination value.

10 Note, however, that the shape of irregularities of the third surface such as a carpet easily changes depending on a use environment and the like. Generally, in a case where the irregular shape of the third surface is kept, the detection signals obtained by floor surface detection sensors 74 exhibit a waveform like the one shown in FIG. 20. However, for example, in a case
15 where threads on a surface of a carpet are lying on the whole, the detection signals obtained by floor surface detection sensors 74 exhibit a waveform similar, for example, to the waveform shown in FIG. 18 or FIG. 19. For this reason, even in a case where the type of floor surface is the third surface, there is a risk of failure to correctly determine the type of floor surface based on a
20 waveform of the detection signals obtained by floor surface detection sensors 74.

 In view of this, cleaner 10 according to the present exemplary embodiment is configured such that, for example, fourth and fifth floor surface detection sensors 74 among floor surface detection sensors 74 of cleaner 10 are
25 provided on a rear side of drive wheels 31 and the like in order to address the failure to correctly determine the type of floor surface (see FIG. 2).

 That is, for example, in a case where the third surface is a carpet,

threads of a part of the carpet which drive wheels 31 and the like of cleaner 10 travelling forward have passed are pressed down. This forms a clear irregular shape on the surface of the carpet.

When cleaner 10 further travels forward, floor surface detection sensors 5 74 provided on a rear side of drive wheels 31 pass above a raised part having an irregular shape. Accordingly, the part where the clear irregular shape is formed is irradiated with near infrared light by floor surface detection sensors 74. Floor surface detection sensors 74 supply detection signals reflecting the irregular shape of the carpet to control unit 70.

10 As described above, control unit 70 sets sucking force of suction unit 60 to first sucking force in a case where it is determined in the first cleaning control that the type of floor surface is the first surface. Meanwhile, control unit 70 sets sucking force of suction unit 60 to second sucking force larger than the first sucking force in a case where it is determined that the type of floor
15 surface is the second surface. Meanwhile, control unit 70 sets sucking force of suction unit 60 to third sucking force larger than the second sucking force in a case where it is determined that the type of floor surface is the third surface. In this way, the sucking force of suction unit 60 is changed in accordance with a difference in the type of floor surface, and thus dust is effectively sucked. As a
20 result, it is possible to efficiently use electric power by preventing unnecessary consumption of electric power of power unit 80.

Control unit 70 executes the first cleaning control as described above.

Next, the second cleaning control executed by control unit 70 is described in detail with reference to FIGS. 21A through 21C.

25 The second cleaning control is control for performing a cleaning operation of intensively cleaning a region where cleaner 10 is travelling (hereinafter referred to as a “concentrated cleaning operation”) in a case where

dust of an amount equal to or larger than a predetermined amount is detected in the region. An amount of dust is determined based on a detection signal obtained by dust sensor 75 (see FIG. 1). The concentrated cleaning operation is determined in accordance with the type of floor surface. In the present
5 exemplary embodiment, for example, one of two kinds of concentrated cleaning operations determined in advance is selected and executed in accordance with the type of floor surface.

Specifically, control unit 70 first selects the first cleaning operation that is one of the two kinds of concentrated cleaning operations in a case where the
10 type of floor surface determined by floor surface detection sensors 74 is the first surface or the second surface. Meanwhile, control unit 70 selects the second cleaning operation that is the other one of the two kinds of concentrated cleaning operations in a case where the type of floor surface determined by floor surface detection sensors 74 is the third surface.

15 First, the first cleaning operation is described with reference to FIG. 21A.

FIG. 21A shows behavior of cleaner 10 in the first cleaning operation.

In the first cleaning operation, control unit 70 controls cleaner 10 to travel back and forth repeatedly in a region to be intensively cleaned
20 (hereinafter referred to as a “concentrated cleaning region”). Cleaner 10 finishes the first cleaning operation in a case where an amount of dust obtained based on a result of detection of dust sensor 75 decreases to less than a predetermined amount during execution of the first cleaning operation.

Next, the second cleaning operation is described with reference to FIGS.
25 21A through 21C.

FIGS. 21A through 21C show behavior of cleaner 10 in the second cleaning operation.

In the second cleaning operation, control unit 70 first controls cleaner 10 to travel back and forth repeatedly in the concentrated cleaning region (see FIG. 21A) as in the case of the first cleaning operation.

When a number of times of back-and-forth travelling of cleaner 10 reaches a predetermined number, control unit 70 changes a travelling direction of cleaner 10 by rotating cleaner 10 in a clockwise direction or a counterclockwise direction by 90 degrees (see FIG. 21B). Then, control unit 70 controls cleaner 10 to travel back and forth repeatedly in the changed travelling direction (see FIG. 21C).

In FIG. 21C, when the number of times of back-and-forth travelling of cleaner 10 reaches a predetermined number, the traveling direction of cleaner 10 is changed to an original direction (see FIG. 21A). Then, control unit 70 controls cleaner 10 to travel back and forth repeatedly as shown in FIG. 21A. Thereafter, operations similar to those shown in FIGS. 21A through 21C are executed repeatedly.

Then, cleaner 10 finishes the second cleaning operation in a case where an amount of dust obtained based on a result of detection of dust sensor 75 decreases to less than a predetermined amount during execution of the second cleaning operation.

A degree of rise of threads (an irregular shape) of a carpet that is the third surface varies depending on a use state. For example, threads in a part that is frequently trodden are more likely to remain lying than other parts. For this reason, in a case where the direction of back-and-forth travelling of cleaner 10 in the concentrated cleaning operation is identical to a direction in which the threads of the carpet is lying, it is hard to suck dust embedded between the threads. However, according to the second cleaning operation, cleaner 10 moves back and forth in a plurality of directions. This is more

likely to raise the lying threads of the carpet. As a result, it is possible to efficiently suck dust embedded in the threads.

Control unit 70 executes the second cleaning control as described above.

Next, the third cleaning control is described in detail with reference to
5 FIG. 22.

Specifically, a case where cleaner 10 cleans along wall P1 of a room and corner P3 between wall P1 and wall P2 is described.

First, control unit 70 causes cleaner 10 to travel along wall P1 such that a distance between side part 20C of a widest part of body 20 and wall P1 is kept
10 constant based on a detection signal obtained from distance measuring sensor 72 (see FIG. 1). In this process, the distance between side part 20C and wall P1 is, for example, kept almost equal to a distance between side part 20C and the front end of short bristle bundle 141 in a case where short bristle bundle 141 is parallel with a width direction of body 20. Accordingly, the distance is
15 kept such that short bristle bundle 141 does not make contact with wall P1 or makes contact with P1 so as to be slightly warped in a case where short bristle bundle 141 is parallel with the width direction of body 20. This can lower a risk of flicking dust away by the above-described recovering force of short bristle bundle 141.

20 Meanwhile, long bristle bundle 142, which is longer than short bristle bundle 141, is warped in a large amount when making contact with wall P1. Then, long bristle bundle 142 recovers from the warped state to an original state as auxiliary brush 100 further rotates.

Auxiliary brush 100 is provided such that short bristle bundle 141 is
25 followed by long bristle bundle 142 in the rotation direction. Accordingly, in a case where dust is present close to wall P1, the dust is basically collected to a region below body 20 by short bristle bundle 141. That is, even in a case

where dust is present in a travelling direction of long bristle bundle 142, the dust is collected to the region below body 20 by preceding short bristle bundle 141. Accordingly, it is less likely that the dust is flicked far away when long bristle bundle 142 returns from the warped state to the original state.

5 Then, the dust collected to the region below body 20 by auxiliary brush 100 is sucked through suction port 20B shown in FIG. 2 into trash can unit 50.

Next, when the front face of body 20 moves close to wall P2 as a result of travelling of cleaner 10 along wall P1, control unit 70 stops travelling of cleaner 10 and keeps a state where main brush 41 and auxiliary brush 100 shown in
10 FIG. 2 are rotated. In this state, long bristle bundle 142 reaches vertex P4 of a corner that is out of reach of short bristle bundle 141. This causes dust close to vertex P4 of the corner to be collected to a region below body 20. As a result, dust can be efficiently collected along a wall surface having a corner.

Control unit 70 executes the third cleaning control as described above.

15 The first moving control is described in detail with reference to FIGS. 23A through 23C.

As shown in FIG. 23A, cleaner 10 is located at corner P3 when the third cleaning control is finished. In this state, a forward distance between the front face of body 20 and wall P2, which is detected by obstacle detection sensor
20 71, is first distance D1. A sideways distance between a side face of body 20 and wall P1, which is detected by distance measuring sensor 72, is second distance D2.

In the first moving control, control unit 70 controls cleaner 10 to move from a first position that is first distance D1 and second distance D2 shown in
25 FIG. 23A to a second position that is third distance D3 longer than first distance D1 and fourth distance D4 longer than second distance D2 shown in FIG. 23C.

A specific operation of cleaner 10 is described below.

First, as shown in FIG. 23B, cleaner 10 is rotated by approximately a certain angle θ at the first position shown in FIG. 23A such that central line L extending in a front-back direction of body 20 changes from a state where
5 central line L is parallel with wall P1 to a state where central line L is directed toward vertex P4 of corner P3. Certain angle θ is, for example, approximately 5° .

Next, control unit 70 causes cleaner 10 that has been rotated as shown in FIG. 23B to retreat to the second position as shown in FIG. 23C. Then, for
10 example, cleaner 10 is moved to clean another place of the region to be cleaned.

That is, cleaner 10 that has completed cleaning corner P3 needs to turn in another direction in order to clean another place or in order to return to a charging device (not shown). Body 20 of cleaner 10 according to the present exemplary embodiment has a planar shape of a Reuleaux triangle with rounded
15 corners. Accordingly, in a case where cleaner 10 retreats from corner P3, there is a risk of contact of body 20 with wall P1 or wall P2 when cleaner 10 rotates on that spot as in a case of a cleaner having a body that has a circular planar shape. In view of this, the first moving control is executed. This allows cleaner 10 to retreat from corner P3 without contact of body 20 with wall P1
20 and wall P2.

Control unit 70 executes the first moving control as described above.

The second moving control is described in detail below.

In general, in a case where cleaner 10 travels back and forth repeatedly, rotating and stopping operations of drive wheel 31 are repeated. In this case,
25 the detection signals obtained by floor surface detection sensors 74 are susceptible to influence of disturbance.

In view of this, in the second moving control, control unit 70 controls

movement such that the process for determining the type of floor surface is suspended in a case where drive wheels 31 of cleaner 10 repeats rotating and stopping operations. That is, for example, control unit 70 disables a detection operation of floor surface detection sensors 74. Alternatively, control unit 70
5 does not use the detection signals obtained from floor surface detection sensors 74 for control.

Execution of the second moving control makes it possible to lower a possibility of erroneous determination of the type of floor surface.

Although an example in which the second moving control is executed in
10 a case where rotating and stopping operations of drive wheels 31 are repeated has been described above, the present exemplary embodiment is not limited to this. For example, the second moving control may be executed in a manner similar to that described above in a case where influence of disturbance against the detection signals obtained from floor surface detection sensors 74 becomes
15 large due to another factor. This makes it possible to obtain similar effects. An example of the other factor is a case where cleaner 10 repeats a spinning operation or a circling operation.

Control unit 70 executes the second moving control as described above.

The third moving control is described in detail with reference to FIGS. 1,
20 2, and 24 through 27.

In the third moving control, control unit 70 controls movement such that a plurality of determining processes are performed in parallel in order to detect a travelling inhibiting factor. The determining processes are, for example, a skid determining process shown in FIG. 24, a collision determining
25 process shown in FIG. 25, a step determining process shown in FIG. 26, and a wheel fall determining process shown in FIG. 27.

First, the skid determining process is described.

In the skid determining process shown in FIG. 24, control unit 70 performs processes as follows.

First, control unit 70 acquires a detection signal from first rotation speed sensor 76. Control unit 70 calculates a rotation speed of drive wheels 31
5 based on the acquired detection signal (step S11).

Next, control unit 70 acquires a detection signal from second rotation speed sensor 77. Control unit 70 calculates a rotation speed of caster 23 based on the acquired detection signal (step S12).

Next, control unit 70 determines whether or not the rotation speed of
10 drive wheels 31 is higher than the rotation speed of caster 23 by a predetermined difference or larger (step S13). The predetermined difference is determined in advance such that whether drive wheels 31 are skidding can be determined based on a difference between the calculated rotation speed of drive wheels 31 and the calculated rotation speed of caster 23. The
15 predetermined difference is, for example, a case where a number of rotations of caster 23 is less than 2 in a case where drive wheels 31 travel at a speed of 30 cm/sec.

In a case where a difference between the rotation speed of drive wheel 31 and the rotation speed of caster 23 is equal to or larger than the
20 predetermined difference (YES in step S13), control unit 70 determines that there is a travelling inhibiting factor. Then, control unit 70 determines that the travelling inhibiting factor is a skid of drive wheels 31 (step S14).

Meanwhile, in a case where the difference between the rotation speeds is less than the predetermined difference (NO in step S13), control unit 70
25 determines that there is no travelling inhibiting factor and that drive wheels 31 are not skidding (step S15).

Then, the skid determining process is finished.

The collision determining process is described below.

In the collision determining process shown in FIG. 25, control unit 70 performs processes as follows.

First, control unit 70 determines whether or not a detection signal has
5 been output by collision detection sensor 73 (step S21). Collision detection sensor 73 is turned on and outputs the detection signal to control unit 70 in a case where bumper 22 collides with an object and is pushed toward body 20.

That is, in a case where the detection signal is output by collision
detection sensor 73 (YES in step S21), control unit 70 determines that there is a
10 travelling inhibiting factor. Then, control unit 70 determines that the travelling inhibiting factor is collision between bumper 22 and the object (step S22).

Meanwhile, in a case where the detection signal is not output by
collision detection sensor 73 (NO in step S21), control unit 70 determines that
15 there is no travelling inhibiting factor and that bumper 22 has not collided with an object (step S23).

Then, the collision determining process is finished.

The step determining process is described below.

In the step determining process shown in FIG. 26, control unit 70
20 performs processes as follows.

First, control unit 70 acquires detection signals from the plurality of
floor surface detection sensors 74. Control unit 70 calculates distances
between parts of body 20 where floor surface detection sensors 74 are provided
and a floor surface based on the acquired detection signals (step S31).

25 Next, control unit 70 determines whether or not the distances between the parts of body 20 and the floor surface are equal to or larger than a predetermined distance (step S32). The predetermined distance is determined

in advance such that whether a step exists below body 20 can be determined based on the calculated distances between the parts of body 20 and the floor surface.

In a case where the distances between the parts of body 20 and the floor surface are equal to or larger than the predetermined distance (YES in step S32), control unit 70 determines that there is a travelling inhibiting factor. Then, control unit 70 determines that the travelling inhibiting factor is a step existing below body 20 (step S33).

Meanwhile, in a case where the distances between the parts of body 20 and the floor surface are less than the predetermined distance, control unit 70 determines that there is no travelling inhibiting factor and that there is no step below body 20 (step S34). The step determined in the step determining process is, for example, a step that causes large impact on cleaner 10 when cleaner 10 falls on the step.

Then, the step determining process is finished.

The wheel fall determining process is described below.

In the wheel fall determining process shown in FIG. 27, control unit 70 performs processes as follows.

First, control unit 70 acquires a detection signal from wheel fall detection sensor 78. Control unit 70 calculates an amount by which drive wheel 31 floats above the floor surface (hereinafter referred to as a “floating amount”) based on the acquired detection signal (step S41).

Next, control unit 70 determines whether or not the calculated floating amount is equal to or larger than a predetermined floating amount (step S42). The predetermined floating amount is determined in advance such that whether drive wheel 31 has fallen can be determined based on the calculated floating amount.

In a case where the calculated floating amount is equal to or larger than the predetermined floating amount (YES in step S42), control unit 70 determines that there is a travelling inhibiting factor. Then, control unit 70 determines that the travelling inhibiting factor is wheel fall of drive wheel 31 (step S43).

Meanwhile, in a case where the calculated floating amount is less than the predetermined floating amount (NO in step S42), control unit 70 determines that there is no travelling inhibiting factor and that drive wheel 31 has not fallen (step S44).

Then, the wheel fall determining process is finished.

The third moving control is executed as described above.

An operation performed in a case where control unit 70 determines that there is a travelling inhibiting factor in any of the determining processes of the third moving control is specifically described below.

First, control unit 70 reverses drive wheels 31 at a rotation speed lower than the rotation speed of drive wheels 31 calculated based on a detection signal obtained from first rotation speed sensor 76. Reversal of drive wheels 31 causes cleaner 10 to retreat from the spot. This sometimes overcomes the travelling inhibiting factor.

Note that in a case where there is a travelling inhibiting factor, there is a possibility that an actual direction of drive wheels 31 is largely deviated from a direction recognized by control unit 70.

However, the third moving control causes cleaner 10 to retreat while rotating drive wheels 31 at a low rotation speed, as described above. This can lower a risk of movement of cleaner 10 in a direction that is markedly different from a direction recognized by control unit 70. Furthermore, it is possible to lower a risk of collision of cleaner 10 with an obstacle. It is therefore possible

to provide cleaner 10 that is good in operation stability.

(Modifications)

The above exemplary embodiment has described examples that can be assumed by the autonomous cleaner; however, the above exemplary
5 embodiment is not limiting.

In other words, the autonomous cleaner of the present exemplary embodiment can include, in addition to the above exemplary embodiment, the following modifications and any mode resulting from a combination of at least two modifications that are mutually consistent, for example.

10 Specifically, the first cleaning control may be freely changed.

For example, the following process may be further added to the first cleaning control.

Specifically, control unit 70 may execute the following control in a case where it is highly likely that detection signals obtained from floor surface
15 detection sensors 74 reflect the first surface or the second surface while cleaner 10 is cleaning the third surface.

In this case, control unit 70 makes a period for determination of the type of floor surface based on detection signals obtained from floor surface detection sensors 74 longer than a period for determination of the type of floor
20 surface in other situations. The other situations are, for example, a case where cleaner 10 is cleaning the first surface and a case where cleaner 10 is cleaning the second surface.

That is, in a case where the type of floor surface on which cleaner 10 is located changes from the third surface to the first surface or the second surface,
25 the detection signals obtained from floor surface detection sensors 74 change from a state where a fluctuation is large to a state where a fluctuation is small. Even in a case where the type of floor surface actually changes, a fluctuation of

the detection signals obtained from floor surface detection sensors 74 does not converge promptly. Accordingly, the state where the fluctuation of the detection signals is large sometimes continues even after the type of floor surface changes. In a case where the type of floor surface is determined in this
5 state, it is highly likely that control unit 70 erroneously determines the type of floor surface. In view of this, the period for determination of the type of floor surface is set long. This makes it more likely that control unit 70 can determine the type of floor surface with more certainty even in such a situation where there is a high risk of erroneous determination.

10 Furthermore, the concentrated cleaning operations in the second cleaning control may be freely changed.

For example, a third cleaning operation may be defined in advance in addition to the first cleaning operation and the second cleaning operation described above, and a concentrated cleaning operation corresponding to the
15 type of floor surface may be selected from among the three kinds of cleaning operations.

A specific operation is described with reference to FIGS. 1, 22, 28A, and 28B.

FIG. 28A shows behavior of cleaner 10 in the first cleaning operation
20 that is similar to that shown in FIG. 21A. FIG. 28B shows an example of another behavior of cleaner 10 in the third cleaning operation.

That is, in the third cleaning operation, cleaner 10 circles about a virtual center of rotation set in a concentrated cleaning region as shown in FIG. 28B. Cleaner 10 spins while circling. The aforementioned cleaning operation
25 makes it easier to raise lying threads of a carpet. As a result, it is possible to reduce an amount of dust that remains without being sucked even on the third surface such as a carpet, and it is therefore possible to clean the third surface

with more certainty.

The third cleaning operation may be arranged as follows. For example, cleaner 10 may performs a cleaning operation while circling about the virtual center of rotation without spinning. Furthermore, a radius of circling of
5 cleaner 10 may be changed based on a detection signal obtained from obstacle detection sensor 71.

For example, control unit 70 sets the radius of circling long in a case where there is no obstacle around body 20. Meanwhile, in a case where there is an obstacle around body 20, control unit 70 sets a circling distance shorter as
10 a distance between the obstacle and body 20 becomes shorter. According to this control, it is possible to efficiently clean a wide range by a concentrated cleaning operation in a range where body 20 does not collide with the obstacle.

Furthermore, the third cleaning control may be freely changed.

For example, control unit 70 first causes cleaner 10 to travel toward
15 wall P2. Then, control unit 70 may stop travelling of cleaner 10 when a distance between body 20 and wall P2 reaches a predetermined distance in a range where a gap is created between body 20 and wall P2. In this state, dust close to wall P2 and dust at corner P3 are collected toward a region below body 20 by rotation of auxiliary brush 100 and are sucked into body 20.

20 The above detailed descriptions are illustrative and are not restrictive. For example, the embodiment or one or more modifications may be combined as needed.

Furthermore, a technical feature or a subject disclosed in the present exemplary embodiment may exist in features less than all features of a specific
25 exemplary embodiment. Accordingly, the claims are incorporated into the detailed description of the invention, and it is needless to say that each claim can claim itself as an individual exemplary embodiment.

Furthermore, it is needless to say that the scope disclosed in the present exemplary embodiment is determined based on both rights given to the claims and whole ranges of equivalents thereof.

As has been described above, the present invention may be an auxiliary
5 brush that is attached to a body so as to be capable of collecting dust to a suction port provided in a bottom surface of the body that constitutes an autonomous cleaner, the auxiliary brush including a short bristle bundle that is a bundle of short bristles and a long bristle bundle that is a bundle of bristles longer than the short bristle bundle.

10 According to the configuration, in a case where the autonomous cleaner equipped with the auxiliary brush cleans a corner of a region to be cleaned, dust close to a vertex of the corner that is out of reach of the short bristle bundle can be collected by the long bristle bundle. Furthermore, in a case where the autonomous cleaner cleans along a wall in the region to be cleaned, the short
15 bristle bundle does not make contact with the wall or an amount of warpage of the short bristle bundle is smaller than the long bristle bundle even in a case where the short bristle bundle makes contact with the wall. This can lower a risk of flicking dust far away by the short bristle bundle. It is therefore possible to efficiently collect dust around the body.

20 Furthermore, the auxiliary brush of the autonomous cleaner according to the present invention may include a brush shaft that is rotated relative to the body by force transmitted from a power source provided in the body, an attachment part that is attached to the brush shaft so as to rotate integrally with the brush shaft, and a bristle holder that is provided so as to protrude
25 from the attachment part and hold the short bristle bundle and the long bristle bundle.

According to the configuration, the brush shaft, the attachment part,

the bristle holder, the short bristle bundle, and the long bristle bundle integrally rotate. Dust around the body is collected by the short bristle bundle and the long bristle bundle. Furthermore, in a case where auxiliary brushes are configured such that front ends of bristle bundles reach the same position, a
5 length of a bristle bundle of a former auxiliary brush can be made shorter than a length of a bristle bundle of a latter auxiliary brush. This makes it possible to reduce an amount of warpage of the bristle bundle that makes contact with a wall.

Furthermore, the auxiliary brush of the autonomous cleaner according
10 to the present invention may be configured such that the bristle holder holds the short bristle bundle and the long bristle bundle such that a gap is created between the short bristle bundle and the long bristle bundle.

According to the configuration, in a case where the autonomous cleaner equipped with the auxiliary brush is placed on a floor surface, the short bristle
15 bundle and the long bristle bundle are pressed against the floor surface, and bristles that constitute the bristle bundles spread. That is, in a case where the short bristle bundle and the long bristle bundle are held by the bristle holder, the spread bristles of the short bristle bundle and the spread bristles of the long bristle bundle are unlikely to overlap each other. This widens contact areas of
20 the short bristle bundle and the long bristle bundle with the floor surface. It is therefore possible to more efficiently collect dust around the body.

Furthermore, the bristle holder of the auxiliary brush of the autonomous cleaner according to the present invention may hold the short bristle bundle and the long bristle bundle such that the short bristle bundle is
25 followed by the long bristle bundle in a rotation direction of the auxiliary brush.

According to the configuration, the short bristle bundle that is less likely to be warped by contact with a wall than the long bristle bundle collects

dust earlier. Accordingly, it is less likely that the dust is flicked far away when the long bristle bundle returns from the warped state to an original state.

Furthermore, the autonomous cleaner according to the present invention may include the auxiliary brush.

5 According to this configuration, effects substantially similar to the effects obtained by the auxiliary brush can be obtained.

Furthermore, the autonomous cleaner according to the present invention includes an obstacle detection sensor that detects a forward distance that is a distance between a front face of the body and an object and a distance
10 measuring sensor that detects a sideways distance that is a distance between a side face of the body and an object. The autonomous cleaner is moved from a first position where the forward distance detected by the obstacle detection sensor is a first distance and the sideways distance detected by the distance
15 measuring sensor is a second distance to a second position where the forward distance detected by the obstacle detection sensor is a third distance longer than the first distance and the sideways distance detected by the distance
measuring sensor is a fourth distance longer than the second distance. For this purpose, the autonomous cleaner may rotate at the first position and then retreat from the first position to the second position after the rotation.

20 According to this configuration, in a case where an object is present close to a front face or close to one of sides, the autonomous cleaner first rotates in order to retreat from the spot. Then, the autonomous cleaner retreats to the second position. Accordingly, even in a case where a shape of the body is not circular, the body is unlikely to collide with a nearby object when retreating
25 from the first position.

Furthermore, the autonomous cleaner according to the present invention may include a dust sensor that detects an amount of dust flowing

from the suction port and travel so as to draw a circle in a case a determined amount of dust is equal to or larger than a predetermined amount based on a detection signal obtained from the dust sensor.

According to this configuration, the autonomous cleaner intensively
5 cleans a region where an amount of dust is large. Furthermore, the autonomous cleaner moves in various directions because of the circular movement. This makes it possible to effectively scrape up and easily suck, for example, dust between threads of a carpet.

Furthermore, the autonomous cleaner according to the present
10 invention may include a drive wheel for traveling of the body and a first rotation speed sensor that detects a rotation speed of the drive wheel and change a method for controlling the drive wheel so as to overcome a travelling inhibiting factor that inhibits travelling of the autonomous cleaner upon detection of the travelling inhibiting factor.

According to this configuration, behavior of the autonomous cleaner is
15 changed by changing the method for controlling the drive wheel. This increases a possibility of overcoming the travelling inhibiting factor. In this case, the drive wheel is rotated at a low speed. Accordingly, it is less likely that a large impact is given to the autonomous cleaner even in a case where the
20 autonomous cleaner makes contact with an obstacle. It is therefore possible to obtain a highly reliable autonomous cleaner.

Furthermore, the autonomous cleaner according to the present invention includes a caster and a second rotation speed sensor that detects a rotation speed of the caster. The drive wheel may be rotated in a reverse
25 direction at a speed lower than the rotation speed detected by the first rotation speed sensor in a case where it is determined that the drive wheel is skidding based on a detection signal obtained from the first rotation speed sensor and a

detection signal obtained from the second rotation speed sensor.

According to this configuration, the autonomous cleaner retreats by the reverse rotation of the drive wheel. This heightens a possibility of overcoming the skid. Furthermore, the autonomous cleaner retreats while rotating the drive wheel at a low speed. Accordingly, it is less likely that a large impact is given to the autonomous cleaner even in a case where the autonomous cleaner makes contact with an obstacle when retreating.

Furthermore, the autonomous cleaner according to the present invention includes a bumper provided on a front part of the body and a collision detection sensor that detects collision of the bumper with an object. The drive wheel may be rotated in a reverse direction at a speed lower than the rotation speed detected by the first rotation speed sensor in a case where it is determined that the bumper has collided with an object based on a detection signal obtained from the collision detection sensor.

According to this configuration, the autonomous cleaner retreats by the reverse rotation of the drive wheel. This makes it possible to promptly move the autonomous cleaner away from the object present ahead of the autonomous cleaner. Furthermore, the autonomous cleaner retreats while rotating the drive wheel at a low speed. Accordingly, it is less likely that a large impact is given to the autonomous cleaner even in a case where the autonomous cleaner makes contact with an obstacle when retreating.

Furthermore, the autonomous cleaner according to the present invention may include a floor surface detection sensor that detects a distance from a floor surface and rotate the drive wheel in a reverse direction at a speed lower than the rotation speed detected by the first rotation speed sensor in a case where it is determined that a step is present below the body based on a detection signal obtained from the floor surface detection sensor.

According to this configuration, the autonomous cleaner retreats by the reverse rotation of the drive wheel. This makes it possible to promptly move the autonomous cleaner to a place where no step is present. Furthermore, the autonomous cleaner retreats while rotating the drive wheel at a low speed.

5 Accordingly, it is less likely that a large impact is given to the autonomous cleaner even in a case where the autonomous cleaner makes contact with an obstacle when retreating.

Furthermore, the autonomous cleaner according to the present invention may include a wheel fall detection sensor that detects fall of the drive

10 wheel and rotate the drive wheel in a reverse direction at a speed lower than the rotation speed detected by the first rotation speed sensor in a case where it is determined that the drive wheel has fallen based on a detection signal obtained from the wheel fall detection sensor.

According to this configuration, the autonomous cleaner retreats by the

15 reverse rotation of the drive wheel. This heightens a possibility of overcoming wheel fall of the autonomous cleaner. Furthermore, the autonomous cleaner retreats while rotating the drive wheel at a low speed. Accordingly, it is less likely that a large impact is given to the autonomous cleaner even in a case where the autonomous cleaner makes contact with an obstacle when retreating.

Furthermore, the autonomous cleaner according to the present invention includes a fence that determines a range where the autonomous cleaner moves and is constituted by a plurality of panels that are connected in a foldable manner. Each of the panels may include a shaft bearing provided at a first end and a rotary shaft provided at a second end, the rotary shaft of one

20 panel being attachable to the shaft bearing of another panel, and the rotary shaft and the shaft bearing being movable relative to each other in a direction normal to a plane including the rotary shaft and the shaft bearing.

According to this configuration, the rotary shaft and the shaft bearing of the panels move relative to each other in the direction normal to the plane when the plurality of panels are folded. This reduces a gap between the one panel and the other panel. It is therefore possible to reduce a space necessary
5 for storage of the fence.

(Notes regarding solution to problem)

Note (1)

An autonomous cleaner including a body having a dust suction port in a bottom surface, a drive wheel for travelling of the body, a floor surface detection
10 sensor that is provided on the body so as to be capable of detecting a distance from a floor surface, and a control unit that reflects a result of detection of the floor surface detection sensor in control concerning cleaning, wherein the floor surface detection sensor is provided closer to a rear side than the drive wheel is.

Note (2)

15 The autonomous cleaner according to Note (1), further including a main brush provided in the suction port opened in the bottom surface of the body, wherein the floor surface detection sensor is provided closer to the rear side than the main brush is.

Note (3)

20 The autonomous cleaner according to Note (1) or Note (2), further including an auxiliary brush that is provided on the body so as to be capable of collecting dust to the suction port, wherein the floor surface detection sensor is provided closer to the rear side than the auxiliary brush is.

Note (4)

25 The autonomous cleaner according to any of Notes (1) through (3), wherein the control unit changes a moving direction of the body to a plurality of directions in a case where it is determined that the floor surface is a carpet

based on a result of detection of the floor surface detection sensor.

INDUSTRIAL APPLICABILITY

The present invention is applicable to various autonomous cleaners
5 such as those for home use and those for business use.

REFERENCE MARKS IN THE DRAWINGS

	1: cleaner system
	10: autonomous cleaner (cleaner)
10	20: body
	20A: bottom surface
	20B: suction port
	20C: side part
	21: panel cover
15	22: bumper
	23: caster
	30: drive unit
	31: drive wheel
	32: housing
20	40: cleaning unit
	41: main brush
	50: trash can unit
	51: trash can
	52: main body
25	52A: inlet
	52B: outlet
	53: lid

	54: hinge
	55: filter
	56: frame
	56A: window
5	56B: middle wall
	56C: guide
	56D: top part
	56E: guide surface
	57: collector
10	58: buckle
	59: handle
	60: suction unit
	70: control unit
	71: obstacle detection sensor
15	72: distance measuring sensor
	73: collision detection sensor
	74: floor surface detection sensor
	75: dust sensor
	76: first rotation speed sensor
20	77: second rotation speed sensor
	78: wheel fall detection sensor
	80: power unit
	90: fence
	91: panel
25	91A: first end
	91B: second end
	92: rotary shaft

	93: shaft bearing
	93A: claw
	93D, 58P, 58Q: gap
	94: base
5	95: panel body
	100: auxiliary brush
	110: brush shaft
	120: attachment part
	130: bristle holder
10	140: bristle bundle
	141: short bristle bundle
	142: long bristle bundle
	D1: first distance
	D2: second distance
15	D3: third distance
	D4: fourth distance
	P1,P2: wall
	P3: corner
	P4: vertex
20	

CLAIMS

1. An auxiliary brush that is attached to a body constituting an autonomous cleaner so as to be capable of collecting dust to a suction port
5 provided in a bottom surface of the body, the auxiliary brush comprising:
 - a short bristle bundle that is a bundle of short bristles; and
 - a long bristle bundle that is a bundle of bristles longer than the short bristle bundle.
- 10 2. The auxiliary brush according to claim 1, further comprising:
 - a brush shaft that is rotated relative to the body by force transmitted from a power source provided in the body;
 - an attachment part that is attached to the brush shaft so as to rotate integrally with the brush shaft; and
 - 15 a bristle holder that is provided so as to protrude from the attachment part and hold the short bristle bundle and the long bristle bundle.
- 20 3. The auxiliary brush according to claim 2, wherein the bristle holder holds the short bristle bundle and the long bristle bundle such that a gap is created between the short bristle bundle and the long bristle bundle.
- 25 4. The auxiliary brush according to claim 2, wherein the bristle holder holds the short bristle bundle and the long bristle bundle such that the short bristle bundle is followed by the long bristle bundle in a rotation direction of the auxiliary brush.
5. An autonomous cleaner comprising the auxiliary brush according to

claim 1.

6. The autonomous cleaner according to claim 5, further comprising:
an obstacle detection sensor that detects a forward distance that is a
5 distance between a front face of the body and an object; and
a distance measuring sensor that detects a sideways distance that is a
distance between a side face of the body and an object,
wherein the autonomous cleaner rotates at a first position where the
forward distance detected by the obstacle detection sensor is a first distance
10 and the sideways distance detected by the distance measuring sensor is a second
distance and then retreats from the first position to a second position where the
forward distance is a third distance longer than the first distance and the
sideways distance is a fourth distance longer than the second distance in order
to move from the first position to the second position after the rotation.

15

7. The autonomous cleaner according to claim 5, further comprising a
dust sensor that detects an amount of dust flowing from a suction port,
wherein the autonomous cleaner travels so as to draw a circle in a case
where a determined amount of dust is equal to or larger than a predetermined
20 amount based on a detection signal obtained from the dust sensor.

8. The autonomous cleaner according to claim 5, further comprising:
a drive wheel for travelling of the body; and
a first rotation speed sensor that detects a rotation speed of the drive
25 wheel,

wherein a method for controlling the drive wheel is changed so as to
overcome a travelling inhibiting factor that inhibits travelling of the

autonomous cleaner upon detection of the travelling inhibiting factor.

9. The autonomous cleaner according to claim 8, further comprising:

a caster; and

5 a second rotation speed sensor that detects a rotation speed of the
caster,

wherein the drive wheel is rotated in a reverse direction at a speed
lower than the rotation speed detected by the first rotation speed sensor in a
case where it is determined that the drive wheel is skidding based on a
10 detection signal obtained from the first rotation speed sensor and a detection
signal obtained from the second rotation speed sensor.

10. The autonomous cleaner according to claim 8, further comprising:

a bumper that is provided on a front part of the body; and

15 a collision detection sensor that detects collision of the bumper with an
object,

wherein the drive wheel is rotated in a reverse direction at a speed
lower than the rotation speed detected by the first rotation speed sensor in a
case where it is determined that the bumper has collided with an object based
20 on a detection signal obtained from the collision detection sensor.

11. The autonomous cleaner according to claim 8, further comprising a
floor surface detection sensor that detects a distance from a floor surface,

wherein the drive wheel is rotated in a reverse direction at a speed
25 lower than the rotation speed detected by the first rotation speed sensor in a
case where it is determined that a step is present below the body based on a
detection signal obtained from the floor surface detection sensor.

12. The autonomous cleaner according to claim 8, further comprising a wheel fall detection sensor that detects wheel fall of the drive wheel,

wherein the drive wheel is rotated in a reverse direction at a speed
5 lower than the rotation speed detected by the first rotation speed sensor in a case where it is determined that the drive wheel has been fallen based on a detection signal obtained from the wheel fall detection sensor.

13. A cleaner system comprising:

10 the autonomous cleaner according to claim 5; and

a fence that determines a range where the autonomous cleaner moves and is constituted by a plurality of panels that are connected in a foldable manner,

wherein each of the panels includes a shaft bearing provided at a first
15 end and a rotary shaft provided at a second end,

wherein the rotary shaft of one of the panels is attachable to the shaft bearing of another one of the panels, and

wherein the rotary shaft and the shaft bearing are movable relative to each other in a direction normal to a plane including the rotary shaft and the
20 shaft bearing.