



(11) **EP 3 679 847 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
15.07.2020 Bulletin 2020/29

(51) Int Cl.:
A47L 9/28 ^(2006.01)

(21) Application number: **17923582.5**

(86) International application number:
PCT/JP2017/031740

(22) Date of filing: **04.09.2017**

(87) International publication number:
WO 2019/043937 (07.03.2019 Gazette 2019/10)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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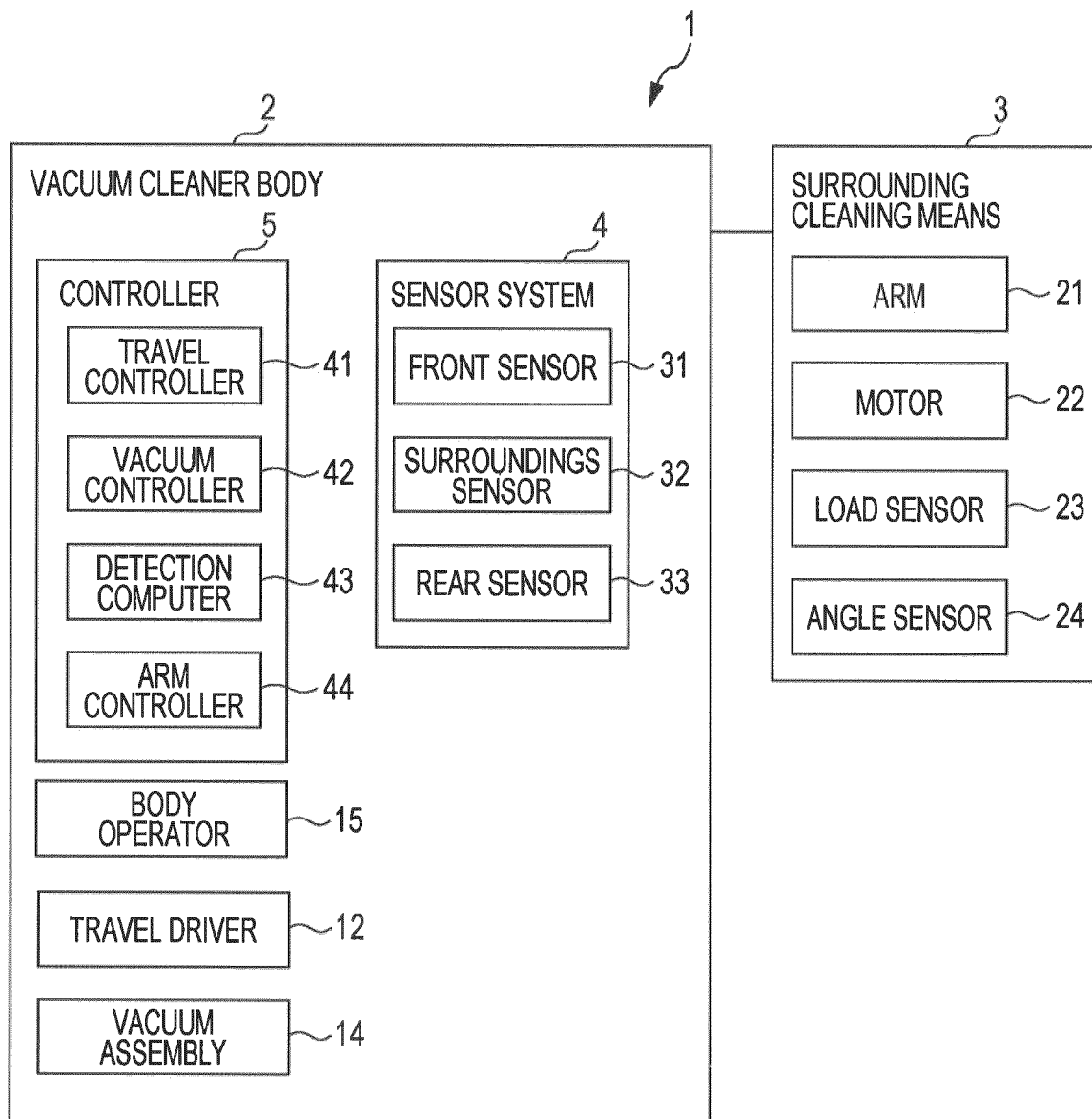
(54) **SELF-PROPELLED VACUUM CLEANER**

(57) An autonomous vacuum cleaner is provided which can clean efficiently around a vacuum cleaner body. An autonomous vacuum cleaner (1) includes a vacuum cleaner body (2) having a wheel (121) for travelling autonomously, a surroundings sensor (32) for detecting an obstacle around the vacuum cleaner body (2), a pivoting cleaner (3) that can clean around the vacuum cleaner body (2), and a controller (5) that controls the surroundings sensor (32) and the pivoting cleaner (3). The pivoting cleaner (3) includes an arm (21) that protrudes

outward from the vacuum cleaner body (2), a motor (22) that drives the arm (21), and a load sensor (23) that detects a load acting on the arm (21) from the outside. The motor (22) is controlled and driven on the basis of the presence or absence of an obstacle detected by the surroundings sensor (32), and travel of the vacuum cleaner body (2) is controlled on the basis of a load detected by the load sensor (23).

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FIG. 19



Description

TECHNICAL FIELD

[0001] The present invention relates to an autonomous vacuum cleaner.

BACKGROUND ART

[0002] As an autonomous vacuum cleaner (vacuum cleaning robot) for cleaning the floor surface, an autonomous vacuum cleaner is conventionally known which includes a travel means for causing a vacuum cleaner body to travel, a main cleaning means that is provided on an undersurface of the vacuum cleaner body to suck up dust and the like on the floor surface, and a surrounding cleaning means that is provided, configured to be capable of protruding sideways from the vacuum cleaner body (refer to, for example, Patent Literature 1). The travel means is configured by a pair of left and right wheels to drive each wheel in a forward direction and a backward direction and cause the vacuum cleaner body to travel in a front-and-rear direction and turn in any direction. The main cleaning means includes a duct communicating with a main vacuum inlet, and a suction fan, and is configured to send the dust and the like that are sucked up through the main vacuum inlet into a dust collection chamber.

[0003] The surrounding cleaning means of the autonomous vacuum cleaner described in Patent Literature 1 includes a movable vacuum member (protrusion) that can protrude outward from the vacuum cleaner body, a torsion spring (biasing means) that biases the movable vacuum member in the protruding direction, and a speed-reduction mechanism-equipped motor (drive means) that stores the movable vacuum member into the vacuum cleaner body against the biasing force of the torsion spring. The drive force from the speed-reduction mechanism-equipped motor to the movable vacuum member is transmitted in the storage direction via first and second transmission means, and is cut off in the protruding direction by the first and second transmission means; accordingly, the drive force is not transmitted but only the biasing force of the torsion spring acts on the movable vacuum member. Therefore, it is configured in such a manner that when the protruding movable vacuum member comes into contact with an obstacle or the like, the movable vacuum member is stored into the vacuum cleaner body against the biasing force of the torsion spring, and when the movable vacuum member moves away from the obstacle, the movable vacuum member protrudes again on the basis of the biasing force of the torsion spring.

CITATION LIST

PATENT LITERATURE

[0004] PATENT LITERATURE 1: JP-A-2008-279066

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] However, in terms of the surrounding cleaning means in such a known autonomous vacuum cleaner as is described in Patent Literature 1, the protrusion (movable vacuum member) is pivotably supported by the vacuum cleaner body, and is stored into the vacuum cleaner body by the drive means (speed-reduction mechanism-equipped motor), but the protrusion simply protrudes in the protruding direction on the basis of the biasing force of the biasing means (such as the torsion spring). Hence, there are, for example, problems that the protrusion amount, pivot angle, and the like of the protrusion cannot be finely controlled, and the cleaning area by the surrounding cleaning means is limited, and it is difficult to efficiently clean around the vacuum cleaner body.

[0006] An object of the present invention is to provide an autonomous vacuum cleaner that can clean efficiently around a vacuum cleaner body.

SOLUTIONS TO THE PROBLEMS

[0007] An autonomous vacuum cleaner according to the present invention is capable of cleaning while traveling along a floor surface, the autonomous vacuum cleaner including: a vacuum cleaner body including a wheel for travelling autonomously; a surrounding detection means for detecting an obstacle around the vacuum cleaner body; a surrounding cleaning means capable of cleaning around the vacuum cleaner body; and a control means configured to control the surrounding detection means and the surrounding cleaning means. The surrounding cleaning means includes: a protrusion capable of protruding outward from the vacuum cleaner body; a drive means configured to drive the protrusion in such a manner as to protrude and retract; and a load detection means configured to detect a load acting on the protrusion from the outside, and the control means controls and drives the drive means on the basis of the presence or absence of an obstacle detected by the surrounding detection means, and controls travel of the vacuum cleaner body on the basis of a load detected by the load detection means.

[0008] According to such a present invention, the autonomous vacuum cleaner includes the surrounding detection means, the surrounding cleaning means, and the control means. The surrounding cleaning means has the drive means that drives the protrusion, and the load detection means. The drive means is controlled and driven on the basis of the presence or absence of an obstacle

detected by the surrounding detection means. The travel of the vacuum cleaner body is controlled on the basis of a load detected by the load detection means. Accordingly, it is possible to finely control the protrusion amount of the protrusion and the travel of the vacuum cleaner body. Therefore, it is possible to appropriately change the cleaning area by the surrounding cleaning means according to, for example, the presence or absence of an obstacle in the cleaning area and the distance to the obstacle, and efficiently clean around the vacuum cleaner body.

[0009] In the present invention, in a case where the load detection means shifts from a load detecting state to a non-load detecting state, it is preferred that the control means judges that the protrusion becomes movable, drives the drive means, and causes the protrusion to move and protrude.

[0010] According to such a configuration, it is judged whether or not the protrusion can move, on the basis of the presence or absence of a load detected by the load detection means and, if it is judged that the protrusion can move, the drive means is driven to cause the protrusion to move and protrude. Accordingly, it is possible to efficiently move the protrusion while reducing excessive load on the drive means.

[0011] In the present invention, in a case where the surrounding detection means detects an obstacle upon the drive means being driven to move the protrusion, it is preferred that the control means controls the drive means in such a manner as to reduce the moving speed of the protrusion with decreasing distance to the obstacle.

[0012] According to such a configuration, the drive means is controlled in such a manner that in the case where the surrounding detection means detects an obstacle, the moving speed of the protrusion is reduced with decreasing distance to the obstacle. Accordingly, it is possible to prevent the protrusion from colliding with the obstacle and reduce the load.

[0013] In the present invention, the surrounding cleaning means preferably includes a biasing means configured to bias the protrusion in a protruding direction.

[0014] According to such a configuration, the protrusion is biased in the protruding direction by the biasing means. Accordingly, the protrusion is displaced by the elasticity of the biasing means upon an external force acting on the protrusion. Consequently, it is possible to reduce loads on the protrusion and the vacuum cleaner body and reduce damage to a wall, furniture, and the like that the protrusion comes into contact with.

[0015] In the present invention, it is preferred that the protrusion is pivotably supported by the vacuum cleaner body, and the drive means drives the protrusion to pivot.

[0016] According to such a configuration, the protrusion is pivotably supported by the vacuum cleaner body, and is driven by the drive means to pivot. Accordingly, it is possible to efficiently clean around the vacuum cleaner body.

[0017] In the present invention, it is preferred that the

protrusion is configured to include: a first pivoting member rotatably supported on one end side thereof by the vacuum cleaner body; and a second pivoting member rotatably supported on the other end side of the first pivoting member.

[0018] According to such a configuration, the protrusion has the first and second pivoting members. Accordingly, it is possible to enlarge the cleaning area by the surrounding cleaning means and efficiently clean corners of a wall and an obstacle by causing the second pivoting member to reach the corners.

[0019] In the present invention, it is preferred that the drive means is a rotation drive means configured to drive and rotate the first pivoting member with respect to the vacuum cleaner body, and the second pivoting member is biased by a rotation biasing means with respect to the first pivoting member in a rotation direction.

[0020] According to such a configuration, the rotation drive means drives and rotates the first pivoting member with respect to the vacuum cleaner body, and the rotation biasing means biases the second pivoting member with respect to the first pivoting member in the rotation direction. Accordingly, the second pivoting member pivots and is displaced by the elasticity of the rotation biasing means upon an external force acting on the second pivoting member. Consequently, it is possible to reduce loads on the first pivoting member and the rotation drive means and reduce damage to a wall, furniture, and the like that the second pivoting member comes into contact with.

[0021] In the present invention, it is preferred that the surrounding cleaning means has a vacuum cleaning function of sucking up dirt and the like on the floor surface through a vacuum inlet provided to the protrusion.

[0022] According to such a configuration, the surrounding cleaning means has the vacuum cleaning function. Accordingly, it is possible to more efficiently enlarge the cleaning area.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

Fig. 1 is a perspective view of an autonomous vacuum cleaner according to one embodiment of the present invention as viewed from above.

Fig. 2 is a perspective view of the autonomous vacuum cleaner as viewed from below.

Fig. 3 is a perspective view of a protruding state of a surrounding cleaning means in the autonomous vacuum cleaner as viewed from above.

Fig. 4 is a perspective view of the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner as viewed from below.

Fig. 5 is a front view illustrating a stored state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 6 is a top view illustrating the stored state of the surrounding cleaning means in the autonomous vac-

uum cleaner.

Fig. 7 is a right-side view illustrating the stored state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 8 is a left-side view illustrating the stored state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 9 is a back view illustrating the stored state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 10 is a bottom view illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 11 is a front view illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 12 is a top view illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 13 is a right-side view illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 14 is a left-side view illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 15 is a back view illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 16 is a bottom view illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 17 is a bottom view of the changed protruding state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 18 is a cross-sectional view illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner.

Fig. 19 is a functional block diagram illustrating the schematic configuration of the autonomous vacuum cleaner.

Fig. 20 is a cross-sectional view illustrating the enlarged surrounding cleaning means.

Fig. 21 is a perspective view illustrating a cross section of the surrounding cleaning means.

Fig. 22 is a perspective view illustrating a cross section of the surrounding cleaning means.

Fig. 23 is a bottom view of the enlarged surrounding cleaning means as viewed from below.

Figs. 24(A) to 24(D) are bottom views illustrating the operation of the surrounding cleaning means.

Figs. 25(A) and 25(B) are plan views illustrating the operation of the autonomous vacuum cleaner.

Figs. 26(A) to 26(C) are plan views illustrating another operation of the autonomous vacuum cleaner.

DESCRIPTION OF THE EMBODIMENTS

[0024] One embodiment of the present invention is de-

scribed hereinafter on the basis of Figs. 1 to 24(A) to 24(D).

[0025] Fig. 1 is a perspective view of an autonomous vacuum cleaner according to one embodiment of the present invention as viewed from above. Fig. 2 is a perspective view of the autonomous vacuum cleaner as viewed from below. Fig. 3 is a perspective view of a protruding state of a surrounding cleaning means in the autonomous vacuum cleaner as viewed from above. Fig. 4 is a perspective view of the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner as viewed from below. Figs. 5 to 10 are a six-view drawing (front view, top view, right-side view, left-side view, back view, bottom view) illustrating a stored state of the surrounding cleaning means in the autonomous vacuum cleaner. Figs. 11 to 16 are a six-view drawing (front view, top view, right-side view, left-side view, back view, bottom view) illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner. Fig. 17 is a bottom view of the changed protruding state of the surrounding cleaning means in the autonomous vacuum cleaner. Fig. 18 is a cross-sectional view illustrating the protruding state of the surrounding cleaning means in the autonomous vacuum cleaner, and is a cross-sectional view at a position indicated by line A-A in Fig. 17. Fig. 19 is a functional block diagram illustrating the schematic configuration of the autonomous vacuum cleaner.

[0026] An autonomous vacuum cleaner 1 is a vacuum cleaning robot that cleans the floor surface, travelling along the floor surface and, as illustrated in Figs. 1 to 18, includes a vacuum cleaner body 2, pivoting cleaners 3 as a surrounding cleaning means (sub-cleaning means) for cleaning around the vacuum cleaner body 2, a sensor system 4 for detecting an obstacle around the vacuum cleaner body 2, and a controller 5 (refer to Fig. 19) as a control means for controlling and driving the vacuum cleaner body 2, the pivoting cleaners 3, and the sensor system 4.

[0027] The vacuum cleaner body 2 includes a body 10 having a top surface 101, a front surface 102, left and right side surfaces 103, and a rear surface 104, a chassis 11 forming an undersurface 105, a travel driver 12 having a pair of left and right wheels 121 for travelling autonomously, a lift 13 that is provided, configured to be capable of lifting up from the top surface 101 of the body 10, a vacuum assembly (main cleaning means) 14 that is provided on the undersurface 105 of the body 10 to suck up dust and dirt on the floor surface, and a body operator 15 (refer to Fig. 19) for operating the vacuum cleaner body 2. The body operator 15 is, for example, a touch sensor switch (not illustrated) provided on the top surface 101 of the vacuum cleaner body 2, and operates the autonomous vacuum cleaner 1 with a touch operation by a user and stops the autonomous vacuum cleaner 1 with a touch operation during operation.

[0028] The pivoting cleaners 3 are provided in a pair on left and right sides of a front part of the vacuum cleaner

body 2. The pivoting cleaner 3 includes an arm 21 as a pivotable pivoting member (protrusion) that protrudes sideway from the vacuum cleaner body 2, a motor 22 described below as a drive means that drives the arm 21 to pivot, a load sensor 23 (refer to Fig. 19) as a load detection means that detects load (torque) acting on the motor 22 from the outside, and an angle sensor 24 (refer to Fig. 19) as an angle detection means that detects the pivot angle of the arm 21 and is described below. The arm 21 is configured including a first arm 21A as a first pivoting member that is rotatably supported on one end side thereof by the vacuum cleaner body 2, and a second arm 21B as a second pivoting member that is rotatably supported on the other end side of the first arm 21A.

[0029] The sensor system 4 is configured including a front sensor 31 provided on the front surface 102 of the body 10, a surroundings sensor 32 as a surrounding detection means provided in the lift 13, and a rear sensor 33 provided on the rear surface 104 of the body 10. The front sensor 31 includes an ultrasonic sensor, an infrared sensor, or the like, and detects an obstacle ahead of the vacuum cleaner body 2. The surroundings sensor 32 is a laser scanner (LIDAR (Light Detection and Ranging or Laser Imaging Detection and Ranging)) that is driven and rotated inside the lift 13 and measures distance by applying laser light such as infrared laser light, and calculates the distance to an obstacle and the shape of the obstacle. The surroundings sensor 32 is not limited to the one provided in the lift 13 and is simply required to be provided at any position in the body 10. The rear sensor 33 is for detecting the distance to and the position of an unillustrated recharging station or the like, and communicates with infrared light or the like with the recharging station or the like.

[0030] The travel driver 12 includes the pair of left and right wheels 121, and a motor (not illustrated) that drives and rotates the pair of wheels 121 independently. Moreover, an auxiliary wheel 122 is provided to a rear part of the chassis 11. The vacuum assembly 14 is connected to a roller brush 141, a duct 142 (refer to Fig. 18), an unillustrated suction fan, a dust collection chamber, and an exhaust port. The vacuum assembly 14 is configured to collect the sucked dust and the like through a filter of the dust collection chamber and exhaust the sucked air from the exhaust port. As illustrated in Fig. 18, the duct 142 or the dust collection chamber for the vacuum assembly 14 is connected to a sub-duct 143 as a dust collection path communicating with the arm 21 of the pivoting cleaner 3.

[0031] As illustrated in Fig. 19, the controller 5 includes a travel controller 41 that controls the travel driver 12, a vacuum controller 42 that controls the vacuum assembly 14, a detection computer 43 that processes detection signals from the front sensor 31, the surroundings sensor 32, and the rear sensor 33 of the sensor system 4, and the load sensor 23 and the angle sensor 24 of the pivoting cleaner 3, and an arm controller 44 that controls and drives the motor 22 of the pivoting cleaner 3 and causes

the arm 21 to pivot.

[0032] The structure and operation of the pivoting cleaner 3 are described in detail below with reference also to Figs. 20 to 24(A) to 24(D). Fig. 20 is a cross-sectional view illustrating the enlarged pivoting cleaner 3. Figs. 21 and 22 are perspective views illustrating a cross section of the pivoting cleaner 3. Fig. 23 is a bottom view of the enlarged pivoting cleaner 3 as viewed from below. Figs. 24(A) to 24(D) are bottom views illustrating the operation of the pivoting cleaner 3.

[0033] As illustrated in Figs. 20 to 22, the first arm 21A of the arm 21 as a whole is formed into a hollow shape. A cylindrical first inner tube member (inner tube) 61 that protrudes and opens upward and a column 62 that protrudes downward are formed on one end side of the first arm 21A. An annular second outer tube member (second outer tube) 63 that opens downward is formed on the other end side. An annular first outer tube member (outer tube) 144 that opens downward is formed in the sub-duct 143. The first inner tube member 61 is inserted into the first outer tube member 144, and is rotatably supported by the first outer tube member 144 via a sliding ring 145 with a low coefficient of friction.

[0034] On the other hand, an annular bearing 11B is formed on a support 11A provided to the chassis 11. The column 62 is inserted into the bearing 11B, and is rotatably supported by the bearing 11B via a sliding ring 11C with a low coefficient of friction. The first inner tube member 61 and the column 62 of the first arm 21A, and the first outer tube member 144 of the sub-duct 143 and the bearing 11B of the chassis 11 configure a rotation support that rotatably supports the first arm 21A on the vacuum cleaner body 2.

[0035] The second arm 21B as a whole is formed into an extra-long cup shape that opens downward. In addition, a cylindrical second inner tube member (second inner tube) 71 that protrudes and opens upward is formed in a middle portion of the second arm 21B. An extension 72 that extends upward and is bent is formed on the second inner tube member 71. The extension 72 is pivotally supported by a pin 73 on an inner surface of the first arm 21A. Moreover, the second inner tube member 71 is inserted into the second outer tube member 63 of the first arm 21A, and rotatably supported on the second outer tube member 63 via a sliding ring 64 with a low coefficient of friction. The second inner tube member 71 of the second arm 21B and the second outer tube member 63 of the first arm 21A configure a second rotation support that rotatably supports the second arm 21B on the first arm 21A.

[0036] The motor 22 is fixed inside the body 10, and is configured to drive and rotate the first arm 21A by reducing the speed of rotation of the motor 22 via a drive gear 22A fixed to an output shaft of the motor 22, and a driven gear 22B supported inside the body 10 and transmit the rotation to the first arm 21A. The motor 22 is provided with an unillustrated load detection circuit that detects a load (rotational resistance) acting from the first

arm 21A. The load detection circuit configures the load sensor 23 (refer to Fig. 19).

[0037] A magnet holder 65 that extends upward and is in sliding contact with an inner surface of a top of the sub-duct 143 is formed in the first inner tube member 61 of the first arm 21A. A permanent magnet 81 as a rotor is held by the magnet holder 65. Moreover, an outer surface of the top of the sub-duct 143, that is, an outer side of the dust collection path, is provided with a magnetic field sensor 82 that detects changes in a magnetic field caused by the rotation of the permanent magnet 81, and a board 83 equipped with a detection circuit including the magnetic field sensor 82. The magnetic field sensor 82 and the board 83 configure the angle sensor 24 (refer to Fig. 19) as an angle detection means that detects the pivot angle of the first arm 21A.

[0038] The second arm 21B includes a vacuum inlet 74 that opens downward and sucks up dirt and the like on the floor surface. A downward concave cover 75 is mounted on an inner side of the vacuum inlet 74. The vacuum inlet 74 communicates with an internal space of the first arm 21A through the inside of the second inner tube member 71; in other words, the inside of the second inner tube member 71 configures a second vacuum channel 76. Furthermore, the internal space of the first arm 21A communicates with an internal space of the sub-duct 143 being the dust collection path through the inside of the first inner tube member 61; in other words, the inside of the first inner tube member 61 configures a vacuum channel 66.

[0039] As illustrated in Figs. 22 and 23, a coil spring 77 as a pivoting biasing means is provided above the cover 75 inside the second arm 21B. The coil spring 77 is a tension spring, and is latched at one end thereof onto a projection 78 provided on a distal end side of the second arm 21B, and at the other end thereof onto a projection 67 extending downward from a distal end side of the first arm 21A (an outer side of the second outer tube member 63). An arc-shaped long hole 79 (refer to Fig. 23) is formed on the second arm 21B along an outer perimeter of the second inner tube member 71. The projection 67 is inserted into the long hole 79, and is guided along the circumferential direction of the long hole 79. Therefore, the pivot angle of the second arm 21B with respect to the first arm 21A is regulated according to the length of the long hole 79 in the circumferential direction (the angle about the center of the second inner tube member 71).

[0040] As illustrated in Figs. 24(A) to 24(D), the second arm 21B is supported in such a manner as to be pivotable on the first arm 21A, and is biased by the coil spring 77 toward an initial position illustrated in Fig. 24(A). At the initial position, the projection 67 of the first arm 21A comes into contact with an edge at one end of the long hole 79 of the second arm 21B to regulate the pivotal movement of the second arm 21B. When an external force acts on the second arm 21B from the front (up in the drawing) to the rear (down in the drawing), the distal end side of the second arm 21B pivots toward the rear

against the biasing force of the coil spring 77 as illustrated in Figs. 24(B) and 24(C). When the distal end side pivots to a maximum pivot position illustrated in Fig. 24(D), the projection 67 comes into contact with an edge at the other end of the long hole 79 to regulate the pivotal movement of the second arm 21B. It is configured in such a manner that the biasing force of the coil spring 77 causes the second arm 21B to return to the initial position when the external force is removed.

[0041] Moreover, when an external force acts on the second arm 21B to cause the second arm 21B to pivot against the biasing force of the coil spring 77, resistance produced by the pivotal movement is transmitted to the first arm 21A and is detected by the load sensor 23 (refer to Fig. 19) of the motor 22 that drives and rotates the first arm 21A. As the pivot angle of the second arm 21B with respect to the first arm 21A increases, the biasing force of the coil spring 77 increases, and the load detected by the load sensor 23 also increases. Therefore, it is possible to cause the pivoting cleaner 3 to function as a contact sensor (collision sensor) with the second arm 21B as a contact (bumper).

[0042] As illustrated in Fig. 17, the above pivoting cleaner 3 is configured in such a manner that the arm 21 pivots between the stored state and the protruding state. When the arm 21 is in the stored state, the second arm 21B is located, overlapping, frontward of the vacuum assembly 14 as indicated by a virtual line (chain double dashed line) in Fig. 17. Here, the width dimension of the vacuum assembly 14 is $W1$, the width dimension of the second arm 21B is $W2$, and the width dimension of the second arm 21B excluding the portion overlapping with the vacuum assembly 14 is $W2a$. Therefore, when the arm 21 is in the stored state, the cleaning width dimension including the vacuum assembly 14 and the left and right pivoting cleaners 3 is $(W1 + 2W2a)$. Moreover, the width dimension between a side end of the vacuum assembly 14 and an outermost edge of the side surface 103 of the body 10 is $W1a$. The width dimension between an outer end of the second arm 21B and the outermost edge of the side surface 103 of the body 10 is $W3$.

[0043] On the other hand, when the arm 21 is in a maximum protruding state orthogonal to the front-and-rear direction as indicated by a solid line in Fig. 17, the second arm 21B is located substantially sideward of the vacuum assembly 14, spaced apart from the vacuum assembly 14. The width dimension of the space between them is $W4$. In the maximum protruding state, the cleaning width dimension including the vacuum assembly 14 and the left and right second arms 21B is $(W1 + 2W2)$, and the width dimension between outer ends of the left and right second arms 21B is $(W1 + 2W2 + 2W4)$. Moreover, the arm 21 is configured to be capable of pivoting farther rearward than in the maximum protruding state.

[0044] Next, the operation of the autonomous vacuum cleaner 1 is described. When the autonomous vacuum cleaner 1 is turned on, the controller 5 raises the lift 13 and drives the surroundings sensor 32, and drives the

front sensor 31 and the rear sensor 33. Furthermore, the travel controller 41 of the controller 5 controls and drives the travel driver 12 in accordance with a preset travel program, and causes the motor to rotate the wheels 121 and causes the vacuum cleaner body 2 to travel autonomously. With the travel of the vacuum cleaner body 2, the vacuum controller 42 controls the vacuum assembly 14 to start a vacuuming operation. At the start of cleaning, the arm 21 of the pivoting cleaner 3 is in the stored state illustrated in Figs. 1, 2, and 5 to 10.

[0045] The autonomous vacuum cleaner 1, which has started the operation, travels autonomously with the travel driver 12, detecting the presence or absence of an obstacle in the surroundings and the distance to the obstacle with the front sensor 31 and the surroundings sensor 32, while cleaning the floor surface with the vacuum assembly 14. In other words, the detection computer 43 computes the distance to an obstacle on the basis of detection signals from the front sensor 31 and the surroundings sensor 32; accordingly, the position and shape of the obstacle around the vacuum cleaner body 2 can be recognized. It may be configured in such a manner that the position and shape of an obstacle is recognized by computations by the front sensor 31 and the surroundings sensor 32 without the computation by the detection computer 43. In this manner, the autonomous vacuum cleaner 1 executes cleaning, storing the pivoting cleaners 3 into the stored state, and causing the arms 21 to pivot into the protruding state, while continuing travelling, recognizing obstacles around the vacuum cleaner body 2.

[0046] Specific control over the drive of the pivoting cleaner 3 during autonomous cleaning is described with reference to Figs. 25(A) and 25(B) and 26(A) to 26(C). Figs. 25(A) and 25(B) are plan views illustrating the operation of the autonomous vacuum cleaner. Figs. 26(A) to 26(C) are plan views illustrating another operation of the autonomous vacuum cleaner, and are drawings illustrating an operation of cleaning against a wall or in a corner of the wall.

[0047] As illustrated in Fig. 25(A), when the arms 21 of the pivoting cleaners 3 are in the stored state, the autonomous vacuum cleaner 1 moves forward to clean the width of the cleaning width dimension ($W1 + 2W2a$) by the vacuum assembly 14 and the left and right pivoting cleaners 3. In such a stored state of the arm 21, the part with the width dimension $W3$ between the outer end of the second arm 21B and the outermost edge of the body 10 is not cleaned. Even if the distance to the wall is reduced in the stored state, a band-shaped area near the wall cannot be cleaned. Therefore, when the surroundings sensor 32 detects a wall surface W (refer to Figs. 26(A) to 26(C)), the arms 21 are caused to pivot into the protruding state according to the distance to the wall surface W as illustrated in Fig. 25(B).

[0048] When the arm 21 of the pivoting cleaner 3 is caused to pivot into the maximum protruding state, the width dimension $W2$ of the second arm 21B is greater than the width dimension $W3$ as illustrated in Fig. 25(B).

Accordingly, it is possible to thoroughly clean against the wall including the band-shaped area that cannot clean in the stored state. The autonomous vacuum cleaner 1 in the state where the arms 21 have been caused to pivot into the maximum protruding state in this manner drives the travel driver 12, moves forward and closer to the wall surface W, and then travels parallel to the wall surface W. At this point in time, the distance between the vacuum cleaner body 2 and the wall surface W may be based on a map of a cleaning area prestored in the controller 5, or the distance detected by the front sensor 31 and the surroundings sensor 32. The autonomous vacuum cleaner 1 travels along the wall surface W in such a manner as to maintain a distance that the distal end of the second arm 21B comes into contact with the wall surface W, or the shortest distance without coming into contact with the wall surface W.

[0049] As illustrated in Figs. 26(A) to 26(C), when cleaning is conducted along the wall with the arm 21 of the pivoting cleaner 3 in contact with the wall surface W, the angle sensor 24 detects the pivot angle of the first arm 21A, and the motor 22 causes the first arm 21A to pivot to a predetermined angle. As illustrated in Fig. 26(A), if the autonomous vacuum cleaner 1 continues moving forward with the distal end of the second arm 21B in contact with the wall surface W, when the distance between the wall surface W and the vacuum cleaner body 2 is reduced, the distal end of the second arm 21B is pushed backward; accordingly, the second arm 21B pivots toward the rear against the biasing force of the coil spring 77. In this manner, even if the distance to the wall surface W changes, the second arm 21B pivots to trace and clean along the wall surface W.

[0050] The front sensor 31 and the surroundings sensor 32 detect the wall surface W ahead. When the distance to the wall surface W ahead is reduced to a predetermined distance, the controller 5 causes the travel controller 41 to control the drive of the travel driver 12 and stops the travel driver 12, and changes direction (turns left) in such a manner as to move away from the wall surface W on the side (the right side in Figs. 26(A) to 26(C)). In this manner, the autonomous vacuum cleaner 1 turns. Accordingly, the distal end of the second arm 21B moves away from the wall surface W on the side, and the biasing force of the coil spring 77 causes the second arm 21B to return to the initial position. The load sensor 23 detects the disappearance of the load on the second arm 21B. On the basis of the detection, the controller 5 stops the turn by the travel controller 41, and then causes the arm controller 44 to drive the motor 22 and cause the arm 21 to pivot back and forth, and consequently causes the pivoting cleaner 3 to vacuum and clean the corner of the wall surface W, as illustrated in Fig. 26(B). In this manner, when the arm 21 is caused to pivot back and forth, the pivot area of the arm 21 is adjusted on the basis of the distance to the wall surface W, and the motor 22 is controlled to reduce the pivot speed of the arm 21 before the distal end of the second arm

21B comes into contact with the wall surface W.

[0051] When the arm 21 is caused to pivot back and forth a predetermined number of times and the cleaning in the corner is finished, the arm controller 44 stops the motor 22 to fix the first arm 21A. The controller 5 then causes the travel controller 41 to control and drive the travel driver 12 to change direction again. With a further forward movement, tracing and cleaning along the wall surface W ahead is conducted as illustrated in Fig. 26(C).

[0052] According to such an embodiment, the following operations and effects can be exerted:

(1) The motor 22 of the pivoting cleaner 3 is controlled and driven on the basis of the presence or absence of an obstacle detected by the surroundings sensor 32, and the travel controller 41 is controlled and driven on the basis of a load detected by the load sensor 23. Accordingly, the amount of protrusion of the arm 21 and the travel operation of the vacuum cleaner body 2 can be finely controlled.

(2) The load sensor 23 detects the disappearance of a load on the second arm 21B when the autonomous vacuum cleaner 1 turns. The turn is stopped on the basis of the detection, and the arm controller 44 drives the motor 22 to cause the arm 21 to pivot back and forth. Accordingly, it is possible to cause the arm 21 to efficiently pivot while reducing excessive load on the motor 22, and clean a corner.

(3) The motor 22 is controlled in such a manner as to reduce the pivot speed of the arm 21 with decreasing distance to an obstacle when the surroundings sensor 32 detects the obstacle. Accordingly, it is possible to prevent a collision of the arm 21 with the obstacle and reduce the load.

(4) The pivoting cleaner 3 includes the first arm 21A and the second arm 21B. Accordingly, the arms 21A and 21B pivot with flexibility in accordance with the shape of an obstacle. It is possible to enlarge the cleaning area of the pivoting cleaner 3, and efficiently clean corners of a wall and an obstacle by causing the second arm 21B to reach the corners.

(5) The motor 22 drives the first arm 21A to rotate with respect to the vacuum cleaner body 2. The coil spring 77 biases the second arm 21B with respect to the first arm 21A in the rotation direction. Accordingly, when an external force acts on the second arm 21B, the second arm 21B pivots and is displaced by the elasticity of the coil spring 77. Consequently, loads on the first arm 21A and the motor 22 can be reduced. Furthermore, the second arm 21B pivots; accordingly, even if the distance to the wall surface W changes to some extent, tracing and cleaning along the wall surface W can be conducted without the second arm 21B moving away from the wall surface W.

(6) The load sensor 23 detects a rotational load acting on the first arm 21A. Accordingly, the pivoting cleaner 3 can be used as a contact sensor, and the

travel of the autonomous vacuum cleaner 1 can be efficiently controlled.

(7) The pivoting cleaner 3 has the vacuum cleaning function of sucking up dirt and the like through the vacuum inlet 74 of the second arm 21B. Accordingly, it is possible to more efficiently enlarge the cleaning area.

(8) When the first arm 21A and the second arm 21B are in the stored state, a part of the second arm 21B overlaps the vacuum assembly 14 and another part of the second arm 21B is located sideward of the vacuum assembly 14. Accordingly, it is possible to enlarge the cleaning area in the width direction during travel of the autonomous vacuum cleaner 1.

(9) The pair of left and right pivoting cleaners 3 is provided to the front part of the vacuum cleaner body 2. Accordingly, when the autonomous vacuum cleaner 1 moves closer to a corner, travelling forward, it is possible to make sure of cleaning the corner, regardless of which side the corner is located, left or right.

(10) The inside of the first inner tube member 61 in the first arm 21A of the pivoting cleaner 3 forms the vacuum channel 66. The vacuum channel 66 is provided along the rotation axis of the rotation support of the first arm 21A. The vacuum channel 66 causes the inside of the first arm 21A and the inside (dust collection path) of the sub-duct 143 to communicate with each other. Accordingly, it is possible to simplify the structures of the rotation support and the vacuum channel 66 of the first arm 21A. Therefore, it is possible to promote a reduction in drive load and an improvement in suction performance while promoting downsizing of the pivoting cleaner 3.

(11) The rotation support of the first arm 21A includes the first outer tube member 144 of the vacuum cleaner body 2 and the first inner tube member 61 of the first arm 21A. The first inner tube member 61 is inserted into the first outer tube member 144, and the inside of the first inner tube member 61 configures the vacuum channel 66. Accordingly, it is possible to smoothly send the sucked dirt and the like to the sub-duct 143 through the inside of the first inner tube member 61 and prevent the dirt and the like from being trapped and left in the vacuum channel 66.

(12) The second rotation support of the second arm 21B includes the second outer tube member 63, the second inner tube member 71, and the second vacuum channel 76. The second inner tube is inserted into the second outer tube, and the inside of the second inner tube configures the second vacuum channel 76. Accordingly, it is possible to smoothly send the dirt and the like that have been sucked up through the vacuum inlet 74 to the inside of the first arm 21A through the inside of the second inner tube member 71 and prevent the dirt and the like from being trapped and left in the second vacuum channel 76.

(13) The first arm 21A is provided with the permanent

magnet 81. The outer side of the sub-duct 143 of the vacuum cleaner body 2 is provided with the magnetic field sensor 82 and the board 83. Accordingly, it is possible to prevent dirt and the like from adhering to the magnetic field sensor 82 and the board 83. Moreover, the angle sensor 24 detects the pivot angle of the first arm 21A on the basis of the position of the permanent magnet 81. Accordingly, it is possible to grasp the state of the pivoting cleaner 3.

[Modifications of Embodiment]

[0053] The present invention is not limited to the embodiment, and includes modifications, improvements, and the like within the scope that can achieve the object of the present invention.

[0054] For example, the pair of left and right pivoting cleaners 3 (surrounding cleaning means) is provided to the front part of the vacuum cleaner body 2 of the autonomous vacuum cleaner 1 of the embodiment. However, the place where the surrounding cleaning means are provided is not limited to the front part of the vacuum cleaner body and may be the side parts or the rear part. The surrounding cleaning means are not limited to being provided in a pair on the left and right sides and may be provided in only one place or three or more places.

[0055] Moreover, in the embodiment, the pivoting cleaner (surrounding cleaning means) 3 is configured including the pivotable arm (pivoting member) 21, and the arm 21 is configured including the first arm (first pivoting member) 21A and the second arm (second pivoting member) 21B. However, the configuration of the surrounding cleaning means is not limited to the one in the embodiment. In other words, the protrusion of the surrounding cleaning means is not limited to the pivotable arm 21, and may be one that is provided, configured to be capable of protruding and retracting linearly or curvedly outward from the vacuum cleaner body. Moreover, the protrusion is not limited to the one that includes two members such as the first and second pivoting members and may be configured including one member or three or more members.

[0056] In the embodiment, the pivoting cleaner (surrounding cleaning means) 3 is configured having the vacuum cleaning function of sucking up dirt and the like through the vacuum inlet 74 of the second arm 21B. However, the surrounding cleaning means is not limited to the one that has the vacuum cleaning function, and may be one that has a sweep cleaning function of collecting dirt and the like on the floor surface with a brush, a rubber blade, or the like toward the main cleaning means, or one that has a wipe cleaning function of wiping dirty spots on the floor surface with a mop, waste (sheet), or the like, or one that has a fluid jetting function of ejecting air or water and cleaning the floor surface.

[0057] In the embodiment, the pivoting cleaner (surrounding cleaning means) 3 is configured in such a manner that the first arm (first pivoting member) 21A is driven

and rotated by the motor (rotation drive means) 22 with respect to the vacuum cleaner body 2, and the second arm (second pivoting member) 21B is biased by the coil spring (rotation biasing means) 77 with respect to the first arm 21A in the rotation direction. However, the surrounding cleaning means is not limited to such a configuration. In other words, the first pivoting member may be biased by the rotation biasing means with respect to the vacuum cleaner body, and the second pivoting member may be driven and rotated by the rotation drive means with respect to the first pivoting member, or at least one of the rotation drive means and the rotation biasing means may be omitted. Moreover, the rotation drive means is not limited to the motor and may include another appropriate drive means, and the rotation biasing means is not limited to the coil spring and may include another appropriate biasing means.

[0058] In the embodiment, the pivoting cleaner (surrounding cleaning means) 3 is configured including the load sensor (load detection means) 23 that a rotational load acting on the first arm 21A, and the angle sensor (angle detection means) 24 that detects the pivot angle of the first arm 21A. However, at least one of the load detection means and the angle detection means may be omitted. Moreover, the load detection means is not limited to the one that includes the load detection circuit that detects rotational resistance acting on the motor 22, and may be one that directly detects load with a strain gauge, a load measuring device, or the like. Moreover, the angle detection means is not limited to the one that is configured including the permanent magnet 81 and the magnetic field sensor 82, and any sensor such as an optical sensor or electromagnetic sensor can be used as the angle detection sensor.

INDUSTRIAL APPLICABILITY

[0059] As described above, the present invention can be suitably used for an autonomous vacuum cleaner that can clean efficiently around a vacuum cleaner body.

LIST OF REFERENCE SIGNS

[0060]

1	Autonomous vacuum cleaner
2	Vacuum cleaner body
3	Pivoting cleaner (sub-cleaning means, surrounding cleaning means)
4	Sensor system
5	Controller (control means)
14	Vacuum assembly (main cleaning means)
21	Arm (pivoting member, protrusion)
21A	First arm (first pivoting member)
21B	Second arm (second pivoting member)
22	Motor (rotation drive means)
23	Load sensor (load detection means)
24	Angle sensor (angle detection means)

32 Surroundings sensor (surrounding detection means)
 61 First inner tube member (inner tube)
 63 Second outer tube member (second outer tube)
 66 Vacuum channel
 71 Second inner tube member (second inner tube)
 76 Second vacuum channel
 77 Coil spring (pivoting biasing means)
 81 Permanent magnet
 82 Magnetic field sensor
 83 Board
 121 Wheel
 143 Sub-duct (dust collection path)
 144 First outer tube member (outer tube)

Claims

1. An autonomous vacuum cleaner capable of cleaning while traveling along a floor surface, comprising:

a vacuum cleaner body including a wheel for travelling autonomously;
 a surrounding detection means for detecting an obstacle around the vacuum cleaner body;
 a surrounding cleaning means capable of cleaning around the vacuum cleaner body; and
 a control means configured to control the surrounding detection means and the surrounding cleaning means, wherein the surrounding cleaning means includes:

a protrusion capable of protruding outward from the vacuum cleaner body;
 a drive means configured to drive the protrusion in such a manner as to protrude and retract; and
 a load detection means configured to detect a load acting on the protrusion from the outside, and

the control means

controls and drives the drive means on the basis of the presence or absence of an obstacle detected by the surrounding detection means, and
 controls travel of the vacuum cleaner body on the basis of a load detected by the load detection means.

2. The autonomous vacuum cleaner according to claim 1, wherein in a case where the load detection means shifts from a load detecting state to a non-load detecting state, the control means judges that the protrusion becomes movable, drives the drive means, and causes the protrusion to move and protrude.

3. The autonomous vacuum cleaner according to claim 1 or 2, wherein in a case where the surrounding detection means detects an obstacle upon the drive means being driven to move the protrusion, the control means controls the drive means in such a manner as to reduce the moving speed of the protrusion with decreasing distance to the obstacle.

4. The autonomous vacuum cleaner according to any of claims 1 to 3, wherein the surrounding cleaning means includes a biasing means configured to bias the protrusion in a protruding direction.

5. The autonomous vacuum cleaner according to any of claims 1 to 4, wherein the protrusion is pivotably supported by the vacuum cleaner body, and the drive means drives the protrusion to pivot.

6. The autonomous vacuum cleaner according to claim 5, wherein the protrusion is configured including:

a first pivoting member rotatably supported on one end side thereof by the vacuum cleaner body; and
 a second pivoting member rotatably supported on the other end side of the first pivoting member.

7. The autonomous vacuum cleaner according to claim 6, wherein the drive means is a rotation drive means configured to drive and rotate the first pivoting member with respect to the vacuum cleaner body, and the second pivoting member is biased by a rotation biasing means with respect to the first pivoting member in a rotation direction.

8. The autonomous vacuum cleaner according to any of claims 1 to 7, wherein the surrounding cleaning means has a vacuum cleaning function of sucking up dirt and the like on the floor surface through a vacuum inlet provided to the protrusion.

FIG. 1

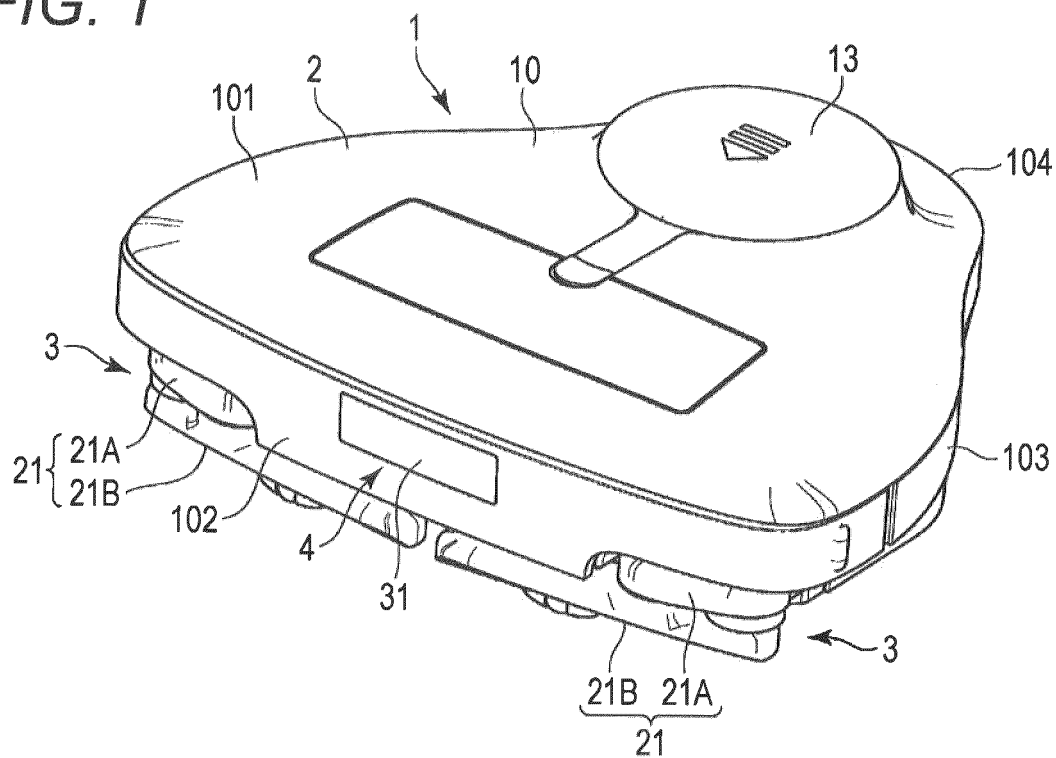


FIG. 2

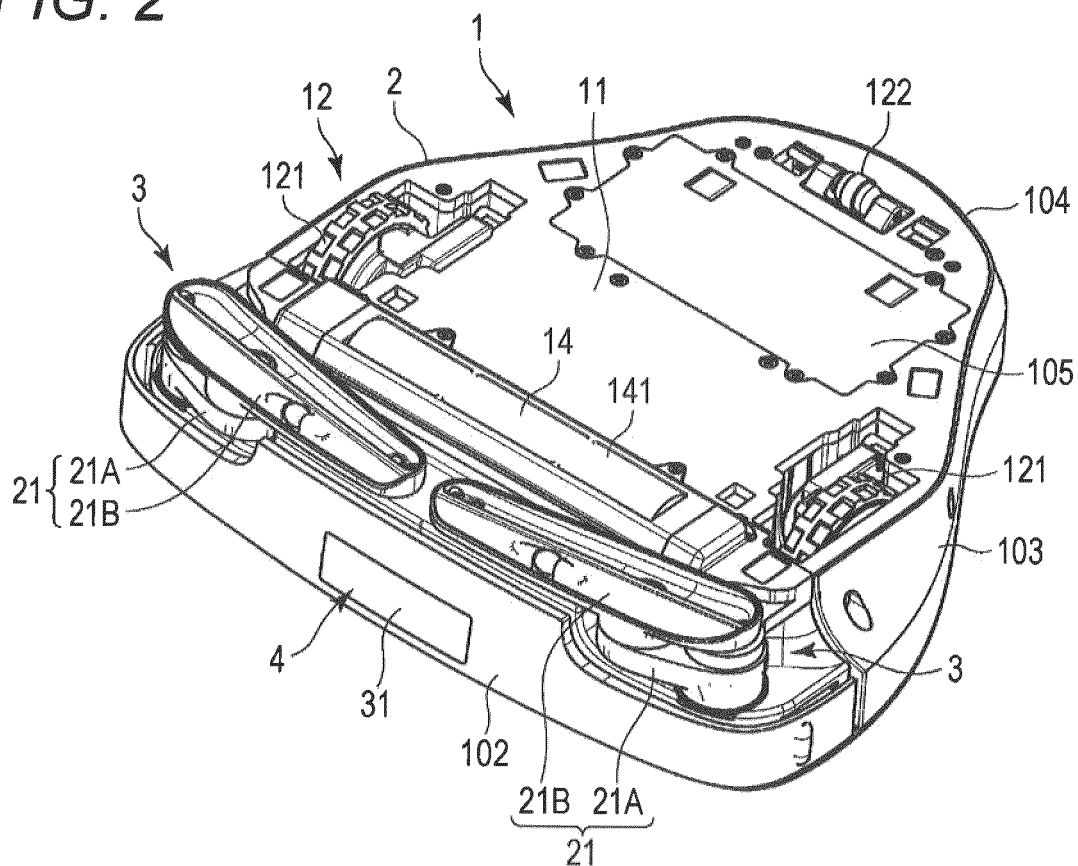


FIG. 3

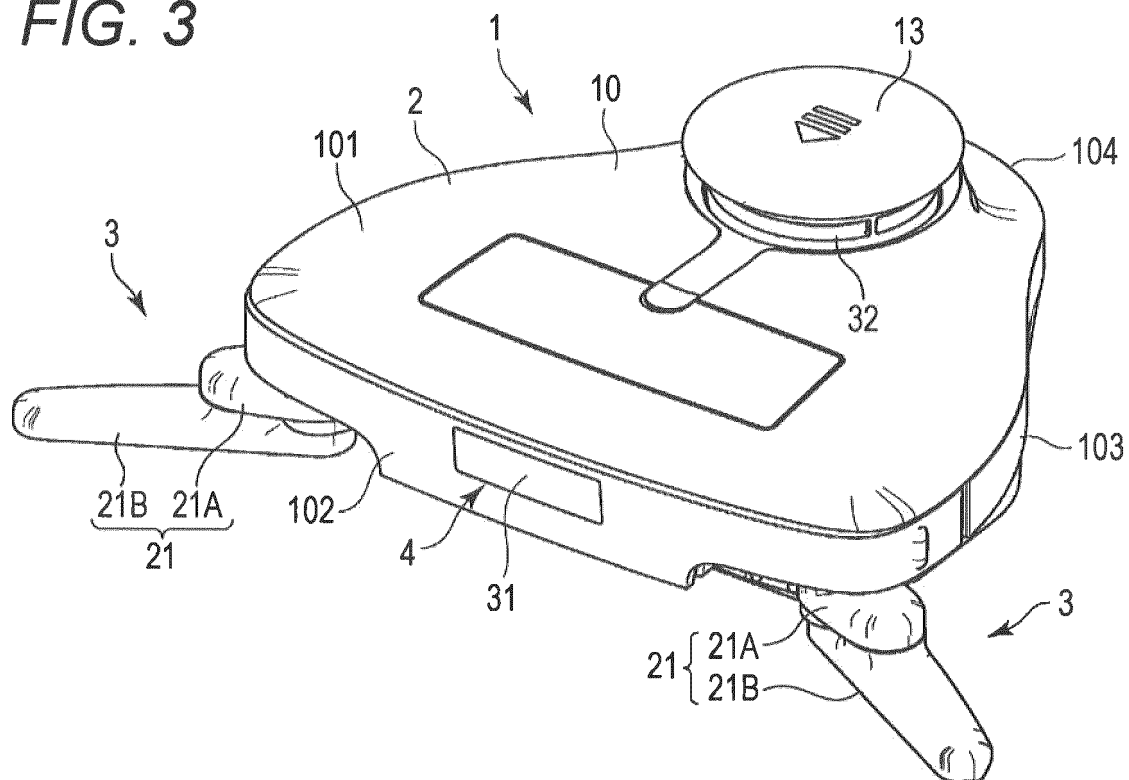


FIG. 4

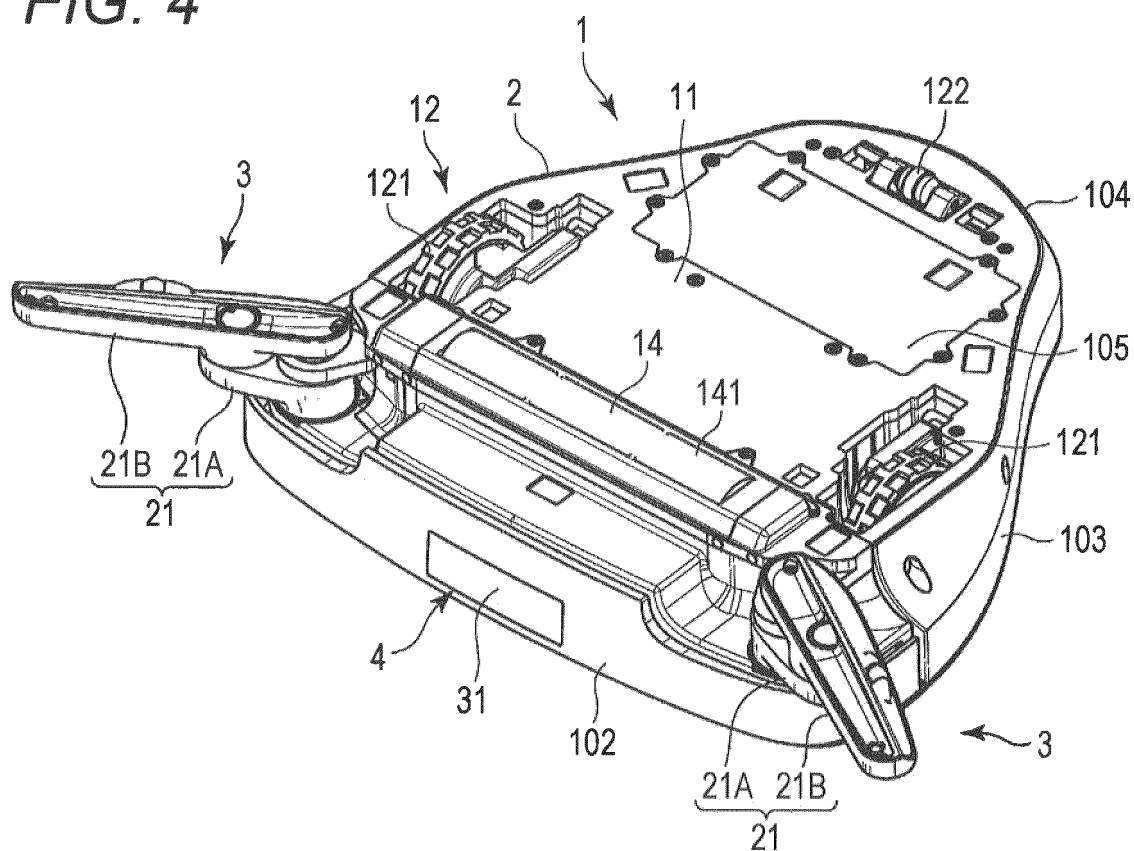


FIG. 5

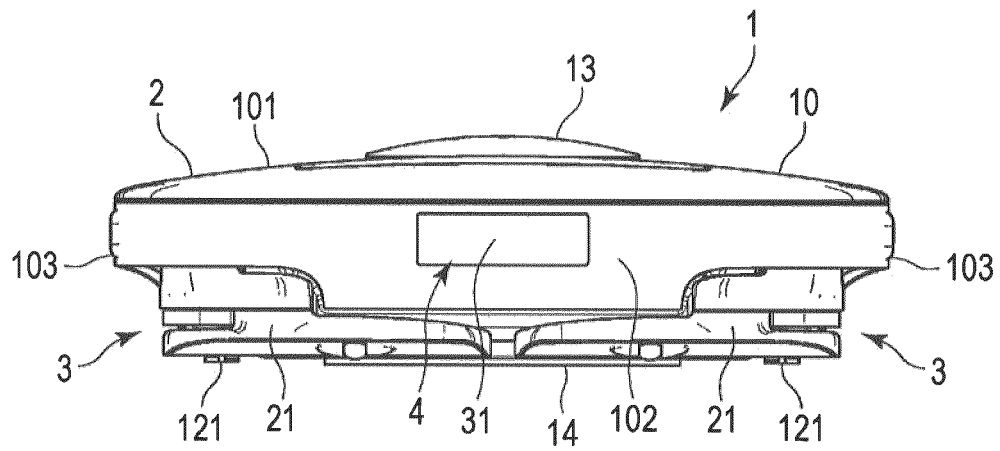


FIG. 6

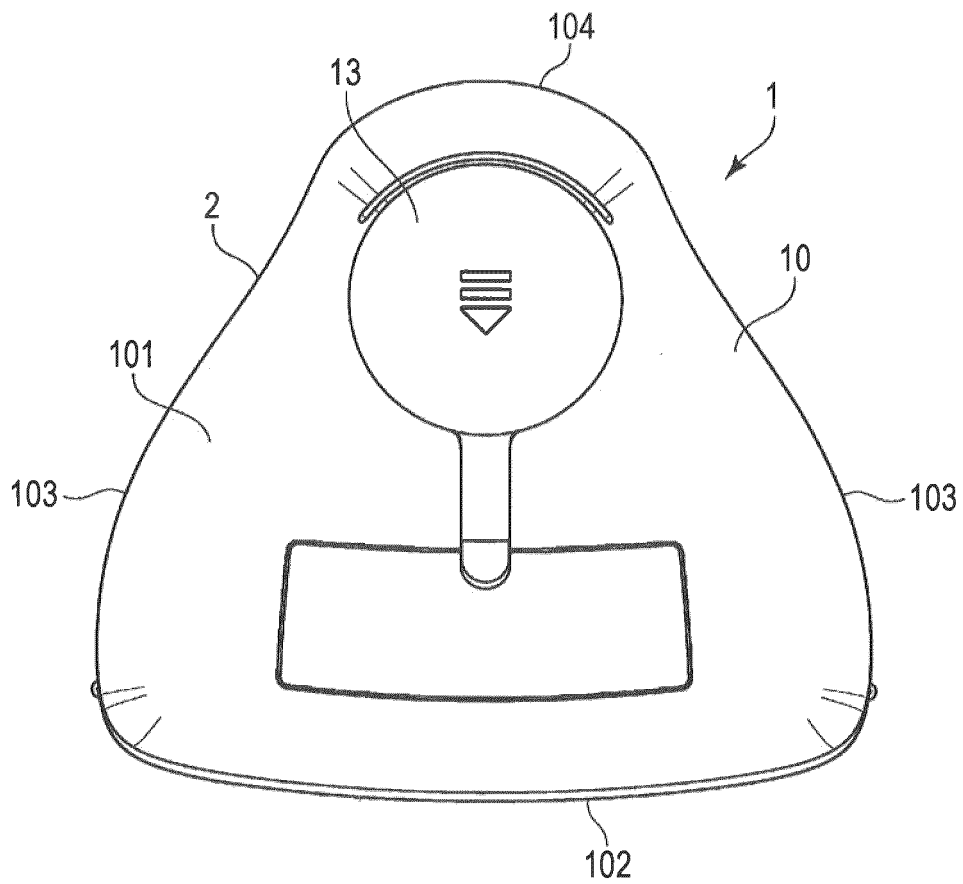


FIG. 7

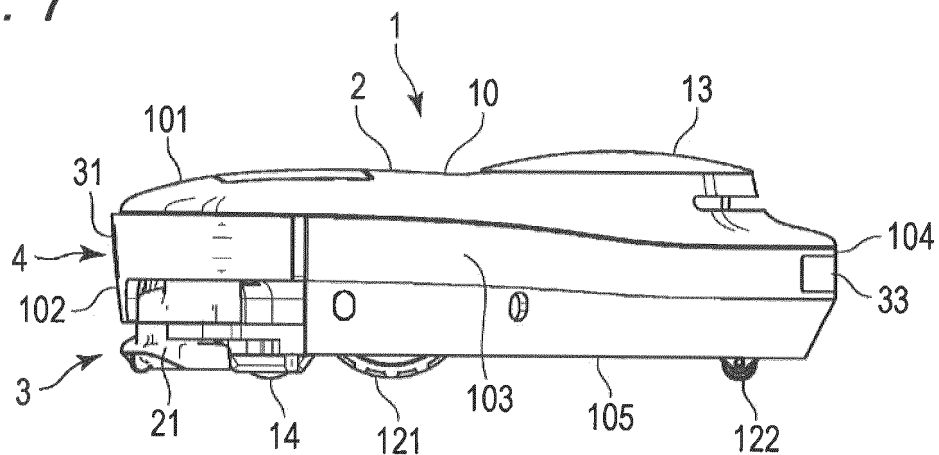


FIG. 8

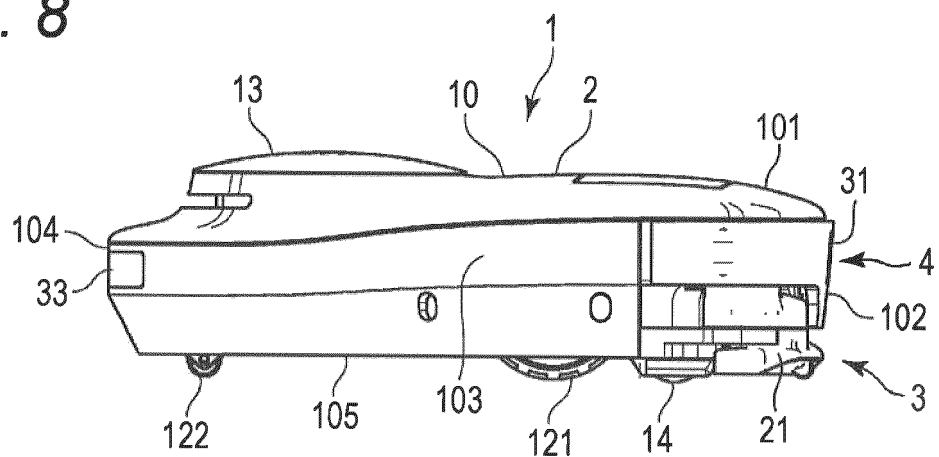


FIG. 9

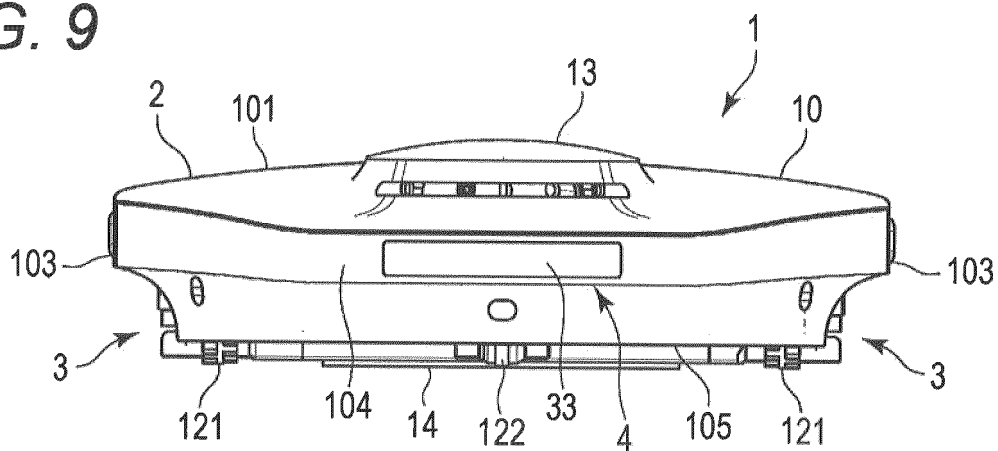


FIG. 10

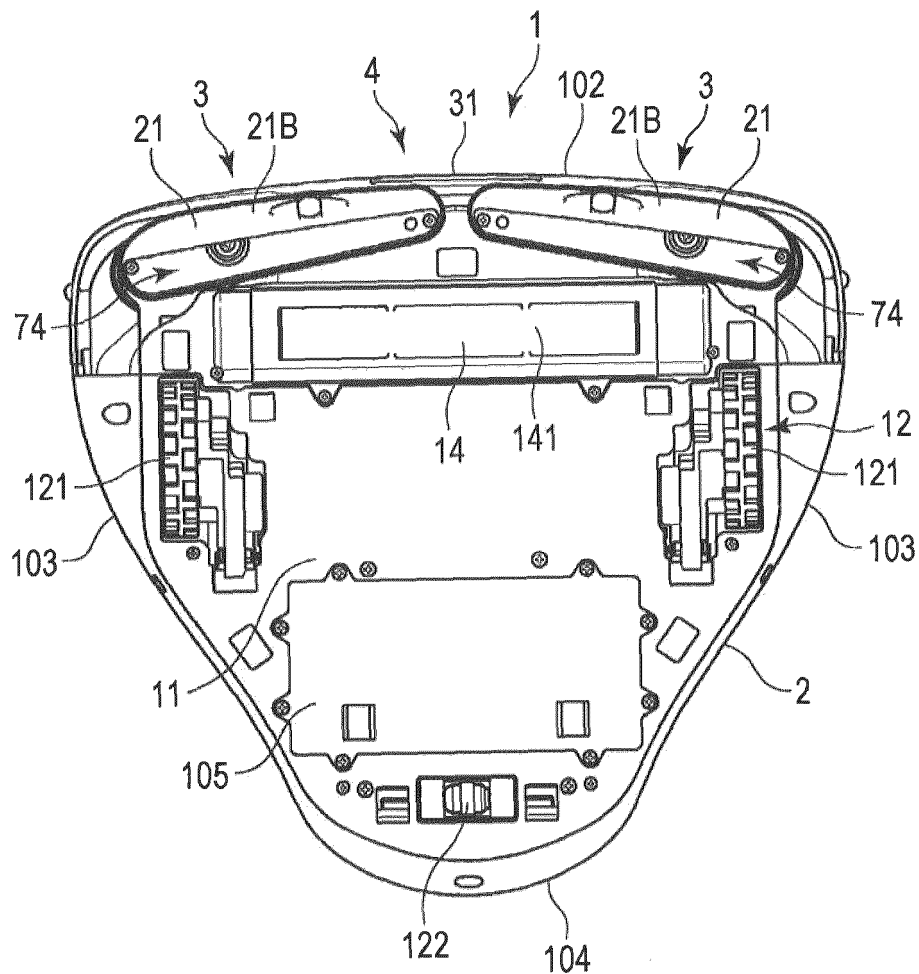


FIG. 11

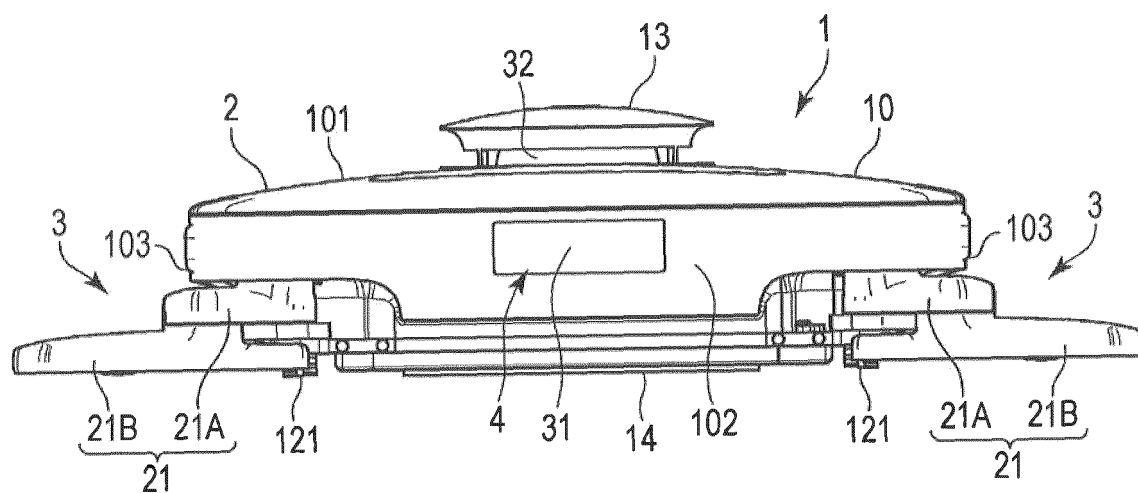


FIG. 12

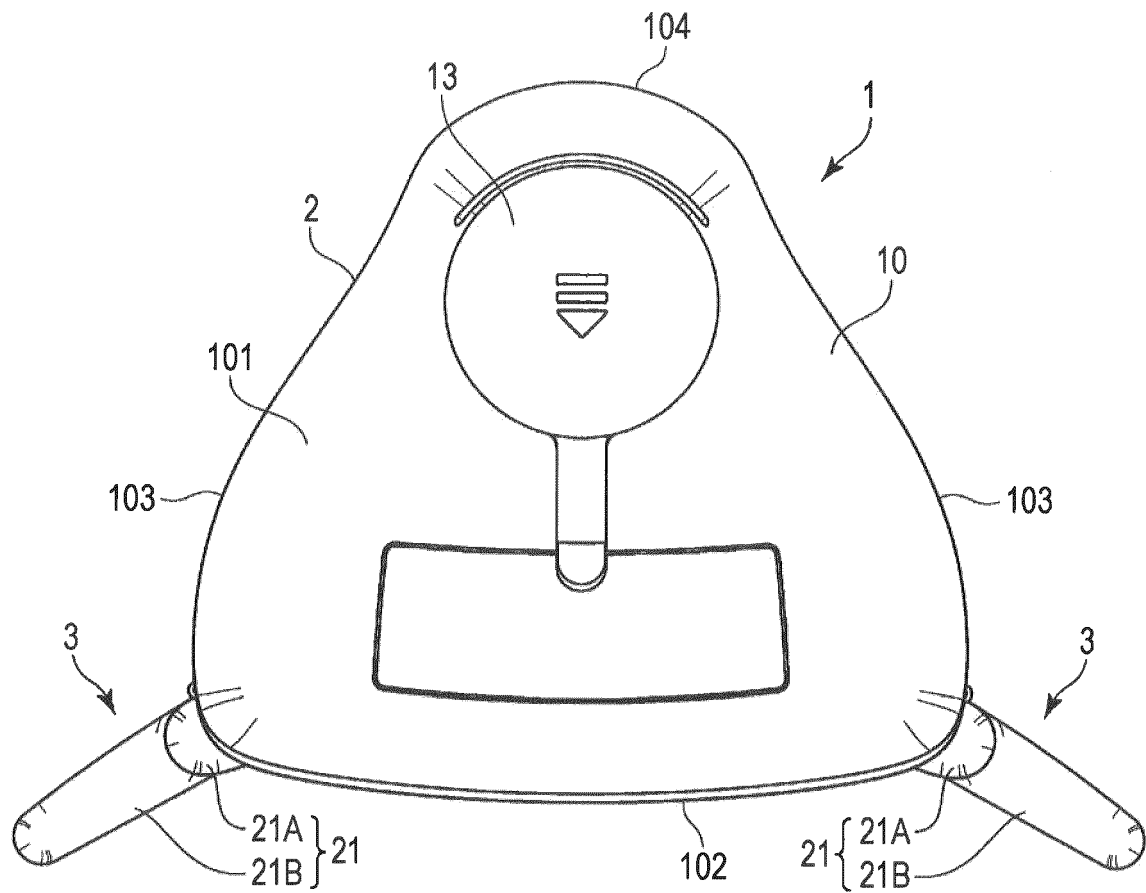


FIG. 13

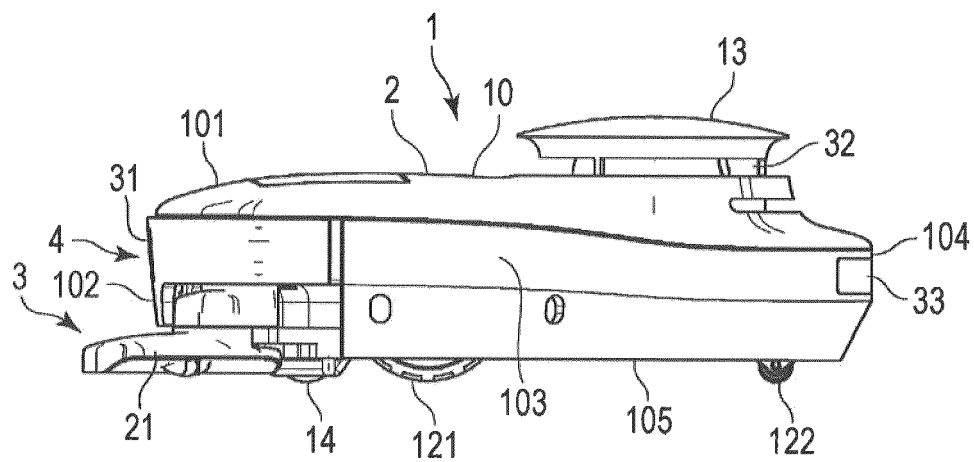


FIG. 14

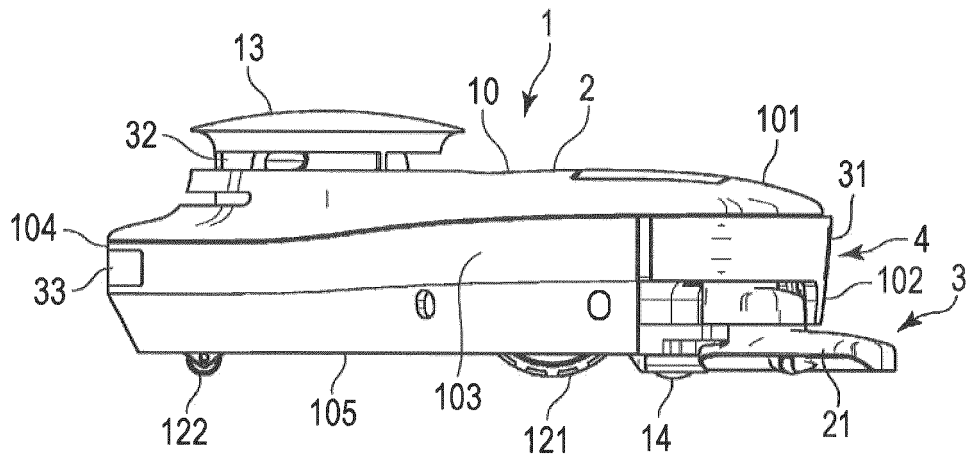


FIG. 15

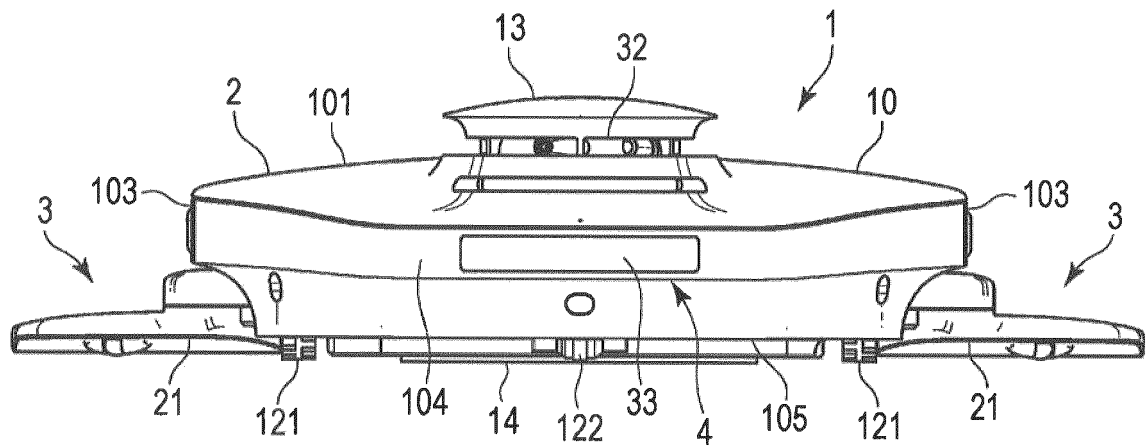


FIG. 16

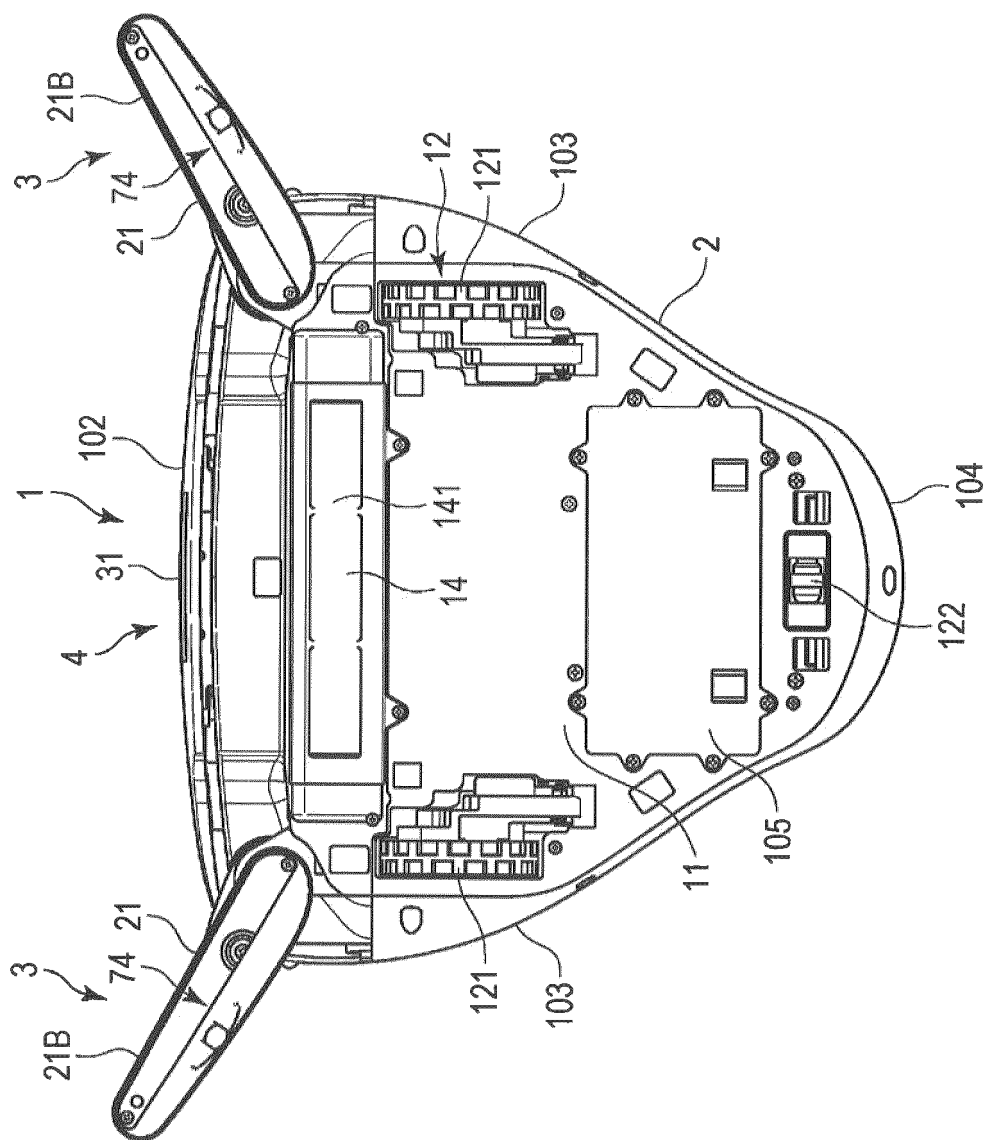


FIG. 17

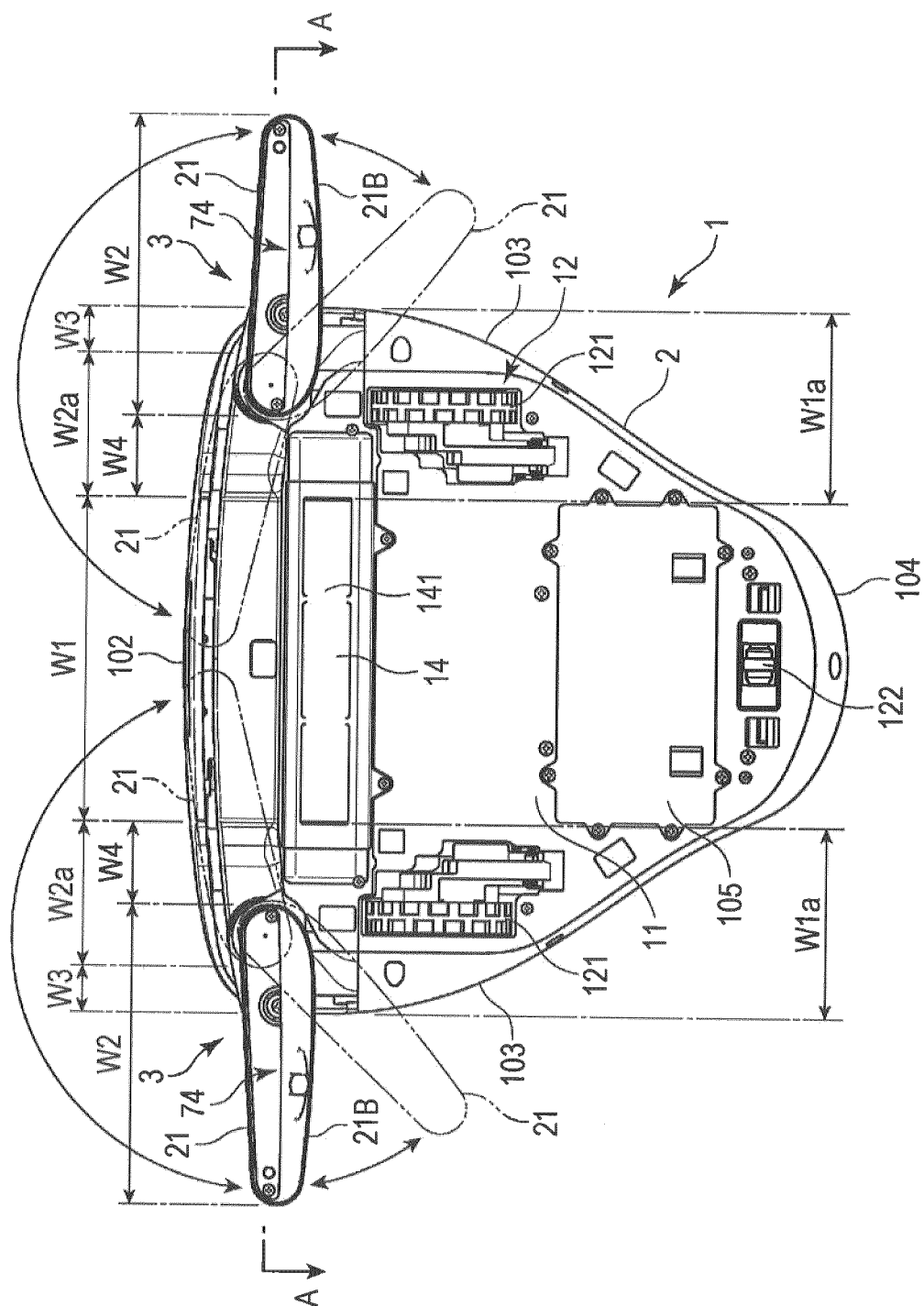


FIG. 18

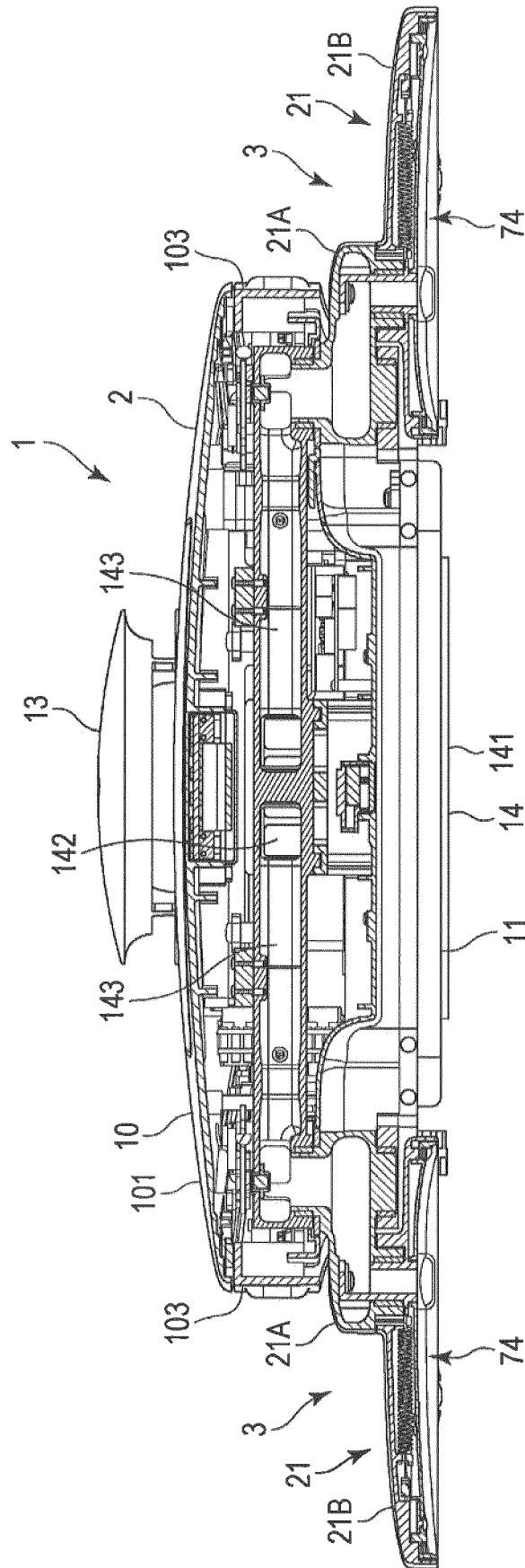


FIG. 19

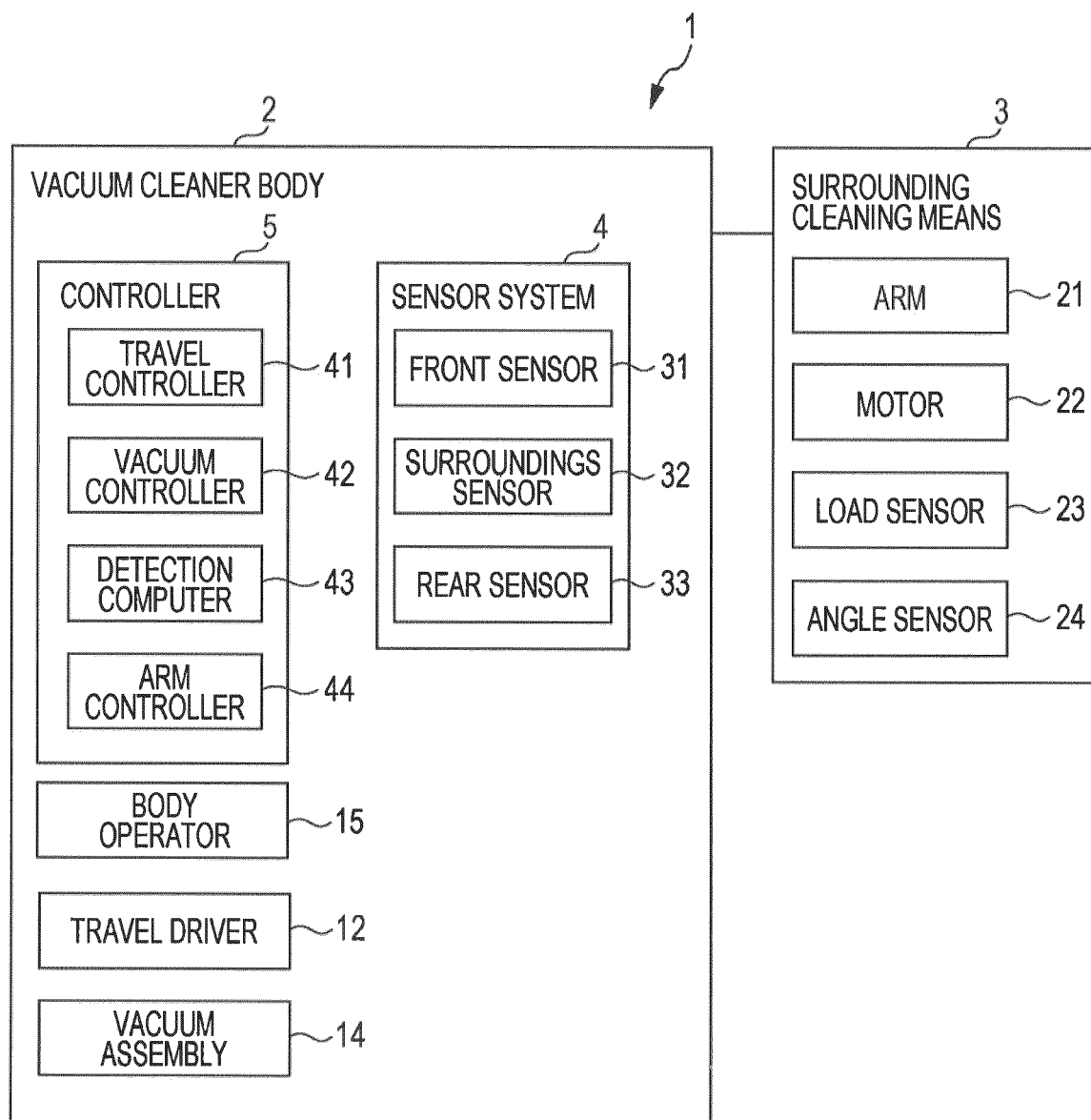


FIG. 20

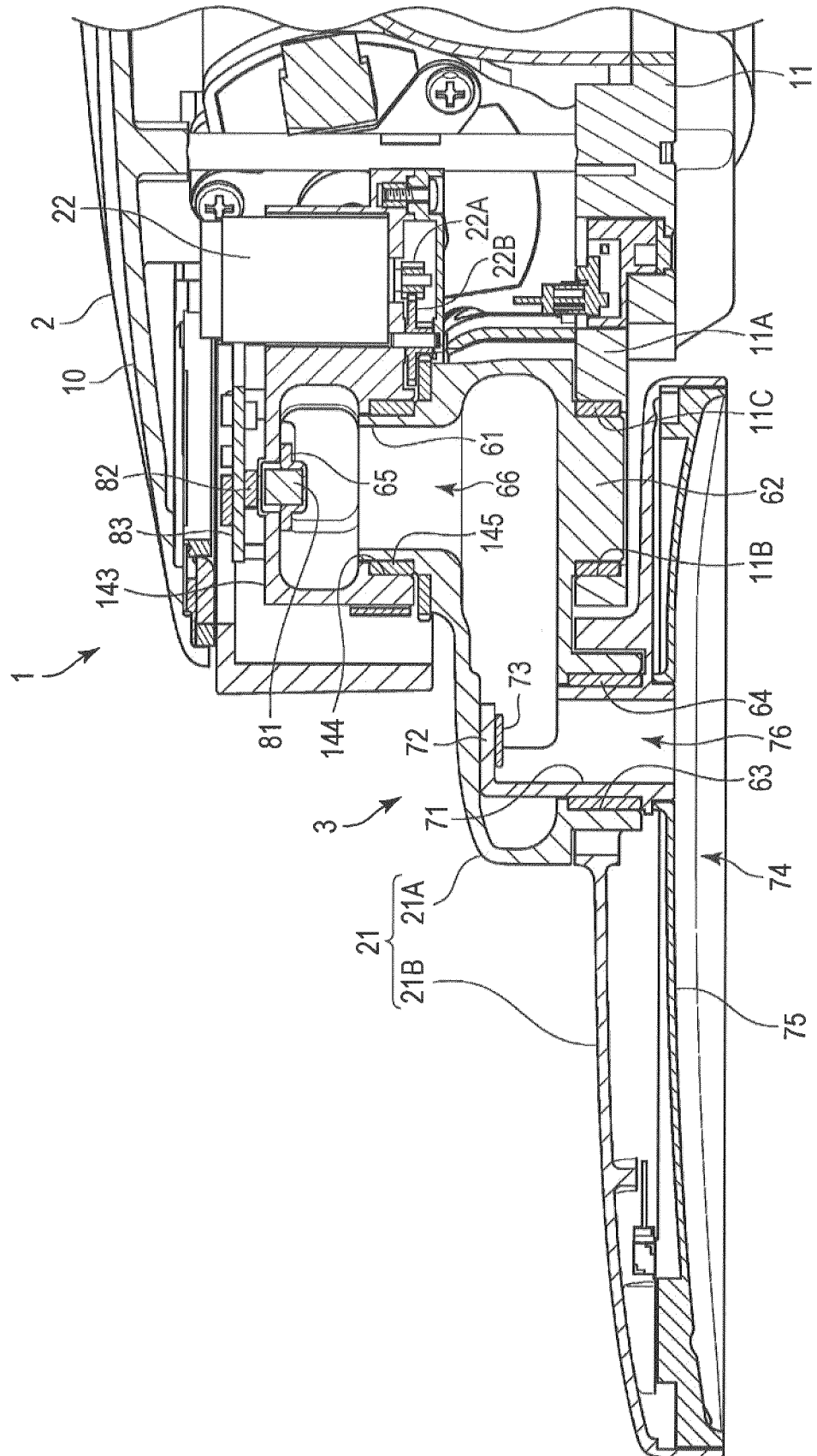


FIG. 21

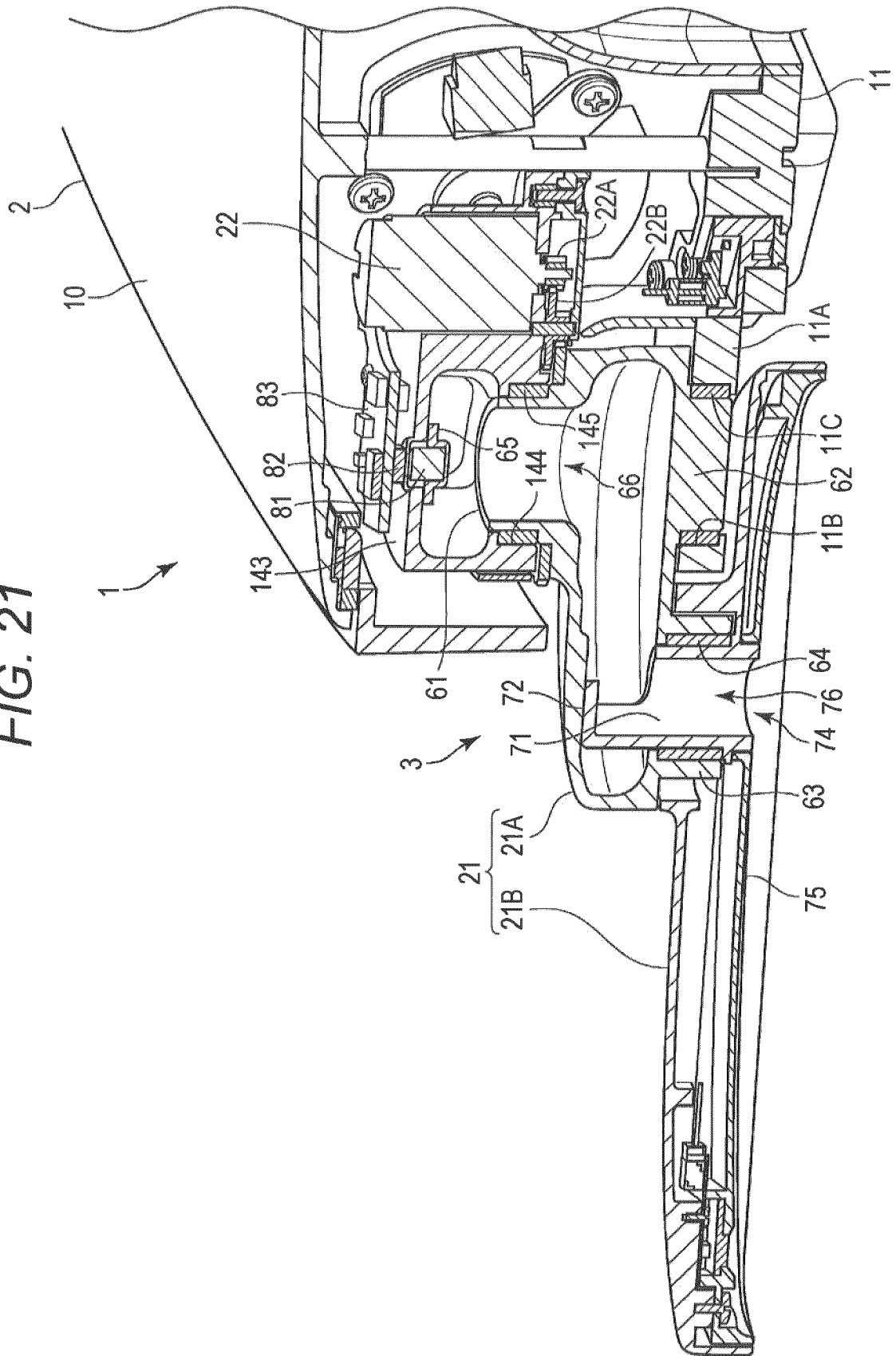


FIG. 22

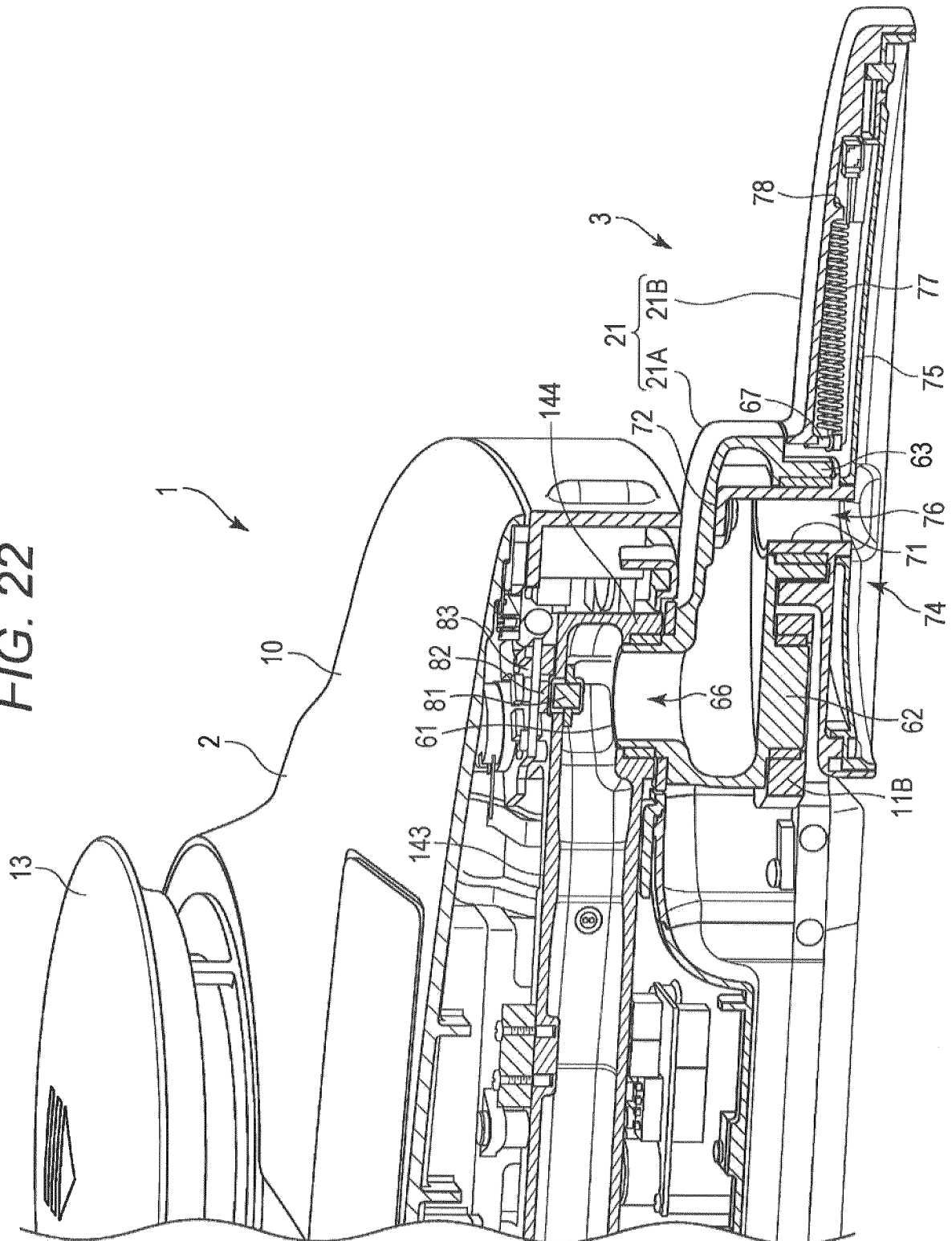


FIG. 23

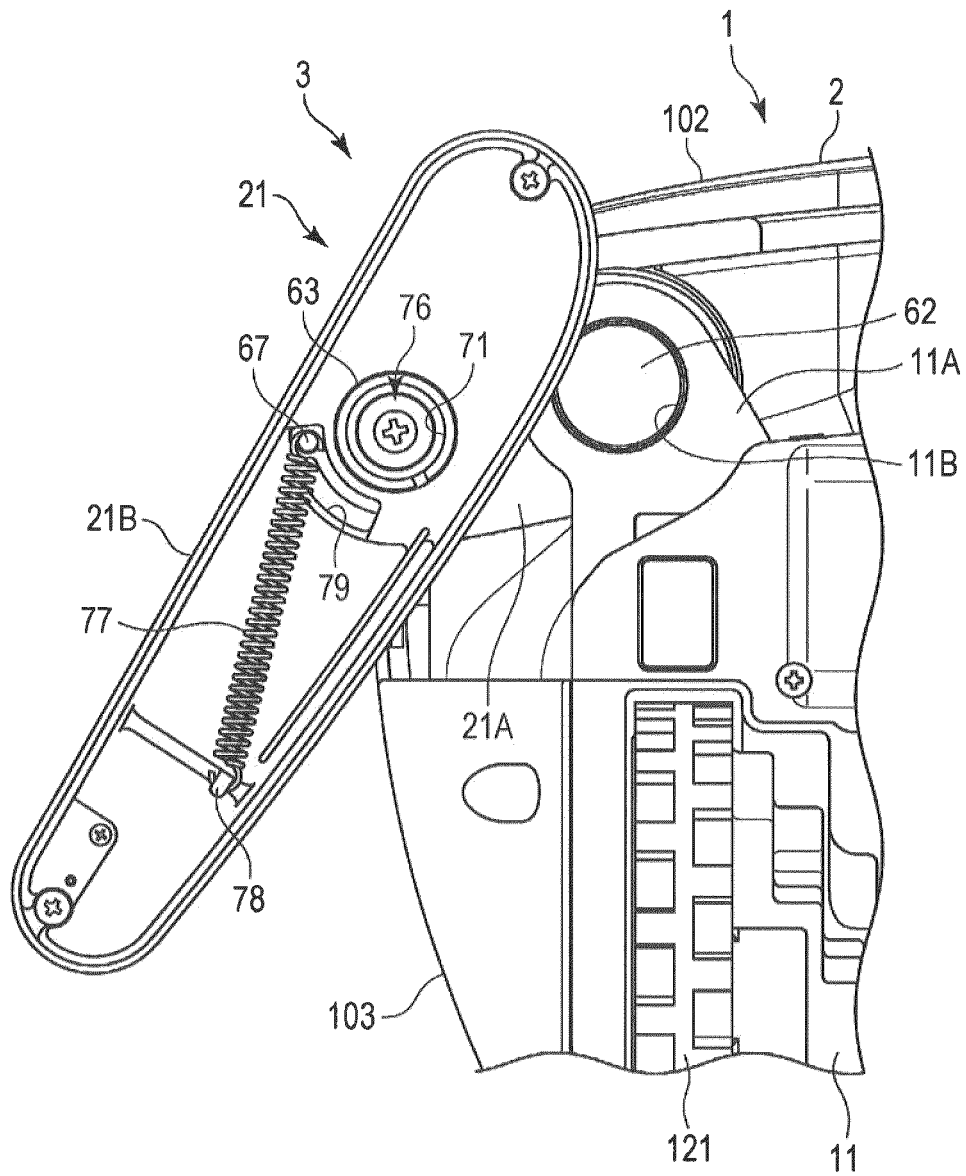


FIG. 24

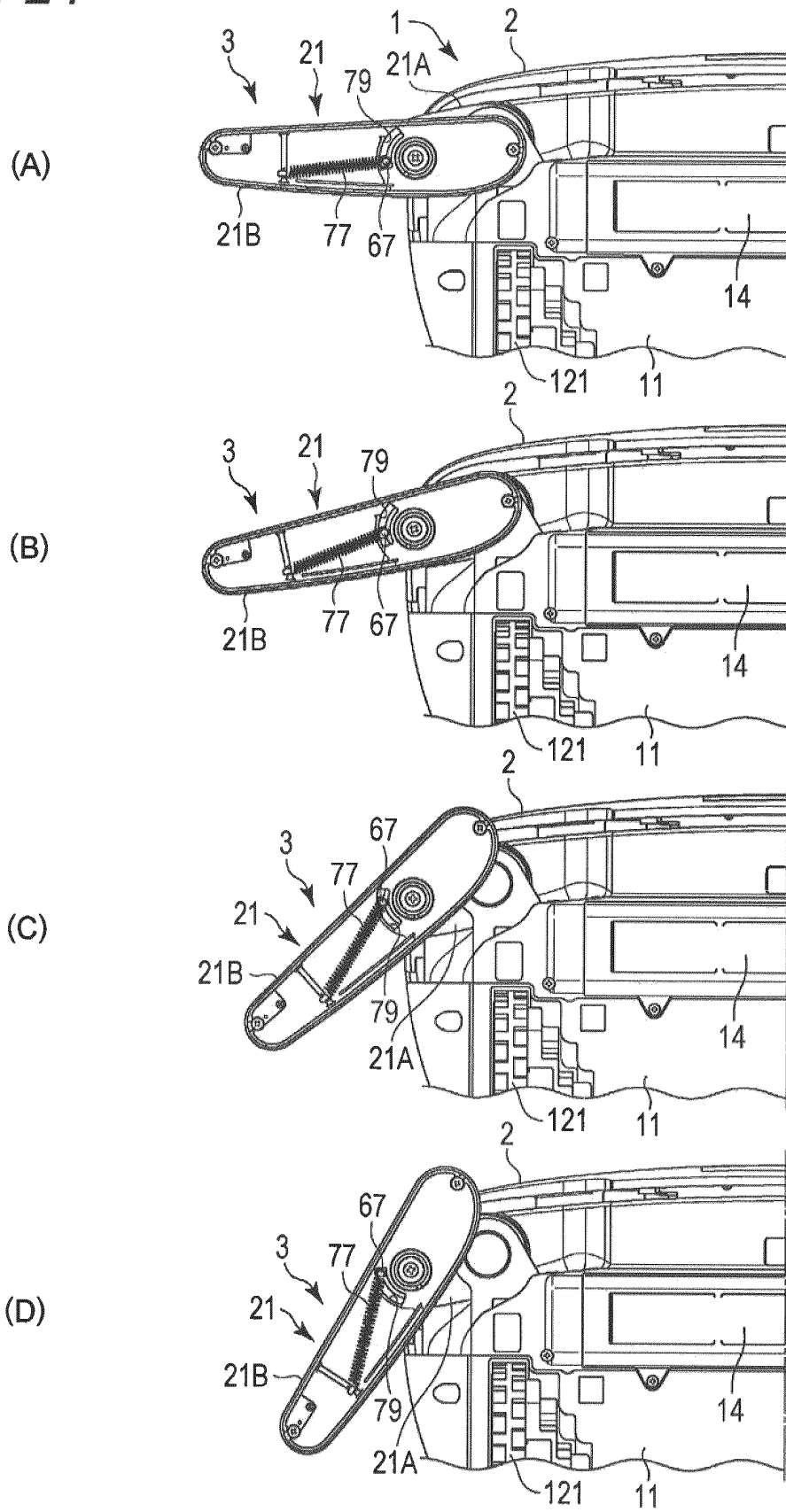


FIG. 25

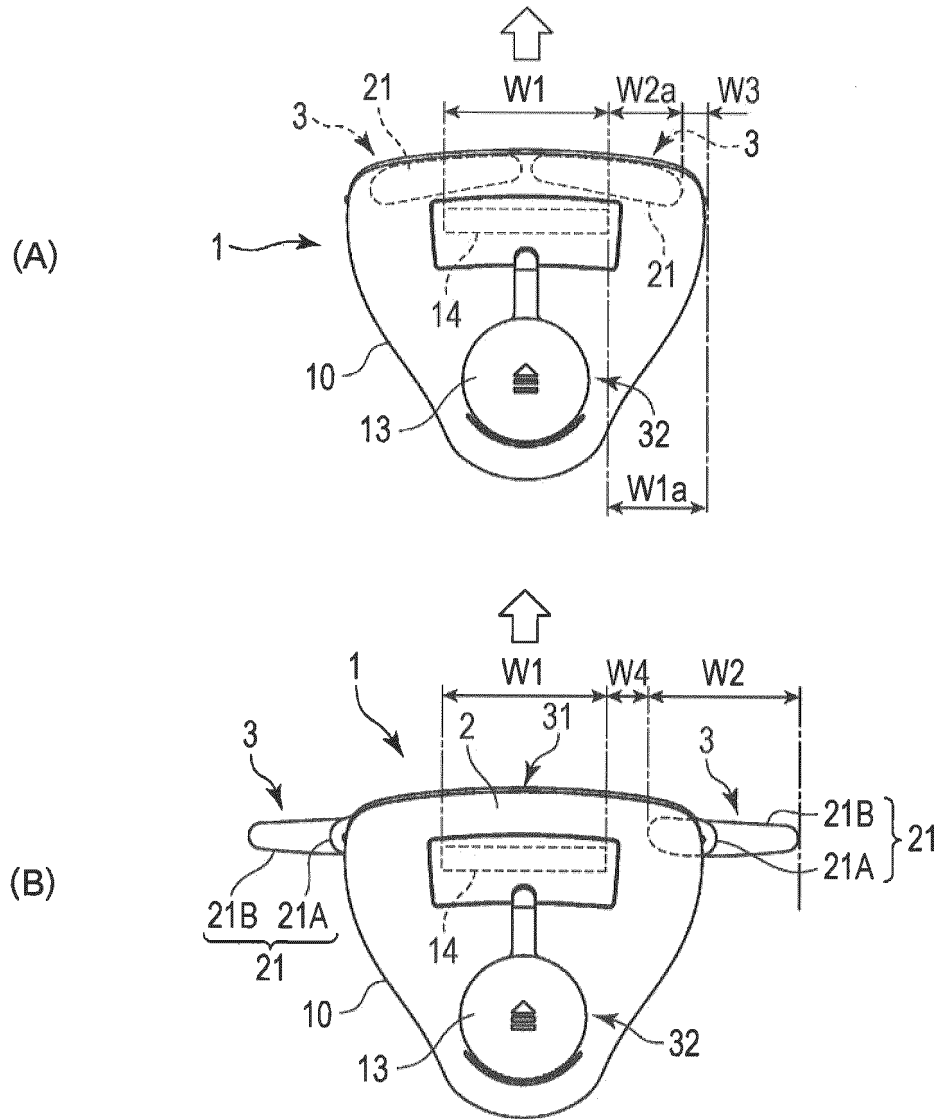
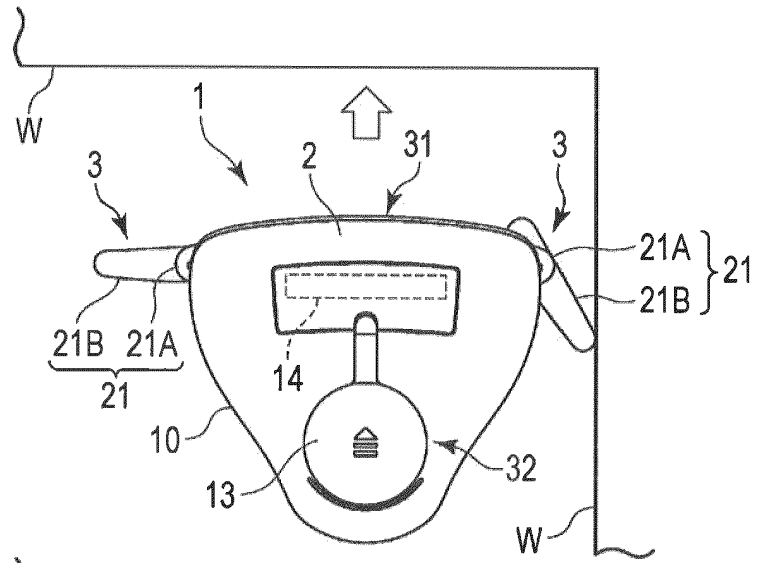
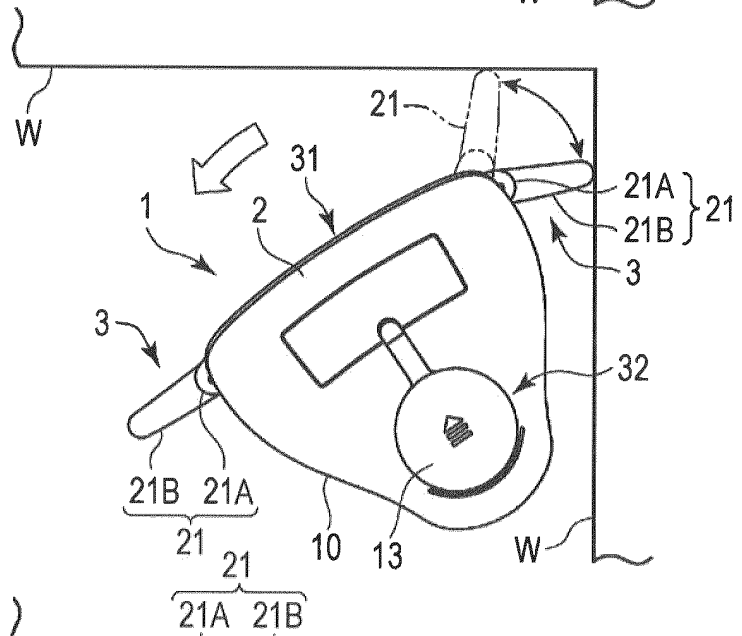


FIG. 26

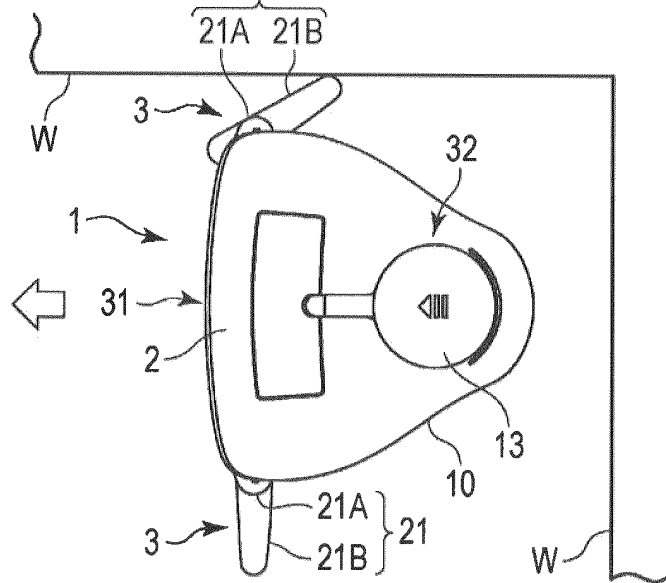
(A)



(B)



(C)



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/031740

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. A47L9/28 (2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. A47L9/28

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2017

Registered utility model specifications of Japan 1996-2017

Published registered utility model applications of Japan 1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2007-299374 A (SAMSUNG ELECTRONICS CO., LTD.) 15	1-2
Y	November 2007, claims, paragraphs [0026]-[0057], fig. 4-10	3-8
	& US 2007/0252549 A1, paragraphs [0039]-[0070], fig. 1, 2, 4-10 & EP 1852761 A2 & KR 10-0772907 B1 & CN 101066198 A	
Y	JP 2002-355204 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 10 December 2002, claim 3 (Family: none)	3-8



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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

"T"

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

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

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

"&"

document member of the same patent family

Date of the actual completion of the international search

28.11.2017

Date of mailing of the international search report

05.12.2017

Name and mailing address of the ISA/

Japan Patent Office

3-4-3, Kasumigaseki, Chiyoda-ku,

Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/031740

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2003-52582 A (TOSHIBA TEC CORPORATION) 25 February 2003, entire text, all drawings (Family: none)	1-8
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 66778/1991 (Laid-open No. 88472/1993) (NEC HOME ELECTRONICS CO., LTD.) 03 December 1993, entire text, all drawings (Family: none)	1-8
A	JP 2007-143645 A (MATSUSHITA ELECTRIC WORKS LTD.) 14 June 2007, entire text, all drawings (Family: none)	1-8

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008279066 A [0004]