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(54) **A FILTER CLEANING DEVICE FOR AN AIR-CONDITIONER**

(57) Provided is a filter cleaning device for an air-conditioner, comprising: a flat filter, a brush, a contact member, a driving unit (730) and a controller (750). The driving unit has a first motor (631) for moving the brush and a second motor (671) for moving the contact member. The controller is configured to control the driving unit such that the brush and the contact member move from one

end side to the other end side of the filter with respect to a first moving direction extending along the filter surface, and also configured to control at least one of the first motor and the second motor such that a gap between the brush and the contact member is within a predetermined range in position with respect to the first moving direction.

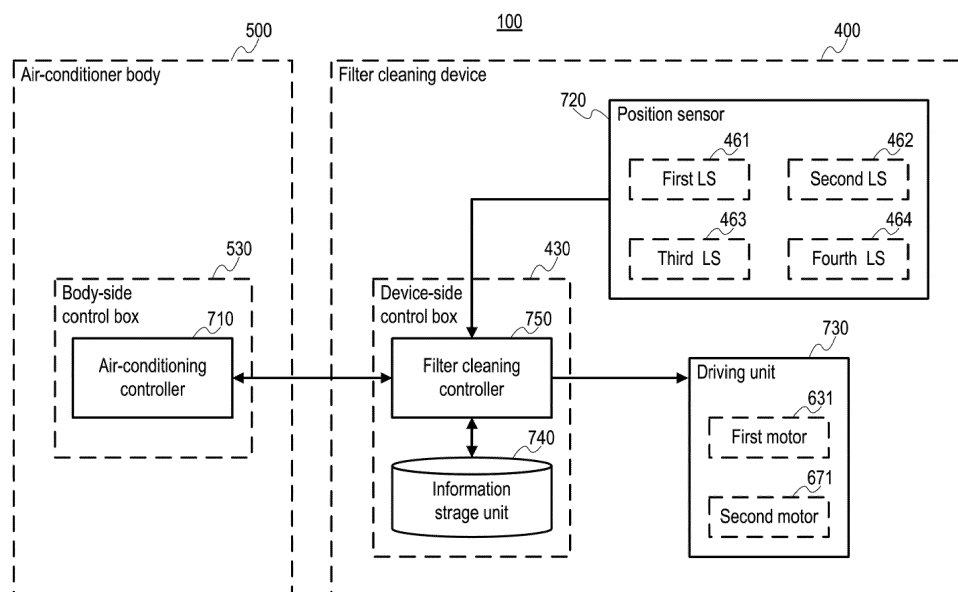


Fig. 13

Description

Field of the Invention

[0001] The present invention relates to filter cleaning device for an air-conditioner.

Background

[0002] Air-conditioners are generally installed with a filter for filtration of the air to be conditioned. The filter needs to be cleaned on a regular basis. The air-conditioner with a filter cleaning function is disclosed in JP 2008-121990 A.

[0003] JP 2008-121990 A discloses an air-conditioner which has a fixedly mounted filter and a slidably mounted box mounter. The box mounter is attached with a dust box and a filter supporting plate which are disposed on opposite sides of the filter. The box mounter is driven to move along the filter by a motor while sandwiching the filter between the dust box and the filter supporting plate. The dust box has a cleaning brush arranged so as to be in contact with the filter. The filter supporting plate is configured to contact with the other side of the filter. By this, dust, fibres, particulate matter or the like (hereinafter simply referred to as "particles") are removed from the filter by the cleaning brush and accumulated in the dust box.

[0004] Being fixedly connected to the cleaning brush, the filter supporting plate is kept in a state of being opposed to the cleaning brush across the filter. Thus, the filter supporting plate functions to prevent scattering the particles from the part where the cleaning brush engages with the filter, and the filter can be cleaned efficiently.

[0005] However, due to structural or design constraints, it is not always feasible to employ a configuration in which a brush and a contact member are connected in a fixed manner across the filter. For example, in a case where the brush moves in a horizontal direction in an apparatus while the height of the apparatus is limited, it would be not always possible to ensure spaces above and below the filter for members which connect the brush and the contact member. Moreover, such spaces would communicate the upstream side and the downstream side of the filter to deteriorate the filtration efficiency. Therefore, it is desirable to allow a filter cleaning device to clean the filter efficiently even in a case where the brush and the contact member are not connected in a fixed manner.

Summary

[0006] The object of the present invention is to provide a filter cleaning device for an air-conditioner that cleans a filter efficiently by using a brush and a contact member disposed on opposite sides of the filter without connecting the brush and the contact member in a fixed manner.

[0007] A first aspect of the present invention provides a filter cleaning device for an air-conditioner comprising

a filter, a brush unit, a driving unit and a controller. The filter has a filter surface and is configured to pass an air flow through the filter surface. The brush unit has a brush and a contact member. The brush is configured to contact with a principal side of the filter surface and is rotatably supported about a rotation axis, the rotation axis extending along the filter surface. The contact member is configured to contact with the other side of the filter surface and sandwich the filter between the brush and the contact member. The driving unit has a first motor and a second motor. The first motor is configured to rotate the brush about the rotation axis in a first rotating direction and move the brush along a first moving direction that extends along the filter surface while rotating the brush in the first rotation direction. The second motor is configured to move the contact member along the first moving direction. The controller is configured to control the driving unit such that the brush and the contact member move from one end side to the other end side of the filter with respect to the first moving direction. The rotation axis of the brush extends along a direction that intersects the first moving direction. The controller is configured to control at least one of the first motor and the second motor such that a gap between the brush and the contact member is within a predetermined range in position with respect to the first moving direction.

[0008] The principal side of the filter is on the upstream side with respect to the air flow in use. It can cause the gap between the brush and the contact member to drive them individually by the first and second motors, respectively. Such a gap is derived from differences between the two motors in size, gear ratio, pulse rates, and the like. Therefore, one of the brush and contact member can move quicker than the other, which results in generating the gap. Accordingly, the controller keeps the gap under the predetermined range by controlling the first and/or second motors.

[0009] Preferably, one of the motors, which moves the brush or contact member quicker than the other, is halted during a predetermined time period P1. Alternatively or in combination with that, the quicker motor may start after the other motor starts. The halting time of one motor and/or the time difference in starting the motors are adjusted to keep the gap between the brush and the contact member under the predetermined range. Thus, an area of the filter which contacts with and is sandwiched between the brush and contact member can be securely maintained.

[0010] A possible gap can be calculated based on parameters of each motor such as the sizes, gear ratios and pulse rates. The predetermined time period P1 can be calculated accordingly.

[0011] It is within the scope of the present invention that the gap is zero. In such a case, there is no need for the controller to halt one of the motors and/or start them at different time points. Such an adjustment is included in the scope of the control by the controller.

[0012] The positions of the brush and the contact mem-

ber are expressed by positions on an axis along the first moving direction. In a case that the filter has a flat and rectangular shape, the position of the brush is indicated as a position on the axis extending along a width direction of the filter. Furthermore, if a part of the contact member being of a part of a cylinder contacts with the filter, the position of the contact member is indicated as a position of the centre axis of the cylinder on the axis. When each of the brush and the contact member has substantially a cylindrical form, the positions of the brush and the contact member are positions of the centre axes of both the cylinders on the axis.

[0013] The brush and the contact member move from one end side to the other end side of the filter with respect to the first moving direction. The first moving direction may be a linear direction or a direction along a curved line. The brush and the contact member can slide along the first moving direction. In practice, it is preferable to arrange a pair of guide rails which extend along the filter surface and guide the brush and the contact member.

[0014] Thus, with the above configuration, since the brush and the contact member are driven individually, it is not necessary to connect the brush and the contact member in a fixed manner across the filter. Moreover, since the relative position between the brush and the contact member is maintained within a predetermined range by the controller, the contact member functions to prevent scattering the particles from the part where the brush engages with the filter. Accordingly, it is possible to clean the filter efficiently by using the brush and the contact member disposed on opposite sides of the filter without connecting the brush and the contact member in a fixed manner.

[0015] According to a preferred embodiment of the filter cleaning device mentioned above, the controller is configured to control the brush unit such that the brush or the contact member halts once or more while moving from one end side to the other end side of the filter with respect to the first moving direction.

[0016] The controller halts one of the motors which moves the brush or the contact member quicker than the other. Accordingly, the slower member can catch up the faster member while the faster member halts. Thus, the gap between the brush and the contact member can be kept within the predetermined range.

[0017] There is a case in that the gap goes beyond the predetermined range while the brush and the contact member move from one end side to the other end side of the filter with respect to the first moving direction. In other words, the gap goes beyond the predetermined range while the brush unit cleans the entire filter. Then it is preferable to halt the faster member during the cleaning. Thereby, the gap between the brush and the contact member can be always within the predetermined range.

[0018] At least one of the motors can be controlled such that the faster member waits for the other at the end of the filter cleaning and/or during the filter cleaning. Accordingly, the faster member can be halted at the end of

the filter.

[0019] According to another preferred embodiment of any one of the filter cleaning device mentioned above, the controller is configured to control the brush unit such that the brush or the contact member halts once or more while moving from one end side to the other end side of the filter with respect to the first moving direction; and the controller is further configured to control the brush unit such that a total time period of each halt period of the brush or the contact member is no longer than a predetermined time period P1.

[0020] When the brush or the contact member halts only once during a halt period H1, the halt period H1 is no longer than the predetermined time period P1.

[0021] When the brush or the contact member halts more than once, the total time period of each halt period is no longer than the time period P1. For example, when the brush halts twice for a halt period H1 and H2, respectively, the total time period of each halt period, i.e. (H1 + H2) is no longer than the predetermined time period P1.

[0022] The predetermined time period P1 can be calculated such that the gap between the brush and the contact member is kept within the predetermined range.

[0023] According to another preferred embodiment of any one of the filter cleaning device mentioned above, the filter cleaning device further comprises a detector configured to detect the gap between the brush and the contact member in position with respect to the first moving direction.

[0024] It is preferable to detect the actual gap between the brush and the contact member. There is a case in that the actual gap differs from the calculated gap due to a foreign body or a slip between gears. The detection of the actual gap enables the filter cleaning device to output an alarm signal, to control motors, and the like.

[0025] An infrared sensor can be employed as the detector to detect each position of the brush and the contact member. Another example of the detector is to a CCD (Charge Coupled Device) camera to scan the image of the brush and the contact member. The actual gap can be obtained by analysing the image scanned.

[0026] According to further another preferred embodiment of any one of the filter cleaning device with the detector mentioned above, the controller is configured to receive a detection result of the detector, and output an alarm signal based on the detection result when the gap goes beyond the predetermined range.

[0027] The controller is configured to determine based on the detection result whether or not the actual gap goes beyond the predetermined range. It is preferable to output the alarm signal in an unusual case in that the brush and the contact member do not face. The alarm signal can prompt an operator to check the filter cleaning device.

[0028] According to further another preferred embodiment of any one of the filter cleaning device with the detector mentioned above, the controller is configured to control at least one of the first motor and second motor based on the detection result.

[0029] It is preferable to halt and/or slow down one of the motors based on the detection result. Thereby, the actual gap between the brush and the contact member can be maintained within the predetermined range in a more secure manner.

[0030] According to further another preferred embodiment of any one of the filter cleaning device mentioned above, the filter is substantially flat; and the brush extends from one end to the other end of the filter with respect to a direction that intersects with the first moving direction.

[0031] According to further another preferred embodiment of any one of the filter cleaning device mentioned above, the filter is substantially flat; and the contact member extends from one end side to the other end side of the filter with respect to a direction that intersects with the first moving direction.

[0032] The configuration above enables the brush and the contact member to clean up the filter surface by moving along the first moving direction while sandwiching the filter. Thereby, the driving mechanism of the filter cleaning device can be simplified.

[0033] According to further another preferred embodiment of any one of the filter cleaning device mentioned above, a storage member disposed under the brush and configured to receive particles from the brush.

[0034] It is preferable that the storage member is disposed immediately under the brush only, although the storage member may be arranged to cover the entire width of the filter. Thereby, it is easier to realise downsizing of the filter cleaning device.

[0035] A second aspect of the present invention provides an air-conditioner having the filter cleaning device mentioned above.

Brief Description of the Drawings

[0036]

Fig. 1 is a schematic view indicating an installation state of the inner air-conditioning unit according to an embodiment of the present invention.

Fig. 2 is a top perspective view of an inner air-conditioning unit according to the present embodiment.

Fig. 3 is a front view of a filter cleaning device according to the present embodiment.

Fig. 4 is a side view of the filter cleaning device according to the present embodiment.

Fig. 5 is a partial top perspective view of the filter cleaning device according to the present embodiment.

Fig. 6 is a top perspective view of a cleaning unit according to the present embodiment.

Fig. 7 is a top perspective view of a brush unit according to the present embodiment.

Fig. 8 is a top perspective view of a cylinder unit according to the present embodiment.

Fig. 9 is a partial horizontal cross-sectional view of the filter cleaning device according to the present embodiment.

Fig. 10 is a schematic top view of the filter cleaning device according to the present embodiment, indicating a movement of the cleaning unit.

Fig. 11 is a schematic side view of the filter cleaning device according to the present embodiment, indicating the movement of the cleaning unit.

Fig. 12 is a partial vertical cross-sectional view of the filter cleaning device according to the present embodiment, indicating transfer of particles

Fig. 13 is a block diagram indicating a functional configuration of an air conditioner according to the present embodiment.

Fig. 14 is a schematic diagram indicating an example of a setting table according to the present embodiment.

Fig. 15 is a schematic diagram indicating another example of the setting table according to the present embodiment.

Fig. 16 is a schematic diagram indicating an example of the setting table with setting adjustment according to the present embodiment.

Fig. 17 is a flow chart indicating a process performed by a filter cleaning controller according to the present embodiment.

Fig. 18 is a flow chart indicating a cleaning operation according to the present embodiment.

Fig. 19 is a flow chart indicating a setting determination according to the present embodiment.

Fig. 20 is a schematic diagram indicating an example of the setting table with an updated setting adjustment according to the present embodiment.

Fig. 21 is a schematic diagram indicating an example of variation in inter-unit gap according to the present embodiment.

Detailed Description of Preferred Embodiments

[0037] An air-conditioner including a filter cleaning device according to a preferred embodiment of the present invention will be described with reference to the drawings.

Overview of Configuration of Air Conditioner

[0038] Fig. 1 is a schematic view indicating an installation state of the air conditioner. The air conditioner is included in an inner air-conditioning unit of an air-conditioning system.

[0039] The inner air-conditioning unit 100 is arranged between a building slab 210 and a false ceiling 220. The inner air-conditioning unit 100 comprises an air inlet duct 310, a filter cleaning device 400, an air-conditioner body 500 and an air outlet duct 320.

[0040] The air-conditioner body 500 has an air inlet port 501 and an air outlet port 502 which are formed on opposite outer sides of the air-conditioner body 500, respectively. The air-conditioner body 500 is hung from the building slab 210 behind the false ceiling 220 by hanging members 211. The air-conditioner body 500 is fixed in a state where two opposite sides thereof are parallel to a horizontal plane and the rest four sides thereof are perpendicular to the horizontal plane. The air inlet port 501 and the air outlet port 502 are positioned on the laterally opposite sides.

[0041] The air-conditioner body 500 has a fan 503 and a heat exchanger 504 inside. The fan 503 is configured to induce an internal airflow going from the air inlet port 501 to the air outlet port 502 through the heat exchanger 504. The heat exchanger 504 is configured to heat and/or cool the air passing through the heat exchanger 504. Thus, a main air-flow in the filter cleaning device 400 goes from the air inlet port 501 to the air outlet port 502.

[0042] The air-conditioner body 500 is attached with the filter cleaning device 400 at the air inlet port 501 by means of a flange coupling or the like (not shown). The filter cleaning device 400 has a rectangular tubular shape with short length. The filter cleaning device 400 has a body side port 401 and a duct side port 402 which are formed on opposite ends of the rectangular tubular shape. The filter cleaning device 400 has a filter (a flat filter) 410 positioned at between the body side port 401 and the duct side port 402. The filter 410 is configured to allow the air to pass through from the body side port 401 to the duct side port 402 while filtrating the air. The body side port 401 is connected to the air inlet port 501 of the air-conditioner body 500. Thus, a main air-flow in the air-conditioner body 500 goes from the duct side port 402 to the body side port 401.

[0043] The filter cleaning device 400 and the air-conditioner body 500 may be produced as a unit, or assembled to be put together after individually manufactured. The filter cleaning device 400 and the air-conditioner body 500 may be taken as an "air-conditioner."

[0044] The air inlet duct 310 connects an inlet grating 221 formed in the false ceiling 220 and the duct side port 402 of the filter cleaning device 400. Hence, the air inlet port 501 of the air-conditioner body 500 leads to, via the filter cleaning device 400, the air inlet duct 310 and the inlet grating 221, a space to which the inlet grating 221 is exposed. In addition, the air outlet duct 320 connects the air outlet port 502 of the air-conditioner body 500 and an outlet grating 222 formed in the false ceiling 220. Hence, the air outlet port 502 of the air-conditioner body 500 leads to, via the air outlet duct 320 and the outlet grating 222, a space to which the outlet grating 222 is exposed.

[0045] The fan 503 has a capacity high enough to make a continuous air flow from the inlet grating 221 to the outlet grating 222. Thus, the inner air-conditioning unit 100 can supply a heated/cooled air, i.e. perform air-conditioning. Moreover, the air passes the filter 410 in the filter cleaning device 400. Thus, the inner air-conditioning unit 100 is capable of not only supplying a clean air to the space to be air-conditioned but also avoiding the parts of the air-conditioner body 500, particularly the heat exchanger 504, from being soiled and clogged.

[0046] The inner air-conditioning unit 100 is concealed behind the false ceiling 220. Therefore, an inspection door 223 is provided on the false ceiling 220 for a purpose of maintenance of the inner air-conditioning unit 100.

[0047] In this embodiment, the terms related to directions are to be interpreted as follows, unless otherwise specified. The terms indicating linear directions pertinent to the inner air-conditioning unit 100 are the linear directions in a case where the inner air-conditioning unit 100 is in use. The term "width" is the length in a direction which is horizontal and perpendicular to the main air-flow direction in the filter cleaning device 400. The term "height" is the length in a direction which is vertical and perpendicular to the main air-flow direction in the filter cleaning device 400. The term "depth" is the length in a direction which is horizontal and parallel to the main air-flow direction in the filter cleaning device 400. The terms "left" and "right" are the left and the right in a horizontal direction when viewed from the upstream side of the main air-flow in the filter cleaning device 400. The term "side" is the side in a horizontal direction with respect to the main air-flow direction in the filter cleaning device 400. The terms indicating rotation directions are the rotation directions when viewed from the above in a case where the inner air-conditioning unit 100 is in use. The configurations explained in this embodiment may be horizontally flipped in the width direction. Therefore, the terms "left" and "right" and the terms "clockwise" and "counterclockwise" in this embodiment may be respectively interchanged.

[0048] Fig. 2 is a top perspective view of the air conditioner comprising the filter cleaning device 400 and the air-conditioner body 500.

[0049] The air-conditioner body 500 comprises an air-conditioner housing 520 having a substantially cuboid

shape. The height of the air-conditioner housing 520 is smaller than either the width and the depth of the air-conditioner housing 520. In other words, the air-conditioner body 500 is configured so as to ensure an internal space large enough to accommodate necessary elements by a horizontally wide and vertically narrow shape. The air-conditioner body 500 is also configured so as to ensure opening spaces of the air inlet port 501 and the air outlet port 502 large enough to intake and outlet the air with small friction loss by the horizontally wide and vertically narrow shape. Since the height is suppressed, the air-conditioner body 500 is applicable to the in-ceiling space having a limitation in height.

[0050] The air-conditioner body 500 comprises a body-side control box 530 mounted on an outer surface of a body side wall 521 which is one of the side walls of the air-conditioner housing 520. In this embodiment, the body side wall 521 is the left side wall of the air-conditioner housing 520.

[0051] The body-side control box 530 includes an arithmetic circuit such as a CPU (Central Processing Unit), a work memory used by the CPU, such as a RAM (Random Access Memory), and a recording medium storing control programs and information used by the CPU, such as a ROM (Read Only Memory), although they are not shown. The body-side control box 530 is configured to receive an electric power supply from an external power source. The body-side control box 530 is connected to each of the electronic elements mounted on the air-conditioner body 500 via power-supply cables and/or control cables (not shown). Thus, the body-side control box 530 is configured to perform information processing and signal processing to control the operation of the air-conditioner body 500 by the CPU executing the control programs, so as to achieve the functions of the filter cleaning device 400.

[0052] In the vicinity area of the body-side control box 530, including the interior space of air-conditioner housing 520, a lot of cables are arranged. Therefore, the air inlet port 501 (see Fig. 1), the air channel (not shown) in the air-conditioner body 500, and the air outlet port 502 (see Fig. 1) are formed closer to another side wall (not shown) than the body side wall 521. The other side wall is one of the walls of the air-conditioner housing 520, which is opposite to the body side wall 521. Thus, the air-conditioner body 500 has a chamber area 551 and a wiring area 552. The chamber area 551 is a width range which lets through the air for air-conditioning. The wiring area 552 is a width range which does not let through the air for air-conditioning.

[0053] The filter cleaning device 400 comprises a device housing 420 having a substantially cuboid shape. The height and width of the device housing 420 are substantially the same as the height and width of the air-conditioner housing 520 of the air-conditioner body 500. By this, the filter cleaning device 400 is also applicable to the in-ceiling space having a limitation in height.

[0054] The duct side port 402, the filter 410 and the

body side port 401 (see Fig. 1) have substantially the same width range as the width range of the air inlet port 501 of the air-conditioner body 500, i.e. the chamber area 551 of the air-conditioner body 500. Thus, the filter cleaning device 400 has a filtering area 451 and a non-filtering area 452. The filtering area 451 is a width range which lets through the air for air-conditioning. The non-filtering area 452 is a width range which does not let through the air for air-conditioning

[0055] The filter cleaning device 400 comprises a device-side control box 430 mounted on an outer surface of a device side wall 421. The device side wall 421 is one of the side walls of the device housing 420, which is on the same side as the body-side control box 530 of the air-conditioner body 500 in the width direction.

[0056] The device-side control box 430 includes an arithmetic circuit such as a CPU, a work memory used by the CPU, such as a RAM, and a recording medium storing control programs and information used by the CPU, such as a ROM, although they are not shown. The device-side control box 430 is configured to receive an electric power supply from an external power source or the body-side control box 530 of the air-conditioner body 500. The device-side control box 430 is connected to each of the electronic elements mounted on the filter cleaning device 400 via power-supply cables and/or control cables (not shown). Thus, the device-side control box 430 is configured to perform information processing and signal processing to control the operation of the filter cleaning device 400 by the CPU executing the control programs, so as to achieve the functions of the filter cleaning device 400.

[0057] The filter 410 of the filter cleaning device 400 is configured to filter out the particles from the air for air-conditioning. The filtered-out particles adhere to the filter 410 on the upstream side. The amount of the adhering particles increases as an air-conditioning operation, which is an operation for air-conditioning, is performed longer. This causes an increase in a friction loss of the air flow, resulting in a deterioration of the air-conditioning performance of the inner air-conditioning unit 100.

[0058] For avoiding such a performance deterioration, the filter cleaning device 400 has a filter cleaning function. The filter cleaning device 400 comprises a cleaning unit (not shown) which is configured to remove the particles adhering to the filter 410 and to accumulate the removed particles inside. The configuration of the cleaning unit will be detailed later. The cleaning unit is controlled to move along the width direction (a first moving axis which extends substantially horizontally and along the filter surface) and park at a predetermined parking position within the above-mentioned non-filtering area (hereinafter referred to as "the parking area") 452.

[0059] The amount of the accumulated particles increases as the air-conditioning operation is performed longer while performing a cleaning operation at intervals. The cleaning operation is an operation for cleaning the filter 410 by the cleaning unit. To avoid the amount of the

accumulated particles exceeds the accumulation capacity of the cleaning unit, the filter cleaning device 400 has a particle-evacuation function. The filter cleaning device 400 comprises an exhaust opening (a second hole) 441, a hose 442 and a suction socket 443.

[0060] The exhaust opening 441 is an opening formed on the device side wall 421, having a cylindrical element projecting inwardly and outwardly from the device side wall 421. The exhaust opening 441 is configured to lead to the internal space of the cleaning unit when the cleaning unit is at the parking position. The hose 442 is connected to the cylindrical element of the exhaust opening 441. The suction socket 443 has a front-side part (not shown) and a back-side part 444. The front-side part is arranged on the surface of the false ceiling 220 so as to be exposed. The hose 442 is connected to the back-side part 444 facing the in-ceiling space. The front-side part is formed with an aperture (not shown) which is configured to lead to the hose 442 through the back-side part 444.

[0061] Thus, the aperture of the suction socket 443 leads to the internal space of the cleaning unit via the hose 442 and the exhaust opening 441. With this configuration, the particles accumulated in the cleaning unit can be easily removed by the operator using a vacuum cleaner attached to the suction socket 443 to suck out the particles.

[0062] As shown in Fig. 2, two or more sets of the hose 442 and the suction socket 443 may be connected to the exhaust opening 441. The suction socket 443 may be arranged on a false wall, a false floor or the like (not shown).

Configuration of Filter Cleaning Device

[0063] Fig. 3 is a front view of the filter cleaning device 400. Here, Fig. 3 shows the state where the cleaning unit is parking at the parking position. Fig. 4 is a side view of the filter cleaning device 400 shown in Fig. 3.

[0064] The filter 410 comprises a filter frame 411 and a mesh sheet (a filter surface) 412. The filter frame 411 extends over the filtering area 451 in parallel to both the width direction and the height direction. The filter frame 411 has a plurality of vertical ribs and a plurality of horizontal ribs. The mesh sheet 412 is fixed to the entirety of the filter frame 411. Thus, the filter 410 has a longitudinal and flat shape perpendicular to the main air-flow direction, having a width W and a height H. In this embodiment, the height H is smaller than the width W. The filter frame 411 and the mesh sheet 412 are, for example, made of plastic material. The mesh sheet 412 is fixed to the filter frame 411 by means of moulding or the like.

[0065] The body side port 401 (see Fig. 1), the filter 410, the duct side port 402 and the air inlet duct 310 (see Fig. 1) are formed in approximately the same size and the same position when seen from the main air-flow direction. This means that the duct side port 402 is narrower than the device housing 420 in the width direction. Thus,

the device housing 420 has a cover wall 422 which covers the rest part of the upstream side of the device housing 420.

[0066] The width of the cleaning unit 600 is narrower than the width of the parking area 452. Therefore, the cleaning unit 600 does not interfere the air flow in the filtering area 451 at least when the cleaning unit 600 is at the parking position in the parking area 452.

[0067] Moreover, the parking area 452 is arranged in an area corresponding to the wiring area 552 of the air-conditioner body 500 in the width direction. The device-side control box 430 is also arranged in an area corresponding to the body-side control box 530 of the air-conditioner body 500 (see Fig. 2) in the width direction. Therefore, it is not necessary to increase the width and/or the height of the air-conditioner (the filter cleaning device 400 and the air-conditioning body 500) for the filter cleaning function.

[0068] Fig. 5 is a partial top perspective view of the filter cleaning device 400, with some parts (in particular, the cover wall 422) omitted.

[0069] The filter cleaning device 400 comprises a plurality of guide rails 423 and a plurality of racks (not shown). Both the guide rails 423 and the racks are arranged in the device housing 420 on both sides of the filter 410 in parallel with the filter 410, extending in the width direction over the width range of the device housing 420. The guide rails 423 are arranged at four corners of the device housing 420 and projecting vertically towards the vertical centre of the device housing 420, respectively. The racks are arranged close to the upper guide rails 423 and projecting horizontally towards the horizontal centre of the device housing 420, respectively.

[0070] The cleaning unit 600 is configured to engage with the guide rails 423 and the racks so as to slide in the width direction by utilizing the guide rails 423 and the racks. The cleaning unit 600 comprises a plurality of wheels 601 and a plurality of pinion gears (not shown).

[0071] The wheels 601 are freely rotatably fixed to the outer surface of the cleaning unit 600. The wheels 601 are configured to mesh with the guide rails 423 such that the attitude and the movement of the cleaning unit 600 are stabilized in a linear traveling along the filter 410. The pinion gears are rotatably fixed to the outer surface of the cleaning unit 600. The pinion gears are configured to mesh with the racks and be rotated by motors (not shown) such that the cleaning unit 600 moves along the filter 410. The motors are controlled by the device-side control box 430 such that the cleaning unit 600 travels in the width direction along the filter 410 under control. The cleaning unit 600 is preferably configured to exert a pressure on each of the wheels 601 towards the corresponding guide rail 423 by means of springs or the like so as to ensure engagements between the wheels 601 and the guide rails 423.

Configuration of Cleaning Unit

[0072] Fig. 6 is a top perspective view of the cleaning unit 600.

[0073] The cleaning unit 600 comprises a brush unit 620 and a cylinder unit 660. The brush unit 620 and the cylinder unit 660 are respectively arranged on opposite sides of the filter 410 with a predetermined distance. In other words, the brush unit 620 and the cylinder unit 660 are configured to sandwich the filter 410 therebetween. The wheels 601 and the pinion gears 602 mentioned above are provided to each of the brush unit 620 and the cylinder unit 660.

[0074] Fig. 7 is a top perspective view of the brush unit 620 as viewed from the cylinder unit 660 side.

[0075] The brush unit 620 comprises a brush-side casing 621 and a plurality of inner walls 622. The inner space of the brush-side casing 621 is sectioned by the inner walls 622 into four spaces of a machine space 623, a brush space 624, a gear space 625, and a storage space 626.

[0076] The machine space 623 and the brush space 624 extend vertically and are adjointly arranged in the width direction. The machine space 623 is positioned closer to the device side wall 421 of the device housing 420 (see Fig. 5) than the brush space 624. The gear space 625 extends horizontally over the machine space 623 and the brush space 624. The storage space 626 extends horizontally under the machine space 623 and the brush space 624.

[0077] The depths of the spaces 623-626 are substantially the same. The widths of the gear space 625 and the storage space 626 are substantially the same as the width of the machine space 623 and the brush space 624 as a unit. The height of the brush space 624 is substantially the same as the height of the filter 410 (i.e. the height H, see Fig. 3). The brush space 624 and the storage space 626 are basically closed spaces. Meanwhile, the brush space 624 is open to the storage space 626 at the bottom side of the brush space 624. The brush space 624 is also open to the outside of the brush-side casing 621 through a brush-side opening 627 formed in a brush-side wall 628. The brush-side wall 628 is one of the side walls of the brush-side casing 621, which faces the cylinder unit 660.

[0078] The brush unit 620 comprises a first motor 631, a gear mechanism 632, a brush 633, two combs (comb-like members), a separation roller and an exhaust port 636 (see the combs 634 and the separation roller 635 in Fig. 9).

[0079] The first motor 631 is a stepping motor arranged in the machine space 623. The first motor 631 is configured to be controlled by the device-side control box 430 (see Fig. 5) to switch between a forward rotation mode and an inverse rotation mode. The first motor 631 is also configured to be controlled by the device-side control box 430 to output a rotational force at a predetermined rotation speed and torque in a given rotation mode to the

gear mechanism 632.

[0080] The gear mechanism 632 is arranged mainly in the gear space 625. The gear mechanism 632 comprises a plurality of gears including the pinion gears 602 mentioned above and a plurality of shafts. The gear mechanism 632 includes the first pinion gear 602a and the second pinion gear 602b which mesh with the same rack. The gear mechanism 632 is configured to transfer the rotational force outputted from the first motor 631 to the first pinion gear 602a so as to move the brush unit 620 with respect to the rack. This movement of the brush unit 620 generates a rotational force of the second pinion gear 602b. The gear mechanism 632 is also configured to transfer the rotational force of the second pinion gear 602b to the brush 633 and the separation roller. Thus, the gear mechanism 632 is configured to transfer the rotational force from the first motor 631 to the first pinion gear 602a, the brush 633 and the separation roller with appropriate rotation directions, rotation speeds and torques according to the rotation of the first motor 631.

[0081] The brush 633 is a roll brush mainly arranged in the brush space 624. The axis of the brush 633 vertically extends from the gear space 625 to the storage space 626. The brush 633 is rotatably supported about the axis (a rotation axis) at the gear space 625 and the storage space 626. The axis of the brush 633 is connected to the gear mechanism 632 in the gear space 625. The brush 633 comprises bristles uniformly arranged around the axis. The bristles are formed over the height range of the brush space 624. In other words, the brush 633 extends from one end side to the other end side of the filter 410 in the height direction, and the height range of the part where the bristles is formed on the brush 633 substantially corresponds to the height range of the mesh sheet 412 of the filter 410.

[0082] The brush 633 is configured and positioned such that the bristles which are located at a predetermined angle range with respect to the axis of the brush 633 protrude from the brush-side opening 627 formed in the brush-side wall 628 when no resisting force is exerted to the bristles. The brush-side opening 627 has a long rectangular shape. Thus, the brush 633 is configured to rotate the bristles while exposing the bristles from the brush-side opening 627 under the control of the body-side control box 530.

[0083] The brush-side opening 627 may have a slightly wider width than the area from which the bristles protrude. Thus, the brush unit 620 has clearance gaps between the brush 633 and the brush-side wall 628 at least on each side of the protruding part of the brush 633 in the brush-side opening 627. The clearance gap allows the particles adhered to the protruding part of the bristles to be smoothly introduced into the brush space 624 along with the rotation of the brush 633.

[0084] The combs are arranged in the brush space 624. The combs are respectively fixed in parallel to the brush 633 and in contact with the bristles of the brush 633. The combs are configured to comb the bristles of

the brush 633 when the brush 633 rotates. The configuration of the combs will be detailed later.

[0085] The separation roller is arranged in the brush space 624 in parallel to one of the comb and in contact with teeth of the comb. The axis of the separation roller is rotatably supported at the gear space 625 and the storage space 626. The separation roller is connected to the gear mechanism 632 in the gear space 625. The separation roller is configured to loosen the particles clotting on the combs. The configuration of the separation roller will be detailed later.

[0086] The exhaust port 636 is arranged in the machine space 623 at the bottom side of the machine space 623. The exhaust port 636 has a shape of a bend tube. One end of the exhaust port 636 leads to the storage space 626 from the above. Another end of the exhaust port 636 is positioned higher than the storage space 626 and leads to the outside of the brush-side casing 621 at a controller-side wall 629. The controller-side wall 629 is one of the side walls of the brush-side casing 621 which faces the device side wall 421 of the device housing 420. Thus, the exhaust port 636 is configured to allow the storage space 626 to communicate with the outside of the brush-side casing 621 at the controller-side wall 629.

[0087] Fig. 8 is a top perspective view of the cylinder unit 660 as viewed from the brush unit 620 side.

[0088] The cylinder unit 660 comprises a cylinder-side casing 661. The inner space of the cylinder-side casing 661 includes four spaces of a cylinder-side machine space 663, a cylinder space 664, a cylinder-side gear space 665 and a lower space 666.

[0089] In a plane parallel to the filter 410, the positions of the cylinder-side machine space 663, the cylinder space 664, the cylinder-side gear space 665 and the lower space 666 correspond to the positions of the machine space 623, the brush space 624, the gear space 625 and the storage space 626 of the brush unit 620, respectively in this order. The cylinder-side machine space 663 and the cylinder space 664 are open to the outside of the cylinder-side casing 661 through a cylinder-side opening 667 formed on a brush-facing side 668. The brush-facing side 668 is one of the sides of the cylinder-side casing 661, which faces the brush unit 620. The cylinder unit 660 may also comprises one or more of inner walls 662 which section the inner space of the cylinder-side casing 661.

[0090] The cylinder unit 660 comprises a second motor 671, a cylinder-side gear mechanism 672 and a cylinder 673.

[0091] The second motor 671 is a stepping motor arranged in the cylinder-side machine space 663. The second motor 671 is configured to be controlled by the device-side control box 430 (see Fig. 5) to switch between a forward rotation mode and an inverse rotation mode. The second motor 671 is also configured to output a rotational force at a predetermined rotation speed and torque in a given rotation mode to the cylinder-side gear mechanism 672.

[0092] The cylinder-side gear mechanism 672 is arranged mainly in the cylinder-side gear space 665. The cylinder-side gear mechanism 672 comprises a plurality of gears including the pinion gear 602 mentioned above and a plurality of shafts. The cylinder-side gear mechanism 672 is configured to transfer the rotational force outputted from the second motor 671 to the pinion gear 602 with appropriate rotation directions, rotation speeds and torques according to the rotation of the second motor 671, so as to move the cylinder unit 660 with respect to the rack.

[0093] The cylinder 673 is a cylindrical member arranged in the cylinder space 664. The axis of the cylinder 673 vertically extends from the cylinder-side gear space 665 to the lower space 666. The axis of the cylinder 673 is freely rotatably supported at the cylinder-side gear space 665 and at the lower space 666. The cylinder 673 comprises a tubular element with constrictions arranged at positions corresponding to the positions of the horizontal ribs of the filter frame 411 (see Fig. 3). The height range of the tubular element is substantially the same as the height range of the part where the bristles are formed on the brush 633.

[0094] The cylinder unit 660 is configured such that the brush-side casing 621 and the cylinder-side casing 661 are at substantially the same position in the width direction when the relative position between the brush unit 620 and the cylinder unit 660 is at a predetermined relative position (hereinafter referred to as "the ideal relative position"). The ideal relative position is, for instance, a relative position in which the positional gap in the width direction between the axis of the brush 633 and the axis of the cylinder 673 is within a predetermined range.

[0095] The cylinder 673 is configured and positioned such that the part of the tubular element which is located at a predetermined angle range with respect to the axis of the cylinder 673 protrude from the cylinder-side opening 667 when no resisting force is exerted to the tubular element.

[0096] Thus, the cylinder 673 is configured to freely rotate the tubular element while exposing the tubular element from the cylinder-side opening 667. The cylinder unit 660 is preferably configured to exert pressure on the cylinder 673 in a direction towards the brush 633 of the brush unit 620 when the brush unit 620 and the cylinder unit 660 are in the ideal relative position. By this pressure exerted on the cylinder 673, the contact between the brush 633 and the cylinder 673 through the filter 410 is ensured.

[0097] Fig. 9 is a partial horizontal cross-sectional view of the filter cleaning device 400 when the filter cleaning device 400 is in use. More specifically, Fig. 9 shows a state of the vicinity part of the cleaning unit 600 when cross-sectioned at a central part of the cleaning unit 600 and viewed from the above.

[0098] The inner space of the device housing 420 of the filter cleaning device 400 is divided by the filter 410 into an upstream side space 403 and a downstream side

space 404. The brush unit 620 is arranged in the upstream side space 403, and the cylinder unit 660 is arranged in the downstream side space 404. The filter cleaning device 400 is configured to move the cleaning unit 600 in the width direction, while keeping the cleaning unit 600 in a second predetermined relative position with respect to the filter 410 in the height direction and in a predetermined clearance with respect to the filter 410 in the depth direction.

[0099] The second predetermined relative position is a relative position by which the height ranges of the brush 633 and the cylinder 673 substantially coincide with the height range of the filter 410. The predetermined clearance is a clearance by which the protruding part of the brush 633 engages with the mesh sheet 412 (see Fig. 3) of the filter 410 at a predetermined depth. The predetermined clearance is also a clearance by which the protruding part of the cylinder 673 contacts with mesh sheet 412 with a predetermined pressure when the brush 633 engages with the mesh sheet 412. The predetermined pressure is a pressure which balances with the pressure exerted to the filter 410 from the opposite side by the engaging brush 633.

[0100] The combs 634 are configured and positioned so as to be substantially symmetrical with respect to a plane 637 which is parallel to the depth direction and passes through the axis of the brush 633. The combs 634 are also positioned opposite to the brush-side wall 628 with respect to the axis of the brush 633.

[0101] Each of the combs 634 comprises a comb body extending in the height direction and a plurality of teeth aligned on the comb body. The teeth are uniformly arranged over the height range of the part where the bristles are formed on the brush 633. The teeth protrude towards the bristles of the brush 633. The teeth are configured to engage with the bristles at a predetermined depth and a predetermined angle with respect to the axis of the brush 633.

[0102] The teeth of a pair of the combs 634 form a V-shape opening towards the brush 633 while respectively engaging with the brush 633. Each of the combs 634 is configured such that the teeth are inclined towards the brush-side wall 628 with respect to a position of the axis of the brush 633. Thus, teeth of each combs 634 are oriented towards upstream side relative to a direction towards the rotation axis of the brush 633 in the corresponding rotation direction. More specifically, the comb 634 positioned on the right is configured to comb the brush 633 when the brush 633 rotates clockwise. The comb 634 positioned on the left is configured to comb the brush 633 when the brush 633 rotates counterclockwise.

[0103] Here, a line at which the outer perimeter of the brush 633 and the teeth of the comb 634 intersect with each other is referred to as "the outer-engaged line." The separation roller 635 has a diameter much smaller than the diameter of the brush 633. The separation roller 635 is positioned near the outer-engaged line so as to be in

contact with both the teeth of the comb 634 which combs the brush 633 when the brush 633 rotates clockwise (i.e. the comb 634 positioned on the right) and the bristles of the brush 633 over the height range of the bristles.

[0104] The separation roller 635 has spiral threads in a form of a left-hand screw around the axis of the separation roller 635 over the height range of the part where the bristles are formed on the brush 633. The separation roller 635 is configured to be rotated in the same rotation direction as the brush 633 by the gear mechanism 632 (see Fig. 7).

[0105] Thus, the separation roller 635 is configured to move, at the outer-engaged line, the spiral threads towards a direction which is downward and opposite to the movement direction of the bristles when the corresponding comb 634 is combing the brush 633. This function is achieved when the brush 633 rotates against the teeth of the corresponding comb 634, i.e. when the brush 633 is combed by the corresponding comb 634.

[0106] Another separation roller 635 corresponding to the comb 634 which combs the brush 633 when the brush 633 rotates counterclockwise (i.e. the comb 634 positioned on the left) may be provided to the brush unit 620. In this case, the other separation roller 635 is positioned near the outer-engaged line of the comb 634 which combs the brush 633 when the brush 633 rotates counterclockwise. The other separation roller 635 has spiral threads in a form of a right-hand screw around the axis of the brush 633. The other separation roller 635 is configured to be rotated in the same rotation direction as the brush 633.

[0107] The gear mechanism 632 of the brush unit 620 is configured to rotate the brush 633 in a predetermined rotation direction. The predetermined rotation direction is a rotation direction by which the protruding part of the bristles moves against the relative movement of the filter 410 with respect to the brush unit 620. In other words, the gear mechanism 632 is configured to rotate the brush 633 clockwise when moving the brush unit 620 rightward, and rotate the brush 633 counterclockwise when moving the brush unit 620 leftward.

[0108] The cylinder unit 660 is controlled to move in width direction synchronously with the brush unit 620 while pressing the protruding part of the cylinder 673 towards the protruding part of the rotating brush 633 through the filter 410. The diameter of the each bristle of the brush 633 is smaller than the diameter of the each mesh of the mesh sheet 412. Therefore, the ends of the bristles protrude from the mesh sheet 412 towards the cylinder unit 660. The cylinder unit 660 is passively rotated by the friction with the protruding ends of the bristles or the surface of the filter 410.

[0109] By this movement of the cleaning unit 600, the particles 101 adhering to the filter 410 is scraped by the bristles. The scraped particles 102 then adhere to the bristles and caught by the comb 634 with the teeth opposed to the transfer direction of the scraped particles 102. While some of the caught particles 103 would im-

mediately fall into the storage space 626 by gravity, the rest would clot on the teeth at the above-mentioned outer-engaged line. The clotting particles are loosened with time by the movement of the threads of the corresponding separation roller 635 to fall into the storage space 626 by gravity.

[0110] Even though the brush unit 620 exerts a pressure to the filter 410, the total pressure exerted to the filter 410 by the cleaning unit 600 is stabilized to nearly zero by the function of the cylinder unit 660. Therefore, it is prevented to damage the filter 410 even if the pressure exerted by the brush unit 620 is great and/or the filter 410 is undulating. This ensures a high cleaning efficiency of the filter cleaning device 400.

[0111] Moreover, since the cylinder unit 660 applies the tubular elements to the brushes of the brush unit 620 from the opposite side of the surface of the filter 410, it is prevented to scatter the particles from the part where the bristles engage with the filter 410.

[0112] Fig. 10 is a schematic top view of the filter cleaning device 400, indicating the movement of the cleaning unit. Fig. 11 is a schematic side view of the filter cleaning device 400, indicating the movement of the cleaning unit.

[0113] As mentioned above, the pinion gears 602 of the cleaning unit 600 mesh with the racks 424 extending in the width direction. The cleaning unit 600 is controlled to travel in the width direction between a starting point (one end side of the filter) 471 and a turnaround point (the other end side of the filter) 472 in the width direction using the racks 424. The starting point 471 is a position close to the device side wall 421 in the inner space of the device housing 420. The starting point 471 is located within the parking area 452. The turnaround point 472 is a position close to an opposite side wall 425 in the inner space of the device housing 420. The opposite side wall 425 is one of the side walls of the device housing 420, which is opposite to the device side wall 421. The filter cleaning device 400 comprises four limit switches (LS) 461-464.

[0114] The first limit switch 461 is disposed on the inner surface of the device side wall 421 of the device housing 420 in the downstream side space 404. The first limit switch 461 is configured to detect whether the cylinder unit 660 is at the starting point 471.

[0115] The second limit switch 462 is disposed on the inner surface of the opposite side wall 425 in the downstream side space 404. The second limit switch 462 is configured to detect whether the cylinder unit 660 is at the turnaround point 472.

[0116] The third limit switch 463 is disposed on the inner surface of the device side wall 421 of the device housing 420 in the upstream side space 403. The third limit switch 463 is configured to detect whether the brush unit 620 is at the starting point 471.

[0117] The fourth limit switch 464 is disposed on the inner surface of the opposite side wall 425 in the upstream side space 403. The fourth limit switch 464 is configured to detect whether the brush unit 620 is at the

turnaround point 472.

[0118] The positions of the first limit switch 461 and the third limit switch 463 are arranged so as to coordinate with the position of the cleaning unit 600 when the cleaning unit 600 is at the starting point 471 with the brush unit 620 and the cylinder unit 660 being in the ideal relative position.

[0119] The positions of the second limit switch 462 and the fourth limit switch 464 are also arranged so as to coordinate with the position of the cleaning unit 600 when the cleaning unit 600 is at the turnaround point 472 with the brush unit 620 and the cylinder unit 660 being in the ideal relative position.

[0120] In this embodiment, the starting point 471 of the cleaning unit 600 is the same as the parking position mentioned above.

[0121] As indicated by broken line arrows 104, 105 in Figs. 10 and 11, for each time of the cleaning operation, the cleaning unit 600 reciprocates along the filter 410. More specifically, the cleaning unit 600 is controlled to move forward after starting from the starting point 471, turn around at the turnaround point 472, and then and move backward to the starting point 471. During the cleaning operation, the particles are removed from the filter 410 and accumulated in the storage space 626 of the cleaning unit 600 as explained along with Fig. 9.

[0122] The cleaning unit 600 is configured to engage the exhaust port 636 with the exhaust opening 441 arranged on the device side wall 421 so as to allow the storage space 626 to communicate with the exhaust opening 441 when the cleaning unit 600 is at the parking position.

[0123] Fig. 12 is a partial vertical cross-sectional view of the filter cleaning device 400, indicating the transfer of the particles. More specifically, Fig. 12 shows a state of the vicinity part of the cleaning unit 600 along with the state of the movement of the particles when cross-sectioned at a central part of the brush unit 620 and viewed from the upstream side of the main air-flow.

[0124] The particles 106 removed from the filter 410 fall from the brush space 624 into the storage space 626 to be accumulated in the storage space 626. The structural part which forms a bottom surface of the brush unit 620 and the storage space 626 may be taken as a storage member 643" disposed under the brush 633 and configured to receive particles having fallen from the brush 633. The cleaning unit 600 is controlled to keep parking at the parking position while the filter cleaning device 400 is not performing the cleaning operation, i.e. when the filter cleaning device 400 is in non-use state. Thus, the exhaust port 636 is connected to the exhaust opening 441 of the device housing 420, allowing the storage space 626 to communicate with the suction socket 443 (see Fig. 2) via the exhaust opening 441 and the hose 442.

[0125] In this state, when an air suction is performed at the suction socket 443, the accumulated particles 107 in the storage space 626 are sucked out to the suction socket 443 via the exhaust port 636, the exhaust opening

441 and hose 442 to be discharged from the storage space 626.

[0126] Accordingly, the brush unit 620 is driven by the first motor 631, and the cylinder unit 660 is driven by the second motor 671.

[0127] To prevent scattering the particles from the part where the brush 633 engages with the filter 410, it is desirable that an inter-unit gap is within a predetermined range. The inter-unit gap is a positional gap in the width direction between the brush unit 620 and the cylinder unit 660. For instance, the inter-unit gap is the distance in the width direction between the axis of the brush 633 (the centre of the brush 633) and the axis of the cylinder 673 (the centre of the cylinder 673). Alternatively, the inter-unit gap may be the distance in the width direction between another predetermined part of the brush 633 and another predetermined part of the cylinder 673.

[0128] However, since the drive loads of the brush unit 620 and the cylinder unit 660 are different, it is difficult to move the brush unit 620 and the cylinder unit 660 at the same speed in the width direction even if different types of motors are employed as the first motor 631 and the second motor 671. Moreover, each the drive load would vary across the ages. Furthermore, each the speed would be unstable due to slipping or jamming of the brush unit 620 and the cylinder unit 660.

[0129] Therefore, as explained in detail hereinafter, the filter cleaning device 400 is configured to control the inter-unit gap to be within the predetermined range.

Functional Configuration of Filter Cleaning Device

[0130] Fig. 13 is a block diagram indicating a functional configuration of the inner air-conditioning unit 100.

[0131] The inner air-conditioning unit 100 has an air-conditioning controller 710, a position sensor 720, a driving unit 730, an information storage unit 740 and a filter cleaning controller 750.

[0132] The air-conditioning controller 710 is disposed in the body-side control box 530 of the air-conditioner body 500. The function of the air-conditioning controller 710 is achieved by information processing and signal processing performed by the arithmetic circuit in the body-side control box 530.

[0133] The air-conditioning controller 710 is configured to execute the air-conditioning operation and transmit air-conditioner information to the filter cleaning controller 750. The air-conditioner information indicates whether the air-conditioning operation is currently performed. The air-conditioning controller 710 transmits the air-conditioner information by transmitting a signal to the filter cleaning controller 750.

[0134] The air-conditioning controller 710, for instance, transmits the air-conditioner information at predetermined intervals. The air-conditioning controller 710 may transmit the air-conditioner information at each time when the air-conditioning operation is started or ended. The air-conditioning controller 710 may transmit the air-

conditioner information upon receiving a request for the air-conditioner information from the filter cleaning controller 750.

[0135] In addition, the air-conditioning controller 710 is configured to refrain from performing the air-conditioning operation when a request for refraining from performing the air-conditioning operation is made by the filter cleaning controller 750.

[0136] The position sensor 720 is disposed in the filter cleaning device 400. The position sensor 720 includes the first limit switch 461, the second limit switch 462, the third limit switch 463 and the fourth limit switch 464 (see Fig. 10).

[0137] The position sensor 720 is configured to detect each of the positions of the brush unit 620 and the cylinder unit 660 in the width direction. The position sensor 720 detects at least whether the brush unit 620 is at the starting point 471, whether the cylinder unit 660 is at the starting point 471, whether the brush unit 620 is at the turnaround point 472, and whether the cylinder unit 660 is at the turnaround point 472 (see Figs. 10 and 11).

[0138] The position sensor 720 is configured to transmit position information to the filter cleaning controller 750. The position information indicates the result of the detection made by the position sensor 720. The position sensor 720 transmits the position information by transmitting a signal to the filter cleaning controller 750. The position sensor 720, for instance, transmits the position information at predetermined intervals. The position sensor 720 may transmit the position information at each time when it is detected that any one of the brush unit 620 and the cylinder unit 660 is at the starting point 471 or the turnaround point 472. The position sensor 720 may transmit the position information upon receiving a request for the position information from the filter cleaning controller 750.

[0139] The driving unit 730 is disposed in the filter cleaning device 400. The driving unit 730 includes the first motor 631 and the second motor 671. As explained above, the first motor 631 and the second motor 671 are configured to generate forces for driving the brush unit 620 and the cylinder unit 660, respectively (see Figs. 7 and 8). The driving unit 730 may further include mechanical members, such as the gear mechanism 632, the cylinder-side gear mechanism 672 and so forth, which are used for driving the brush unit 620 and the cylinder unit 660.

[0140] The driving unit 730 is configured to move each of the brush unit 620 and the cylinder unit 660 individually along the width direction between the starting point 471 and the turnaround point 472 while rotating the brush 633 about the rotation axis, under the control by the filter cleaning controller 750. The driving unit 730 rotates the brush 633 such that the bristles which are in contact with the filter 410 moves against the relative movement of the filter 410 with respect to the cleaning unit 600.

[0141] The first motor 631 and the second motor 671 may be different in size, step angle, gear reduction ratio,

motor shaft rotation, gear shaft rotation, and so forth. The first motor 631 and the second motor 671 accordingly may be different in the trail distance per shaft rotation. When each the trail distance per shaft rotation is not adjustable, the traveling speed of each of the brush unit 620 and the cylinder unit 660 is determined by the pulse rate applied thereto. Meanwhile, when the first motor 631 and the second motor 671 are different in trail distance per shaft rotation, it is not necessarily possible to make the traveling speeds of the brush unit 620 and the cylinder unit 660 substantially the same such that the inter-unit gap is maintained within the predetermined range.

[0142] The information storage unit 740 is disposed in the device-side control box 430 of the filter cleaning device 400. The information storage unit 740 includes a memory area of the recording medium in the device-side control box 430. The information storage unit 740 is configured to store the control programs and the information necessary for the operation of the filter cleaning device 400. In particular, the information storage unit 740 stores information necessary for controlling the inter-unit gap to be within the predetermined range. The information storage unit 740 stores a setting table which indicates at least default settings for operations of the first motor 631 and the second motor 671. As detailed later, the first motor 631 and the second motor 671 are driven according to the setting table.

[0143] Fig. 14 is a schematic diagram indicating an example of a setting table.

[0144] The setting table 810a states, for each item 811 of the first motor 631 and the second motor 671, a default setting 812 and a setting adjustment 813. The default setting 812 is an operation specification of the first motor 631 or the second motor 671. The setting adjustment 813 is an operation adjustment which is to be applied to the default setting 812. The setting adjustment 813 may be null if no operation adjustment is necessary.

[0145] For example, the setting table 810a states the default settings 812 as follows.

- The default setting 812 for the first motor 631 (the brush unit 620):
 - Pulse rate: 235 pps
 - Default velocity: 15.4 mm/sec
 - Nonstop traveling
- The default setting 812 for the second motor 671 (the cylinder unit 660):
 - Pulse rate: 600 pps
 - Default velocity: 15.4 mm/sec
 - Nonstop traveling

[0146] As mentioned above, it depends on the configuration of the driving unit 730 whether the default traveling speeds of the brush unit 620 and the cylinder unit 660 are substantially the same or not. The setting table 810a is an example when the default traveling speeds (default velocities) are the same.

[0147] Fig. 15 is a schematic diagram indicating another example of a setting table.

[0148] As shown in Fig. 15, the setting table 810b may state the default settings 812 as follows.

- The default setting 812 for the first motor 631 (the brush unit 620):
 - Pulse rate: 200 pps
 - Default velocity: 13.1 mm/sec
 - Nonstop traveling
- The default setting 812 for the second motor 671 (the cylinder unit 660):
 - Pulse rate: 500 pps
 - Default velocity: 12.8 mm/sec
 - Nonstop traveling

[0149] In this example, the default traveling speeds are different. The default velocity of the cylinder unit 660 is 12.8 mm/sec, while the default velocity of the brush unit 620 is 13.1 mm/sec. Thus, the brush unit 620 is faster than the cylinder unit 660 by 0.3 mm/sec. When a travel distance D_t is 1,027 mm, and the inter-unit gap reaches approximately 22 mm. The travel distance D_t is a distance between the starting point 471 and the turnaround point 472.

[0150] In such a case, the setting table may include the setting adjustment 813 which indicates how to control the first motor 631 and the second motor 671 for maintaining the inter-unit gap within a predetermined range in advance.

[0151] Fig. 16 is a schematic diagram indicating an example of a setting table with a setting adjustment.

[0152] As shown in Fig. 16, the setting table 810c states the same default settings 812 as the setting table 810b shown in Fig. 15. Meanwhile, the setting table 810c further states a setting adjustment 813 for the first motor 631 (the brush unit 620) as follows.

- Stop Interval $Is1$: 16.6 sec
- Stop time $Ls1$: 0.4 sec

[0153] The stop interval Is is an interval between stopping periods, i.e. the time length from when a stopping period ends to when the next stopping period starts. The

stop time L_s (a predetermined time period $P1$) is a time length of each the stopping period. The stopping period is a time period when the brush unit 620 or the cylinder unit 660 is stopped.

[0154] Thus, the above setting adjustment 813 indicates that the first motor 631 should be stopped for 0.4 sec at 16.6 sec intervals (i.e. every 17.0 sec) during the travel between the starting point 471 and the turnaround point 472. By implementing this operation adjustment, the brush unit 620, which is faster than the cylinder unit 660, halts intermittently to decrease the inter-unit gap.

[0155] The stop interval I_s and a stop time L_s are prepared and described in the setting table 810c in advance. The stop interval I_s and a stop time L_s are calculated, for example, by the air-conditioning controller 710 using the following formulae (1)-(3).

$$G0 = Vf0 - Vs0 \quad \dots(1)$$

$$I_s = Gth / G0 \quad \dots(2)$$

$$L_s = Gth / Vs0 \quad \dots(3)$$

[0156] A faster travel speed $Vf0$ is the faster one among the default velocities of the brush unit 620 and the cylinder unit 660. A slower travel speed $Vs0$ is the slower one among the default velocities of the brush unit 620 and the cylinder unit 660. A gap per unit time $G0$ is an increment of the inter-unit gap per unit time. A threshold Gth is a maximum allowable absolute value of the inter-unit gap. The threshold Gth is determined based on experiments or the like and stored in the information storage unit 740 in advance. It is preferable that the calculation result of the formula (2) is rounded down to a predetermined digit.

[0157] For instance, it is assumed that the faster travel speed $Vf0$ is 13.1 mm/sec and the slower travel speed $Vs0$ is 12.8 mm/sec, and the threshold Gth is 5 mm. In this case, the gap per unit time $G0$ is calculated to be 0.3 mm/sec (13.1 mm/sec - 12.8 mm/sec), the stop interval I_s is calculated to be 16.6 sec (5 mm / 0.3 mm/sec, rounded down to one decimal place), and the stop time L_s is calculated to be 0.4 sec (5 mm / 12.8 mm/sec). Thus, the stop interval $I_s=16.6$ sec and the stop time $L_s=0.4$ sec are derived and included in the setting table 810c as the setting adjustment 813 for the first motor 631 (the brush unit 620) as shown in Fig. 16.

[0158] The stop interval I_s may be calculated in any one of pulse number and time length. Since the pulse rate of one of the brush unit 620 and the cylinder unit 660 which has the faster travel speed $Vf0$ (here, the brush unit 620) is 200 pps, the stop interval I_s1 may be calculated to be 3320 pulses (16.6 sec x 200 pps).

[0159] The filter cleaning controller 750 is disposed in the device-side control box 430 of the filter cleaning device 400. The function of the filter cleaning controller 750 is achieved by information processing and signal processing performed by the arithmetic circuit in the device-side control box 430.

[0160] The filter cleaning controller 750 is configured to execute the operation of the filter cleaning device 400 according to the control programs and the information including the setting table 810 stored in the information storage unit 740. The filter cleaning controller 750 is especially configured to execute the cleaning operation by using the position sensor 720 and by controlling the driving unit 730.

Operation of Filter Cleaning Device

[0161] The operation of the filter cleaning device 400 is executed by the filter cleaning controller 750 performing a process.

[0162] Fig. 17 is a flow chart indicating the process performed by the filter cleaning controller 750.

[0163] At step S1000, the filter cleaning controller 750 determines whether a timing for cleaning the filter 410 has arrived.

[0164] The timing for cleaning the filter 410 may be a timing which comes at predetermined intervals, a timing when the air-conditioning operation is ended, or upon receiving a request for cleaning the filter 410. If a particle sensor is mounted on the filter cleaning device 400, the request for cleaning the filter 410 may be transmitted from the particle sensor. The particle sensor is, for instance, configured to detect whether the amount of the particles adhering to the filter 410 exceeds a predetermined level. The request for cleaning the filter 410 may be transmitted from a user interface or an information processing unit (both not shown) which is disposed in the distance.

[0165] When the timing for cleaning the filter 410 has not arrived (S1000: No), the filter cleaning controller 750 advances the process to step S5000 explained later. When the timing for cleaning the filter 410 has arrived (S1000: Yes), the filter cleaning controller 750 advances the process to step S2000.

[0166] At step S2000, the filter cleaning controller 750 acquires the air-conditioner information. The filter cleaning controller 750 may acquire the air-conditioner information by referring the air-conditioner information stored in the information storage unit 740, which is prestored by the filter cleaning controller 750 upon receiving the air-conditioner information. The filter cleaning controller 750 may acquire the air-conditioner information by transmitting a request for the air-conditioner information to the air-conditioning controller 710 and by receiving a response.

[0167] At step S3000, the filter cleaning controller 750 determines, based on the acquired air-conditioner information, whether the air-conditioning operation is current-

ly performed. In other words, the filter cleaning controller 750 determines whether the air-conditioner body 500 is air-conditioning. When the air-conditioner body 500 is air-conditioning (S3000: Yes), the filter cleaning controller 750 advances the process to step S5000. When the air-conditioner body 500 is not air-conditioning (S3000: No), the filter cleaning controller 750 advances the process to step S4000.

[0168] At step S4000, the filter cleaning controller 750 executes the cleaning operation, and then advances the process to step S5000.

[0169] At step S5000, the filter cleaning controller 750 determines whether it is indicated to complete the process by the operator or the like. When it is not indicated to complete the process (S5000: No), the filter cleaning controller 750 returns the process to the step S1000. When it is not indicated to complete the process (S5000: Yes), the filter cleaning controller 750 completes the process.

[0170] Fig. 18 is a flow chart indicating the process of the cleaning operation (Fig. 17, step S4000), performed by the filter cleaning controller 750.

[0171] At step S4010, the filter cleaning controller 750 transmits a start notification to the air-conditioning controller 710, as the request for refraining from performing the air-conditioning operation.

[0172] At step S4020, the filter cleaning controller 750 adjust initial positions of the brush unit 620 and cylinder unit 660 for the cleaning operation to the starting point 471 (see Figs. 10 and 11).

[0173] At step S4030, the filter cleaning controller 750 controls the driving unit 730 such that the brush unit 620 and the cylinder unit 660 move forward, i.e. in a direction away from the device side wall 421 in the width direction (rightward). The filter cleaning controller 750 controls the driving unit 730 using the current setting indicated by the setting table 810 (see Figs. 14-16) stored in the information storage unit 740.

[0174] For instance, it is assumed that the setting table 810b shown in Fig. 15 is stored. In this case, the filter cleaning controller 750 controls the driving unit 730 to drive the first motor 631 at a pulse rate of 200 pps, and drive the second motor 671 at a pulse rate of 500 pps, without stopping any of the first motor 631 and the second motor 671.

[0175] Alternatively, it is assumed that the setting table 810c shown in Fig. 16 is stored. In this case, the filter cleaning controller 750 controls the driving unit 730 to drive the first motor 631 at a pulse rate of 200 pps, drive the second motor 671 at a pulse rate of 500 pps while stopping the first motor 631 for 0.4 sec at 16.6 sec intervals.

[0176] At step S4040, the filter cleaning controller 750 determines whether both the brush unit 620 and cylinder unit 660 have reached the turnaround point 472 (see Figs. 10 and 11) according to the position information transmitted from the position sensor 720. When any one of the brush unit 620 and cylinder unit 660 has not

reached the turnaround point 472 (S4040: No), the filter cleaning controller 750 returns the process to the step S4030. When both the brush unit 620 and cylinder unit 660 have reached the turnaround point 472 (S4040: Yes), the filter cleaning controller 750 advances the process to step S4050.

[0177] At step S4050, the filter cleaning controller 750 performs the setting determination, and then advances the process to step S4070 explained later. By the setting determination, the filter cleaning controller 750 determines whether an adjustment on the current operation setting is necessary and adjust the operation setting when the adjustment is determined necessary. However, the step S4050 may be skipped if it is not necessary. The setting determination will be detailed later.

[0178] At step S4070, the filter cleaning controller 750 controls the driving unit 730 such that the brush unit 620 and the cylinder unit 660 move backward, i.e. in a direction closer to the device side wall 421 in the width direction (leftward). The filter cleaning controller 750 controls the driving unit 730 using the current operation setting indicated by the setting table 810 stored in the information storage unit 740. The operation setting used in step S4070 is different from the operation setting used in step S4030 when the operation setting (i.e. the contents of the setting table 810) is adjusted in step S4050.

[0179] At step S4080, the filter cleaning controller 750 determines whether both the brush unit 620 and cylinder unit 660 have reached the starting point 471 (see Figs. 10 and 11) according to the position information transmitted from the position sensor 720. When any one of the brush unit 620 and cylinder unit 660 has not reached the starting point 471 (S4080: No), the filter cleaning controller 750 returns the process to the step S4070. When both the brush unit 620 and the cylinder unit 660 have reached the starting point 471 (S4080: Yes), the filter cleaning controller 750 advances the process to step S4090.

[0180] At step S4090, the filter cleaning controller 750 performs the setting determination, and then advances the process to step S4110. However, the step S4090 may be skipped if it is not necessary.

[0181] At step S4110, the filter cleaning controller 750 transmits an end notification to the air-conditioning controller 710, as a cancellation of the request for refraining from performing the air-conditioning operation. Then the filter cleaning controller 750 returns the process to the step S5000 in Fig. 17. The parking position of the cleaning unit 600 is accordingly set to the starting point 471.

[0182] Fig. 19 is a flow chart indicating the process of the setting determination (Fig. 18, steps S4050 and S4090), performed by the filter cleaning controller 750.

[0183] At step S4051, the filter cleaning controller 750 acquires a total pulse number N_p of the faster unit and the inter-unit gap G_p . Here, "the faster unit" is one of the brush unit 620 and the cylinder unit 660 that reached the starting point 471 or the turnaround point 472 earlier than the other one. Similarly, one of the brush unit 620 and

the cylinder unit 660 that reached the starting point 471 or the turnaround point 472 later than the other one is referred as "the slower unit". The total pulse number N_p is the number of pulses which have been sent to the corresponding motor. The corresponding motor is one of the first motor 631 or the second motor 671 which drives the faster unit during the travel between the starting point 471 and the turnaround point 472.

[0184] The filter cleaning controller 750 may calculate the inter-unit gap G_p by acquiring a time gap G_t between the brush unit 620 and the cylinder unit 660. The time gap G_t is a time length of a time period between a first arriving timing and a second arriving timing. The first arriving timing is a timing when one of the brush unit 620 and the cylinder unit 660 first reached the starting point 471 or the turnaround point 472. The second arriving timing is a timing when the other one next reached the same of the starting point 471 and the turnaround point 472.

[0185] In this case, the filter cleaning controller 750 calculates the inter-unit gap G_p by multiplying the acquired time gap G_t by the travel speed V of the slower unit.

[0186] For instance, it is assumed that the setting table 810b or the setting table 810c is stored (see Figs. 15 and 16), the brush unit 620 is the faster unit, and the time gap G_t is 1.4 sec. In this case, since the travel speed V_2 of the cylinder unit 660 is 12.8 mm/sec, the inter-unit gap G_p is calculated to be 17.9 mm ($1.4 \text{ sec} \times 12.8 \text{ mm/sec}$).

[0187] It should be noted that the actual travel speed of the slower unit would be slower than the travel speed as the default velocity. Yet, in such a case, the inter-unit gap G_p might be calculated to be greater than the actual inter-unit gap. Thus, it is prevented to determine the inter-unit gap G_p smaller than the actual inter-unit gap.

[0188] Alternatively, the filter cleaning controller 750 may count, during the time gap G_t , the pulse sent to the first motor 631 or the second motor 671 which corresponds to the slower unit. In this case, the filter cleaning controller 750 may calculate the inter-unit gap G_p from the counted pulse number, the total pulse number N_p of the slower unit, and the travel distance D_t .

[0189] At step S4052, the filter cleaning controller 750 determines whether the absolute value of the inter-unit gap G_p (i.e. $|G_p|$) is equal to or smaller than a predetermined threshold G_{th} . The range from $-G_{th}$ to G_{th} is a range of the inter-unit gap with which the cylinder 673 functions to prevent scattering the particles from the part where the brush 633 engages with the filter at a predetermined level.

[0190] When the inter-unit gap G_p is equal to or smaller than the threshold G_{th} (S4052: Yes), the filter cleaning controller 750 advances the process to the corresponding one of steps S4070 and S4110 in Fig. 18. When the inter-unit gap G_p is greater than the threshold G_{th} (S4052: No), the filter cleaning controller 750 advances the process to step S4053.

[0191] At step S4053, the filter cleaning controller 750 determines whether either the brush unit 620 or the cyl-

inder unit 660 already has an adjusted setting. In other words, the filter cleaning controller 750 determines whether the setting table 810 describes the setting adjustment 813 for any one of the first motor 631 and the second motor 671.

[0192] When neither the brush unit 620 nor the cylinder unit 660 has any adjusted setting (S4053: No), the filter cleaning controller 750 advances the process to step S4055 explained later. When either the brush unit 620 or the cylinder unit 660 has any adjusted setting (S4053: Yes), the filter cleaning controller 750 advances the process to step S4054.

[0193] For instance, when the setting table 810a shown in Fig. 14 or the setting table 810b shown in Fig. 15 is stored, the process proceeds to step S4054. Meanwhile, when the setting table 810c shown in Fig. 16 is stored, the process proceeds to step S4054.

[0194] At step S4054, the filter cleaning controller 750 calculates the inter-unit gap G_p for a case where no adjusted setting is described in the setting table 810, based on the setting table 810 and the detection result.

[0195] For instance, it is assumed that the setting table 810c shown in Fig. 16 and the information indicating the travel distance $D_t=1,027 \text{ mm}$ are stored. The traveling time T_1 of the brush unit 620, when the brush unit 620 does not stop, is calculated to be 78.4 sec ($1,027 \text{ mm} / 12.8 \text{ mm/sec}$). The number of times that the first motor 631 stops is calculated, for instance, to be 4 ($78.4 \text{ sec} / 16.6 \text{ sec}$). The filter cleaning controller 750 may count or calculate the number of times that the first motor 631 has stopped. The brush unit 620 would reach the turnaround point 472 further earlier by 1.6 sec ($0.4 \text{ sec} \times 4$) if the brush unit 620 does not stop. Thus, the time gap G_t in a case of no adjusted setting is calculated to be 3.0 sec ($1.4 \text{ sec} + 1.6 \text{ sec}$), and the inter-unit gap G_p in a case of no adjusted setting is calculated to be 38.4 mm ($3.0 \text{ sec} \times 12.8 \text{ mm/sec}$).

[0196] It should be noted that there would be a case where the slower unit has the adjusted setting of intermittently stopping the travel. Therefore, if the adjusted setting were cancelled, the slower unit would be the faster unit.

[0197] At step S4055, the filter cleaning controller 750 calculates, for the potentially faster unit, a stop frequency F_s , the stop interval I_s and stop time L_s which are necessary for maintaining the inter-unit gap within the predetermined range.

[0198] Here, "the potentially faster unit" is one of the brush unit 620 and the cylinder unit 660 that would have reached the starting point 471 or the turnaround point 472 earlier than the other one if the adjusted setting had not been applied. Similarly, one of the brush unit 620 and the cylinder unit 660 that would have reached the starting point 471 or the turnaround point 472 later than the other one if the adjusted setting had not been applied is referred to as "the potentially slower unit".

[0199] The stop frequency F_s is the number of times that the potentially faster unit stops. The predetermined

range is preferably equivalent to the range from -Gth to Gth. The filter cleaning controller 750 uses the inter-unit gap Gp in a case of no adjusted setting, which is calculated in step S4055, when either the brush unit 620 or the cylinder unit 660 has an adjusted setting.

[0200] The filter cleaning controller 750 calculates, for example, the stop frequency Fs, the stop interval Is and the stop time Ls by using the following formulae (4)-(6).

$$Fs = [Gp / Gth] \quad \dots(4)$$

$$Is = Np / Fs \quad \dots(5)$$

$$Ls = Gth / Vs \quad \dots(6)$$

[0201] The slower travel speed Vs is the travel speed (the default velocity) of the potentially slower unit. It is preferable that the calculation result of the formula (5) is rounded down to a predetermined digit.

[0202] For instance, it is assumed that the setting table 810b or the setting table 810c is stored (see Figs. 15 and 16), the brush unit 620 is the potentially faster unit, the inter-unit gap Gp is 17.9 mm, the threshold Gth is 5 mm, and the total pulse number Np1 of the brush unit 620 is 16,046 pulses. In this case, a new operation adjustment needs to be applied, and the inter-unit gap Gp in a case of no adjusted setting is calculated to be 38.4 mm as mentioned above. Accordingly, the stop frequency Fs1 is calculated to be 8 ($\lceil 38.4 \text{ mm} / 5 \text{ mm} \rceil$) for the brush unit 620, the stop interval Is1 is calculated to be 2,005 pulses (16,046 pulses / 8) for the brush unit 620, and the stop time Ls1 is calculated to be 0.4 sec (5 mm / 12.8 mm/sec) for the brush unit 620.

[0203] The stop interval Is1 may be calculated in any one of pulse number and time length. Since the pulse rate of the potentially faster unit (here, the brush unit 620) is 200 pps, the stop interval Is1 may be calculated to be 10.0 sec (2,005 pulses / 200 pps).

[0204] It should be noted that at least one of the stop interval Is and the stop time Ls might be calculated to be decreased value or zero when either the brush unit 620 or the cylinder unit 660 already has an adjusted setting. This would happen when the existing adjusted setting acts in a direction for increasing the inter-unit gap.

[0205] At step S4056, the filter cleaning controller 750 updates the operation setting of corresponding unit based on the calculation results made in step S4055. Then, the process advances to the corresponding one of steps S4070 and S4110 in Fig. 18. The filter cleaning controller 750 rewrites the contents of the setting table 810 according to the calculated the stop interval Is and the stop time Ls.

[0206] When an adjusted setting is included in the setting table 810 and the stop interval Is and the stop time Ls have been calculated based on the assumed case of no adjusted setting in step S4055, the filter cleaning controller 750 deletes the existing adjusted setting.

[0207] For instance, it is assumed that the setting table 810b or the setting table 810c is stored (see Figs. 15 and 16), the brush unit 620 is the potentially faster unit, the stop interval Is1 is calculated to be 10.0 sec for the brush unit 620, and the stop time Ls1 is calculated to be 0.4 sec (5 mm / 12.8 mm/sec) for the brush unit 620. The filter cleaning controller 750 rewrites the stored setting table 810 according to the calculated stop interval Is1 and stop time Ls1.

[0208] Fig. 20 is a schematic diagram indicating an example of the setting table with an updated setting adjustment, which is rewritten according to the above calculation result.

[0209] The setting table 810d is a setting table which was originally the setting table 810b shown in Fig. 15. Compared to the setting table 810b, the setting table 810d has additionally a setting adjustment 813 for the first motor 631 corresponding to the brush unit 620 as follows.

- Stop Interval Is1: 10.0 sec
- Stop time Ls1: 0.4 sec

[0210] By the filter cleaning controller 750 controlling the driving unit 730 according to the setting table 810d, the brush unit 620 stops intermittently to maintain the inter-unit gap less than or equal to 5 mm.

[0211] Thus, the filter cleaning controller 750 is configured to perform the setting determination in the cleaning operation to control at least one of the first motor 631 and the second motor 671 such that the inter-unit gap is within the predetermined range.

[0212] Even after performing the setting determination, the inter-unit gap might increase as time passes. Yet, the filter cleaning controller 750 would adjust the operation setting again such that the inter-unit gap is within the predetermined range immediately after the inter-unit gap goes outside the predetermined range.

[0213] Fig. 21 is a schematic diagram indicating an example of variation in the inter-unit gap.

[0214] In a coordinate system 820 shown in Fig. 21, the horizontal axis 821 indicates the distance from the starting point 471 in the width direction, and the vertical axis 822 indicates the elapsed time from when the brush unit 620 and the cylinder unit 660 departed the starting point 471.

[0215] Here, it is assumed that the brush unit 620 is the faster unit in a case where neither the brush unit 620 nor the cylinder unit 660 has an adjusted setting at first. In this case, in the coordinate system 820, an inclination of a line 831 indicating the travel of the brush unit 620 is more gentle than an inclination of a line 832 indicating

the travel of the cylinder unit 660. Here, the maximum amount of the inter-unit gap is represented by the maximum distance D1 between the line 831 and the line 832 in the direction of the horizontal axis 821.

[0216] It is also assumed that the brush unit 620 has an adjusted setting to be controlled to stop twice during the travel between the starting point 471 and the turnaround point 472. In this case, the brush unit 620 stops twice for a given stop time Ls at a given stop interval Is. A line 833 indicating the travel of the brush unit 620 with the adjusted setting draws a polygonal line so as to be closer to the line 832 than the line 831. Thus, the maximum distance D2 between the line 833 and the line 832 in the direction of the horizontal axis 821 is much smaller than the above maximum distance D1.

[0217] Accordingly, the maximum amount of the inter-unit gap becomes smaller by the filter cleaning controller 750 stopping the faster unit intermittently.

Advantageous Effect

[0218] As explained above, the filter cleaning device 400 is configured to drive the brush unit 620 by the first motor 631, drive the cylinder unit 660 by the second motor 671, detect the amount of the inter-unit gap, and control the first motor 631 and the second motor 671 such that the inter-unit gap is within the predetermined range based on the detected amount. With this configuration, the inter-unit gap is maintained within the predetermined range even though the brush unit 620 and the cylinder unit 660 are driven independently. Accordingly, and it is prevented to scatter the particles from the part where the brush 633 engages with the filter 410. Thus, the filter cleaning device 400 can clean the filter 410 efficiently without connecting the brush 633 and the cylinder 673 in a fixed manner.

[0219] Moreover, the filter cleaning device 400 is configured to control the inter-unit gap by halting the faster one of the brush unit 620 and the cylinder unit 660 once or more times in the travel between the starting point 471 the turnaround point 472. The brush unit 620 and the cylinder unit 660 are halted just by stopping driving the first motor 631 and the second motor 671, respectively. Thus, the above control is achieved with simple configuration and simple process.

[0220] Furthermore, the filter cleaning device 400 is configured to control one of the brush unit 620 and the cylinder unit 660, which is faster than the other, such that a total time period of each halt period is no longer than a predetermined time period, i.e. stop time Ls. The stop time Ls is determined, for instance, from the threshold Gth which is a maximum allowable value of the inter-unit gap. The greater detected inter-unit gap is, i.e. the higher the difference in the travel speed is, the greater number of times that the faster unit stops is set. Thus, the inter-unit gap is maintained within the predetermined range throughout the travel between the starting point 471 the turnaround point 472.

Variations

[0221] The configuration of the inner air-conditioning unit according to the present embodiment explained above may be modified. Some examples of such modifications are mentioned below. The each of modification examples may be combined with one or more of the other modification examples.

[0222] The position sensor 720 may have a sensor which is configured to detect the amount of the inter-unit gap during the travel of the cleaning unit 600 in real time or nearly real time. For example, a sensor unit may be mounted on the cleaning unit 600 so as to detect the relative position in the width direction between the brush unit 620 and the cylinder unit 660. Alternatively, a sensor unit may be disposed near the starting point 471 or the turnaround point 472 so as to detect the distance to each of the brush unit 620 and the cylinder unit 660 from the starting point 471 or the turnaround point 472. In any case, the sensor unit may include an infrared sensor, a CCD camera or the like.

[0223] The position sensor 720 may be configured to simply detect whether the inter-unit gap is within the predetermined range or not. For instance, the position sensor 720 may include a separation type photo sensor comprising a light emitter and a light detector separately mounted on the brush unit 620 and the cylinder unit 660. The light detector may be configured to receive the light emitted from light emitter only when the inter-unit gap is within the predetermined range. In this case, it is preferable that the air-conditioning controller 710 adjust the travelling operation of the brush unit 620 and/or the cylinder unit 660 little by little so as to avoid that the inter-unit gap is rather increased by the adjustment.

[0224] In the case where the detection of the inter-unit gap is performed during the travel of the cleaning unit 600, the air-conditioning controller 710 may adjust the operation setting during the travel of the cleaning unit 600.

[0225] The air-conditioning controller 710 may perform the adjustment of operation setting on condition that the inter-unit gap is determined to be outside of the predetermined range for a predetermined number of times in series and/or for a predetermined frequency. By this, it is possible to ignore temporal increases in the inter-unit gap, and therefore it is prevented to rather increase the inter-unit gap by adjusting the operation setting.

[0226] The timing to update the setting table 810 is not limited to the timing described above. For instance, the air-conditioning controller 710 may perform the detection of the inter-unit gap when the cleaning unit 600 is moving towards the turnaround point 472, and update the setting table 810 after the cleaning unit 600 has returned to the starting point 471.

[0227] The air-conditioning controller 710 may add newly determined stop time Ls and stop interval Is to the existing stop time Ls and stop interval Is. In this case, the air-conditioning controller 710 determines the addi-

tional stop time L_s and stop interval I_s without performing the step S4054 (see Fig. 19).

[0228] The setting table 810 may indicate the different operation setting for the forward travel and the backward travel of the cleaning unit 600. Thus, the air-conditioning controller 710 may perform the detection of the inter-unit gap and the adjustment of operation setting respectively for each of the forward travel and the backward travel of the cleaning unit 600. It is also preferable to perform both the step 4050 and the step 4090 in Fig. 18, since the operation environments in the forward travel and the backward travel would vary differently with time.

[0229] The filter cleaning device 400 may be configured to control the movement of the brush unit 620 and/or the cylinder unit 660 by changing the pulse rate of the first motor 631 and/or the second motor 671, instead of or in addition to stopping the first motor 631 and/or the second motor 671. In this case, the air-conditioning controller 710 acquires, for instance, the inter-unit gap G_p in the number of pulses for the first motor 631 or the second motor 671, and calculates a new pulse rate which cancels out or decreases the inter-unit gap G_p based on the current total pulse number N_p of the first motor 631 or the second motor 671. Particularly in this case, the filter cleaning device 400 may be configured to control only predetermined one of the brush unit 620 and the cylinder unit 660 thereamong.

[0230] Regarding the threshold G_{th} to be compared to the detected inter-unit gap, the first threshold which is used for determining whether the adjustment of operation setting is necessary and the second threshold which is used for determining the contents of operation setting adjustment, parameters such as the stop time L_s and the stop interval I_s , may be different.

[0231] The air-conditioning controller 710 does not necessarily need to calculate the parameters for each time when the operation setting adjustment is determined to be necessary. In this case, for instance, the setting table includes a plurality of the operation setting adjustments in advance, which are associated with the different patterns of the relative position between the brush unit 620 and the cylinder unit 660 (i.e. the relative position between the brush 633 and the cylinder 673). The air-conditioning controller 710 just look up the parameters corresponding to detection result.

[0232] The filter cleaning device 400 does not necessarily need to perform the detection of the inter-unit gap. In this case, the filter cleaning device 400 is configured to control the first motor 631 and/or the second motor 671 such that the inter-unit gap is maintained within the predetermined range according to a stored information which indicates how to operate the first motor 631 and the second motor 671, like the setting table 810c shown in Fig. 16. Although the inter-unit gap which arises posteriori would not be resolved, the inter-unit gap which would potentially and constantly arise is decreased.

[0233] The configuration of the driving unit 730 is not limited to the above-explained configuration. For exam-

ple, the driving unit 730 may include wheels for traveling on the inner bottom surface of the device housing 420, which are disposed in each of the brush unit 620 and the cylinder unit 660 and driven by the corresponding motors, respectively.

[0234] The first motor 631 and the second motor 671 may be disposed outside of the cleaning unit 600 and configured to drive the brush unit 620 and the cylinder unit 660 from outside. For example, the first motor 631 and the second motor 671 may be attached to the device housing 420 at positions near the device side wall 421 or the opposite side wall 425, and configured to rotate endless annular belts to which the brush unit 620 and the cylinder unit 660 are fixed. In this case, the brush 633 and the separation roller 635 may be driven by the movement of the brush unit 620 with respect to the filter 410.

[0235] The air-conditioner may be obliquely positioned with respect to a horizontal plane. For instance, when the false ceiling is an oblique ceiling, the air-conditioner may be obliquely positioned such that the housing bottom surface is substantially parallel with the false ceiling.

[0236] The filter cleaning device may be incorporated in the air-conditioner body. In this case, at least a part of the air-conditioner housing serves as the device housing. Alternatively, the filter cleaning device may be distanced from the air-conditioner body and connected to the air-conditioner body via a duct.

[0237] The filter cleaning controller may control the cleaning unit to reciprocate a plurality of times for one cleaning operation.

[0238] The filter cleaning controller may control the cleaning unit to move to the parking position upon receiving an indication transmitted from a user interface, an information processing unit or the like. In this case, the parking position does not necessarily need to be the same as the starting point of the cleaning unit.

[0239] The filter cleaning device may have a sensor which is configured to detect the accumulated particles state in the storage member 643, such as a photo-sensor, and output information indicating the detection result to a user interface, an information processing unit or the like. This configuration allows the operator to perform an evacuation of the accumulated particles at appropriate timings.

[0240] The cleaning unit may be configured to cover the brush-side opening with a lid while the cleaning unit is at the parking position. With this configuration, it is prevented that the accumulated particles in the storage space would leak from the brush-side opening.

[0241] The brush unit may have only one comb or more than two combs. The comb may be configured such that the teeth are protruding towards the axis of the brush. The brush unit may have more than two separation rollers. Alternatively, the brush and/or the separation roller does not necessarily need to be provided in the brush unit. For instance, the brush unit may have a rod instead of the comb 634. The rod may be fixed in the brush space in parallel to and in contact with the bristles of the brush.

With such a configuration, the bristles of the brush are caught by the rod as the brush rotates, and the particles on the bristles are scraped off by the rod.

[0242] The brush may be configured not to rotate. In this case, the brush does not necessarily need to be a roll brush. If the bristles are fixed at a position in which the ends of the bristles are in contact with the filter and have high resilience, the particles scraped by the bristles are introduced into the brush space by the back action of the bristles against the filter.

[0243] The cylinder unit may have a counter member with a different shape, such as a plate configured to be in contact with the surface of the filter, instead of the cylinder.

[0244] The filter may have a shape curved in the width direction and/or the height direction. In the case where the filter curves in the width direction, the filter cleaning device is configured to move the cleaning unit in a line curved along the curved shape of the filter. In the case where the filter curves in the height direction, the cleaning unit has the brush and the counter member which have a shape curved along the curved shape of the filter.

[0245] The filter cleaning controller may be arranged separately from the rest part of the filter cleaning device. For instance, the filter cleaning controller may be arranged in the control box of the air-conditioner body, or an information processing unit disposed away from the air conditioner. The filter cleaning controller may communicate with the parts to be controlled by the filter cleaning controller by means of wire communication and/or wireless communication.

[0246] The filter cleaning device may be applied to an air-conditioner which is not ceiling-mounted duct type.

[0247] While only selected embodiments and modifications have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from this disclosure that various changes and further modifications can be made herein without departing from the scope of the invention as defined in the appended claims.

[0248] For example, unless specifically stated otherwise, the size, shape, location or orientation of the various components can be changed as needed and/or desired so long as the changes do not substantially affect their intended function. Unless specifically stated otherwise, components that are shown directly connected or contacting each other can have intermediate structures disposed between them so long as the changes do not substantially affect their intended function. The functions of one element can be performed by two, and vice versa unless specifically stated otherwise.

[0249] The structures and functions of one embodiment can be adopted in another embodiment. It is not necessary for all advantages to be present in a particular embodiment at the same time. Thus, the foregoing descriptions of the embodiments according to the present invention are provided for illustration only.

Reference list

[0250]

5	100:	Inner air-conditioning unit
	210:	Building Slab
	220:	False Ceiling
	221:	Inlet Grating
	222:	Outlet Grating
10	223:	Inspection Door
	310:	Air Inlet Duct
	320:	Air Outlet Duct
	400:	Filter Cleaning Device
	401:	Body Side Port
15	402:	Duct Side Port
	410:	Filter
	411:	Filter Frame
	412:	Mesh Sheet
	420:	Device Housing
20	421:	Device Side Wall
	422:	Cover Wall
	423:	Guide Rail
	424:	Racks
	425:	Opposite Side Wall
25	430:	Device-Side Control Box
	441:	Exhaust Opening
	442:	Hose
	443:	Suction Socket
	444:	Back-Side Part
30	461:	First Limit Switch
	462:	Second Limit Switch
	463:	Third Limit Switch
	464:	Fourth Limit Switch
	500:	Air-Conditioner Body
35	501:	Air Inlet Port
	502:	Air Outlet Port
	503:	Fan
	504:	Heat Exchanger
	520:	Air-Conditioner Housing
40	521:	Body Side Wall
	530:	Body-Side Control Box
	600:	Cleaning Unit
	601:	Wheels
	602:	Pinion Gear
45	620:	Brush Unit
	621:	Brush-Side Casing
	622, 662:	Inner Wall
	623:	Machine Space
	624:	Brush Space
50	625:	Gear Space
	626:	Storage Space
	627:	Brush-Side Opening
	628:	Brush-Side Wall
	629:	Controller-Side Wall
55	631:	First Motor
	632:	Gear Mechanism
	633:	Brush
	634:	Comb

635:	Separation Roller	
636:	Exhaust Port	
640:	Cylinder Unit	
643:	Storage Member	
660:	Cylinder Unit	5
661:	Cylinder-Side Casing	
663:	Cylinder-Side Machine Space	
664:	Cylinder Space	
665:	Cylinder-Side Gear Space	
666:	Lower Space	10
667:	Cylinder-Side Opening	
668:	Brush-facing Side	
671:	Second Motor	
672:	Cylinder-Side Gear Mechanism	
673:	Cylinder	15
710:	Air-Conditioning Controller	
720:	Position Sensor	
730:	Driving Unit	
740:	Information Storage Unit	
750:	Filter Cleaning Controller	20

Claims

1. A filter cleaning device for an air-conditioner, comprising:

a filter having a filter surface and configured to pass an air flow through the filter surface;
a brush unit having a brush and a contact member,

the brush being configured to contact with a principal side of the filter surface and being rotatably supported about a rotation axis, the rotation axis extending along the filter surface, and
the contact member being configured to contact with the other side of the filter surface and sandwich the filter between the brush and the contact member;

a driving unit having a first motor and a second motor,

the first motor being configured to rotate the brush about the rotation axis in a first rotating direction and move the brush along a first moving direction that extends along the filter surface while rotating the brush in the first rotation direction, and
the second motor being configured to move the contact member along the first moving direction;

a controller configured to control the driving unit such that the brush and the contact member move from one end side to the other end side

of the filter with respect to the first moving direction; wherein
the rotation axis of the brush extends along a direction that intersects the first moving direction; and
the controller is configured to control at least one of the first motor and the second motor such that a gap between the brush and the contact member is within a predetermined range in position with respect to the first moving direction.

2. The filter cleaning device according to claim 1, wherein
the controller is configured to control the brush unit such that the brush or the contact member halts once or more while moving from one end side to the other end side of the filter with respect to the first moving direction.

3. The filter cleaning device according to claim 1 or 2, wherein
the controller is configured to control the brush unit such that the brush or the contact member halts once or more while moving from one end side to the other end side of the filter with respect to the first moving direction; and
the controller is further configured to control the brush unit such that a total time period of each halt period of the brush or the contact member is no longer than a predetermined time period P1.

4. The filter cleaning device according to any one of claims 1, 2 and 3, further comprising:

a detector configured to detect the gap between the brush and the contact member in position with respect to the first moving direction.

5. The filter cleaning device according to claim 4, wherein
the controller is configured to receive a detection result of the detector, and output an alarm signal based on the detection result when the gap goes beyond the predetermined range.

6. The filter cleaning device according to claim 4 or 5, wherein
the controller is configured to control at least one of the first motor and second motor based on the detection result.

7. The filter cleaning device according to any one of claims 1 to 6, wherein
the filter is substantially flat; and
the brush extends from one end to the other end of the filter with respect to a direction that intersects with the first moving direction.

8. The filter cleaning device according to any one of claims 1 to 7, wherein the filter is substantially flat; and the contact member extends from one end side to the other end side of the filter with respect to a direction that intersects with the first moving direction. 5
9. The filter cleaning device according to any one of claims 1 to 8, further comprising: 10
- a storage member disposed under the brush and configured to receive particles from the brush.
10. An air-conditioner having the filter cleaning device according to any one of claims 1 to 9. 15

Amended claims in accordance with Rule 137(2) EPC. 20

1. A filter cleaning device (400) for an air-conditioner (500), comprising: 25
- a filter (410) having a filter surface and configured to pass an air flow through the filter surface; a brush unit (600) having a brush (633) and a contact member (673), 30
- the brush being configured to contact with a principal side of the filter surface and being rotatably supported about a rotation axis, the rotation axis extending along the filter surface, 35
- the contact member being configured to contact with the other side of the filter surface and sandwich the filter between the brush and the contact member; 40
- a driving unit (730) having a first motor (631), the first motor being configured to rotate the brush about the rotation axis in a first rotating direction and move the brush along a first moving direction that extends along the filter surface while rotating the brush in the first rotation direction; and 45
- a controller (750) configured to control the driving unit, wherein 50
- the rotation axis of the brush extending along a direction that intersects the first moving direction, 55
- characterized in that:**
- the driving unit further has a second motor (671), 60
- the second motor being configured to move the contact member along the first moving direction; 65

the controller is configured to control the driving unit such that the brush and the contact member move from one end side to the other end side of the filter with respect to the first moving direction; and 70

the controller is configured to control at least one of the first motor and the second motor such that a gap between the brush and the contact member is within a predetermined range in position with respect to the first moving direction. 75

2. The filter cleaning device according to claim 1, wherein 80
- the controller is configured to control the brush unit such that the brush or the contact member halts once or more while moving from one end side to the other end side of the filter with respect to the first moving direction. 85
3. The filter cleaning device according to claim 1 or 2, wherein 90
- the controller is configured to control the brush unit such that the brush or the contact member halts once or more while moving from one end side to the other end side of the filter with respect to the first moving direction; and 95
- the controller is further configured to control the brush unit such that a total time period of each halt period of the brush or the contact member is no longer than a predetermined time period P1. 100
4. The filter cleaning device according to any one of claims 1, 2 and 3, further comprising: 105
- a detector (720) configured to detect the gap between the brush and the contact member in position with respect to the first moving direction. 110
5. The filter cleaning device according to claim 4, wherein 115
- the controller is configured to receive a detection result of the detector, and output an alarm signal based on the detection result when the gap goes beyond the predetermined range. 120
6. The filter cleaning device according to claim 4 or 5, wherein 125
- the controller is configured to control at least one of the first motor and second motor based on the detection result. 130
7. The filter cleaning device according to any one of claims 1 to 6, wherein 135
- the filter is substantially flat; and 140
- the brush extends from one end to the other end of the filter with respect to a direction that intersects with the first moving direction. 145

8. The filter cleaning device according to any one of claims 1 to 7, wherein
the filter is substantially flat; and
the contact member extends from one end side to the other end side of the filter with respect to a direction that intersects with the first moving direction. 5
9. The filter cleaning device according to any one of claims 1 to 8, further comprising:
a storage member (643) disposed under the brush and configured to receive particles from the brush. 10
10. An air-conditioner (100) having the filter cleaning device according to any one of claims 1 to 9. 15

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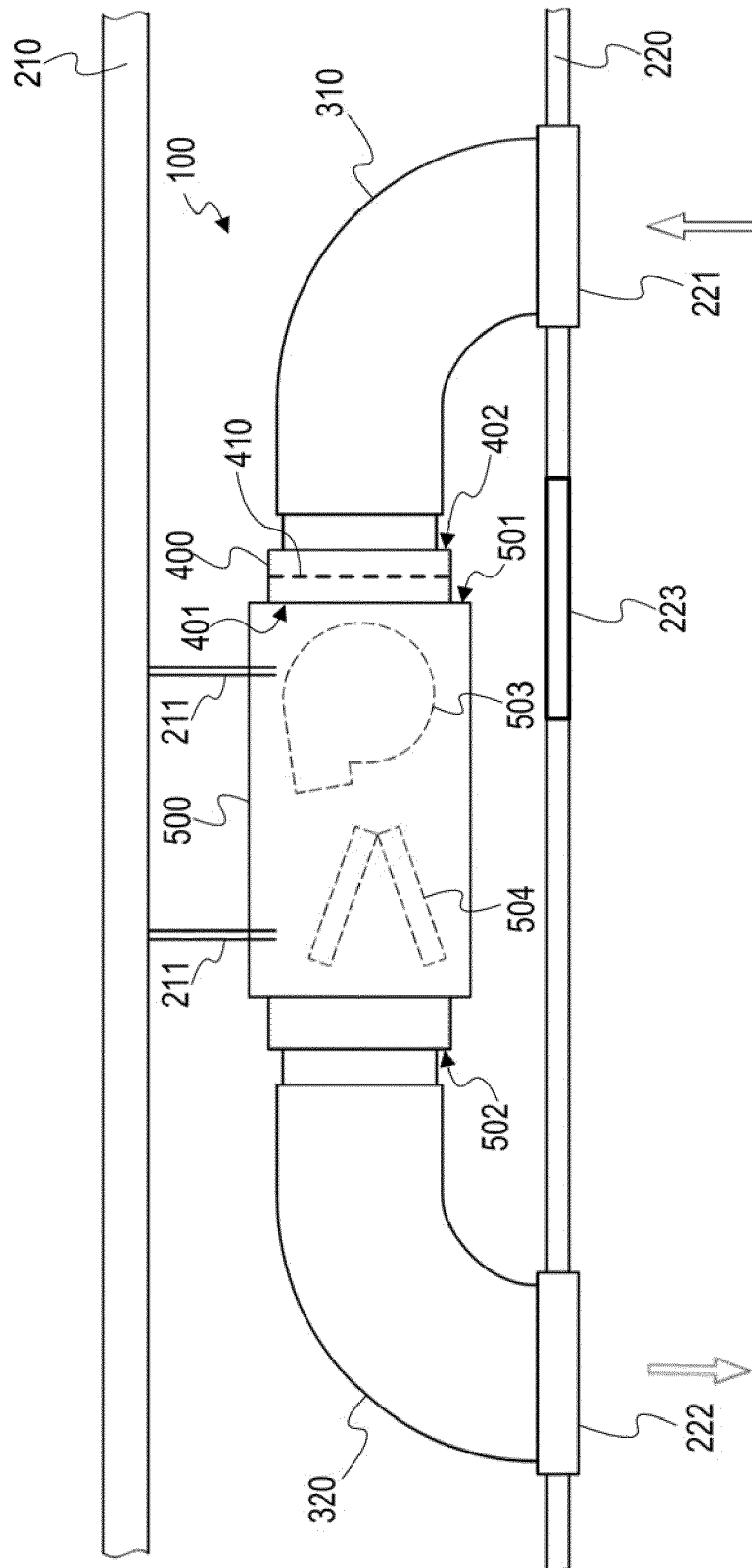


Fig. 1

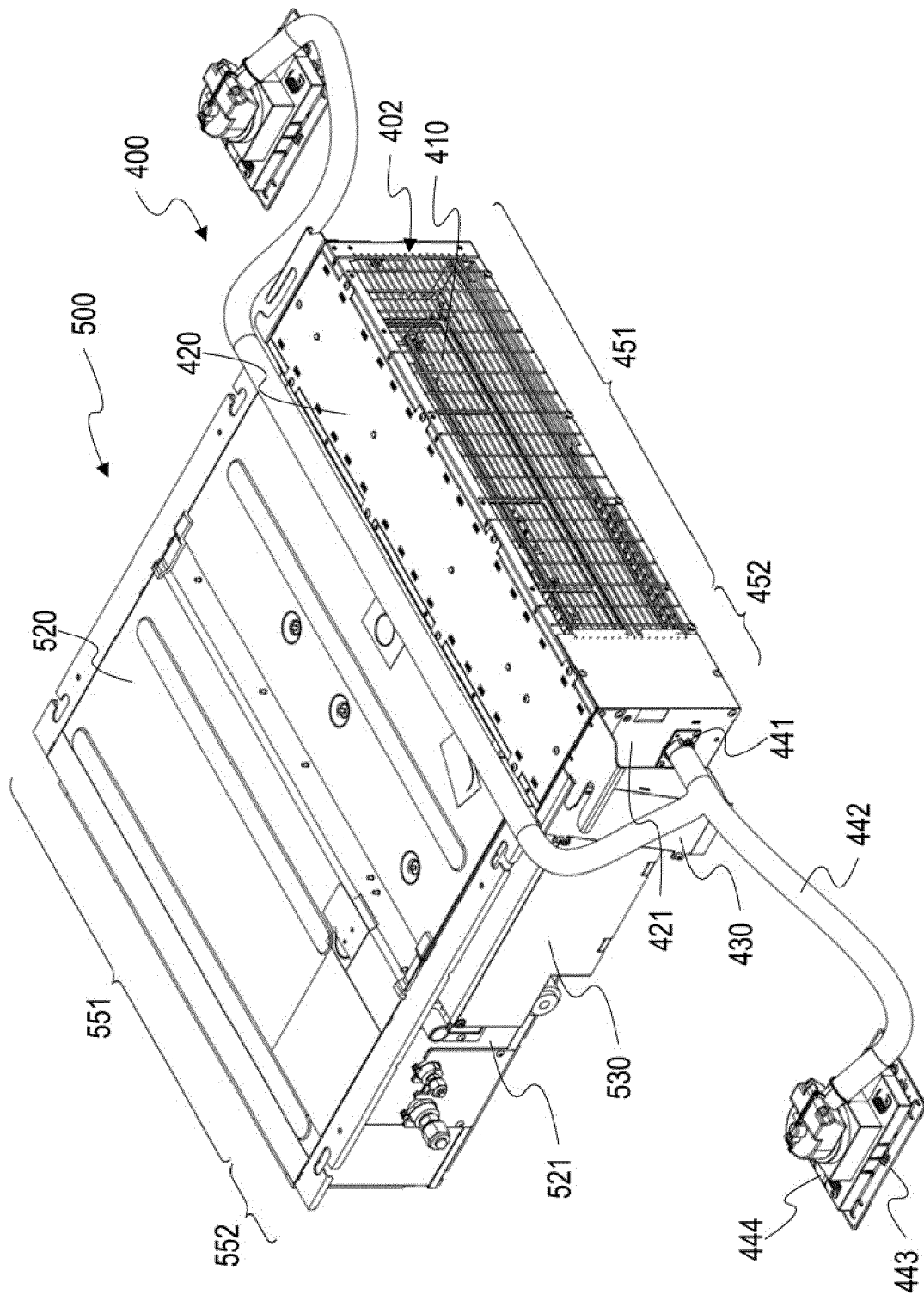


Fig. 2

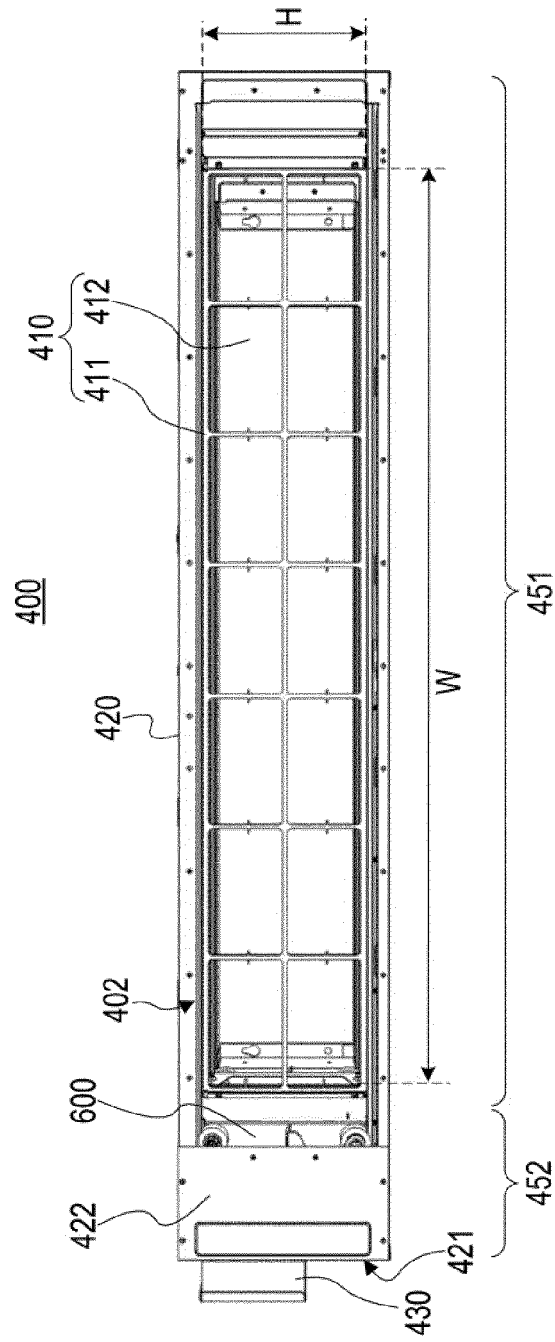


Fig. 3

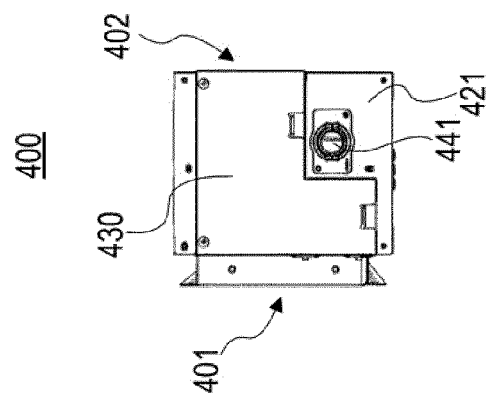


Fig. 4

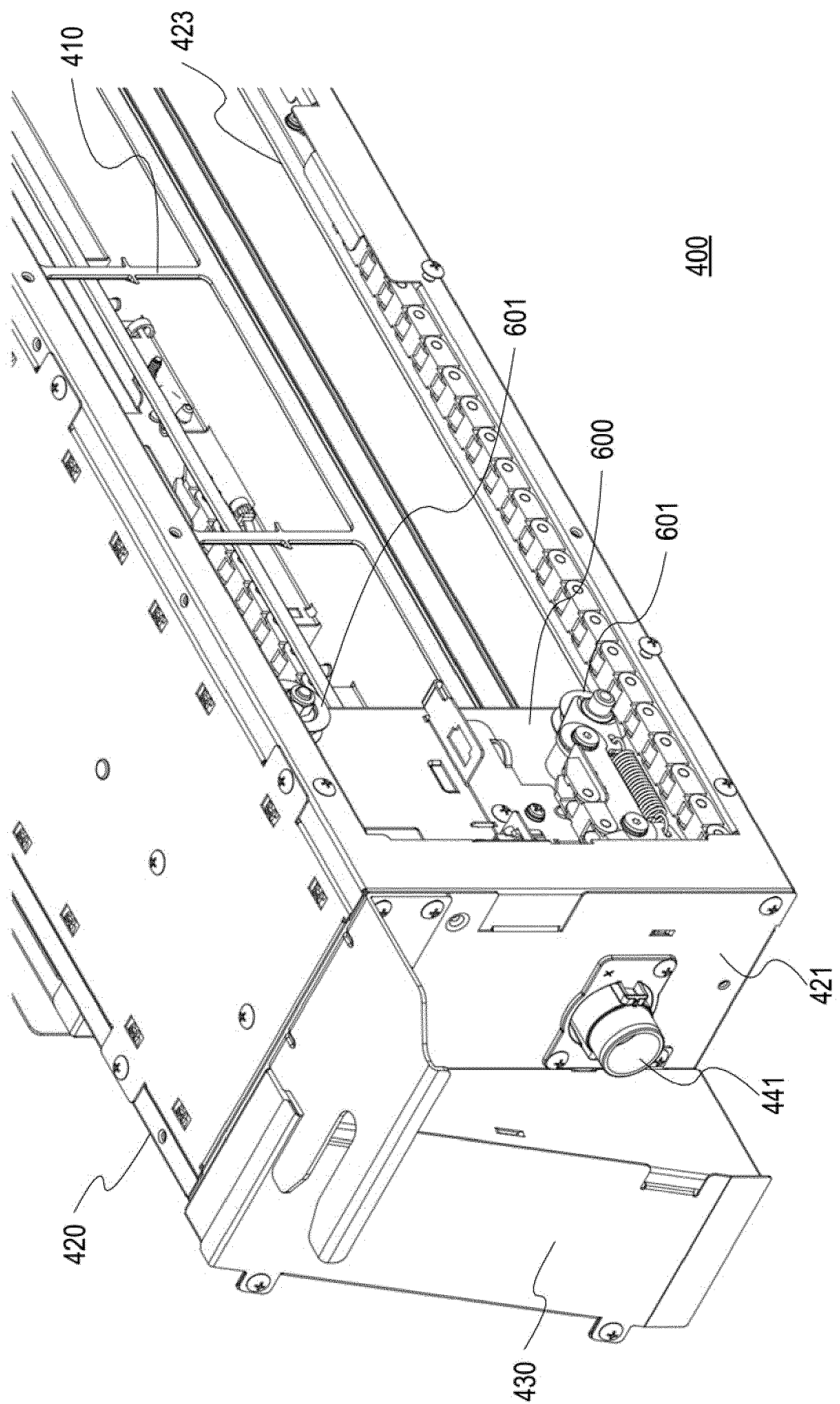


Fig 5

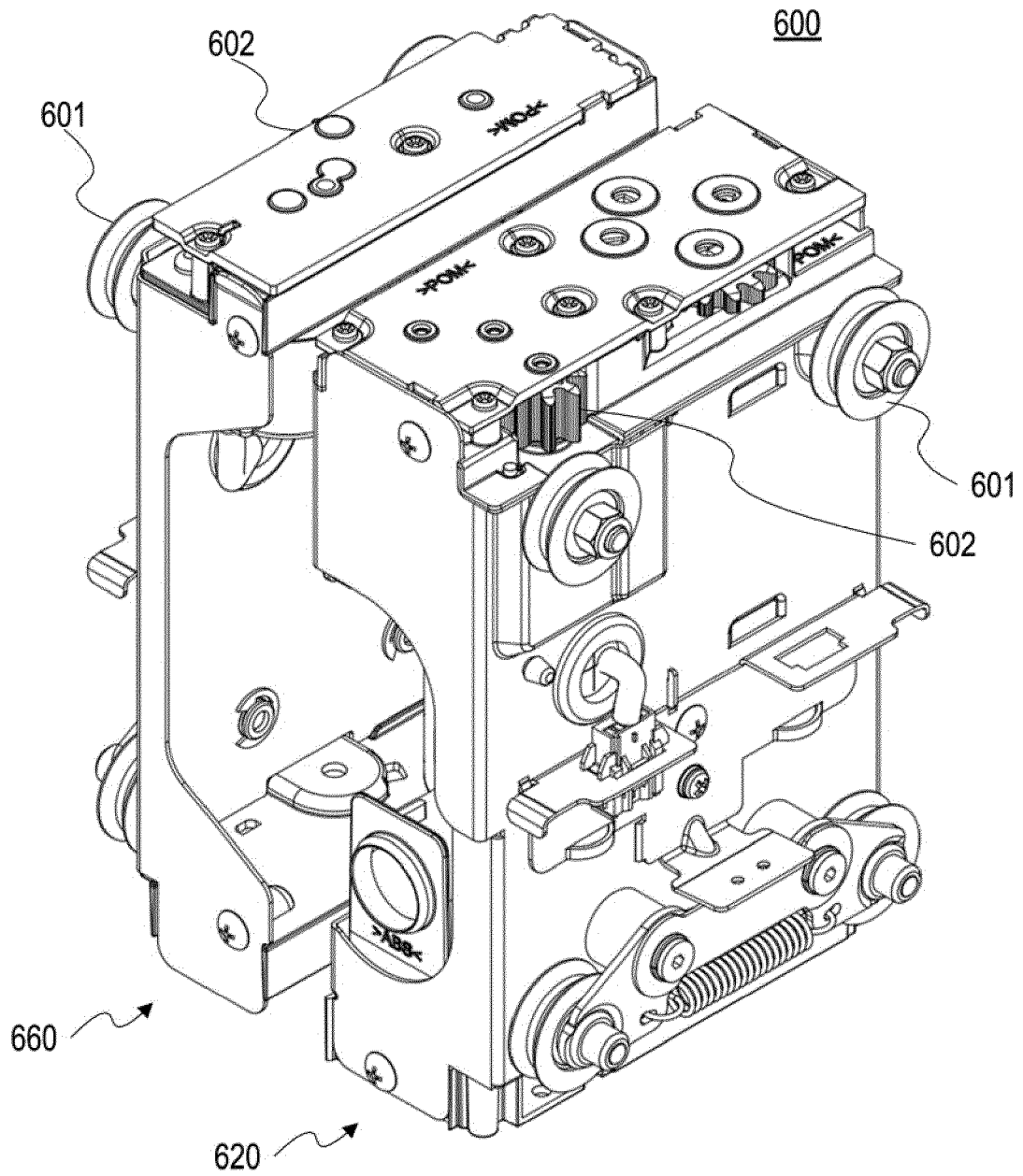


Fig. 6

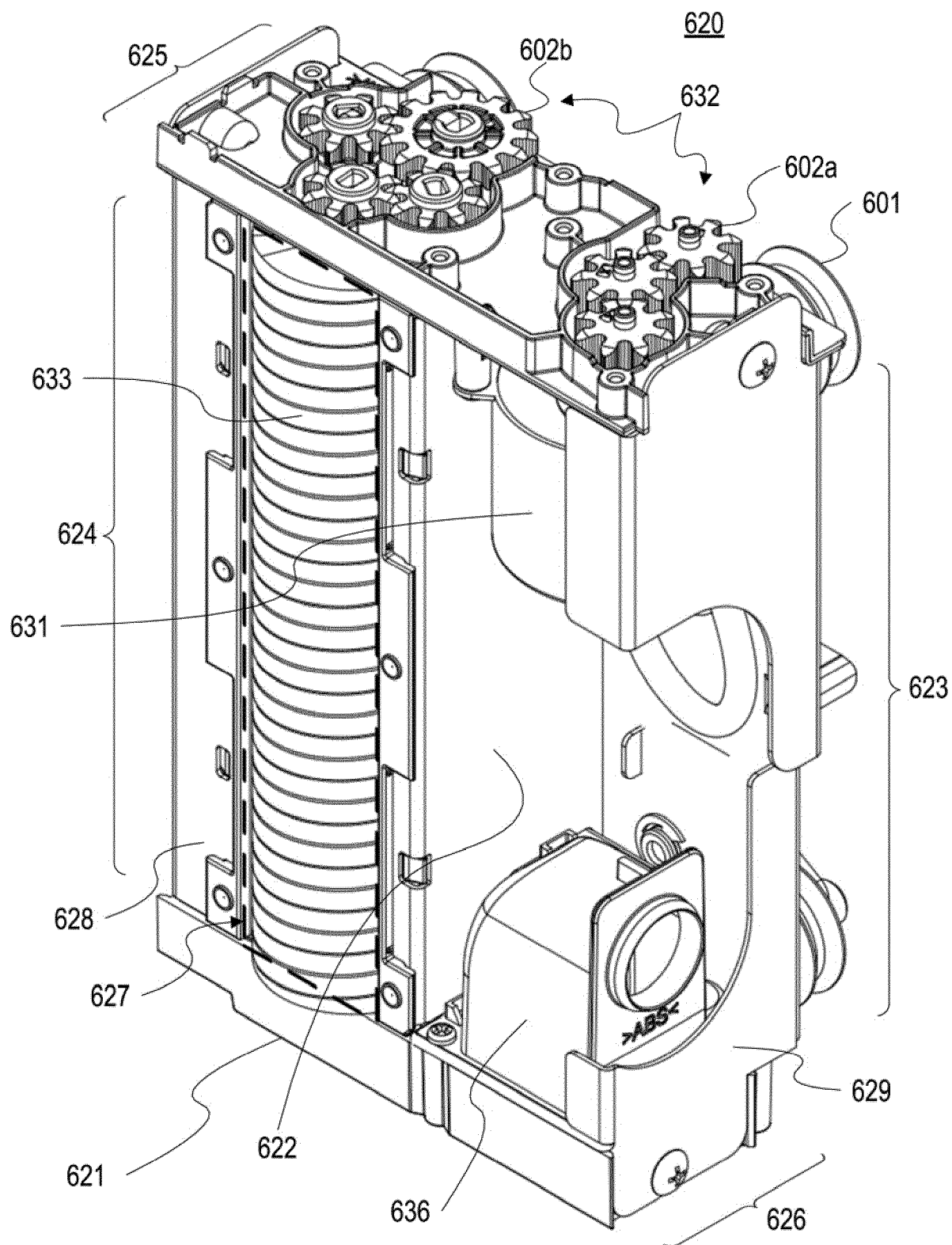


Fig. 7

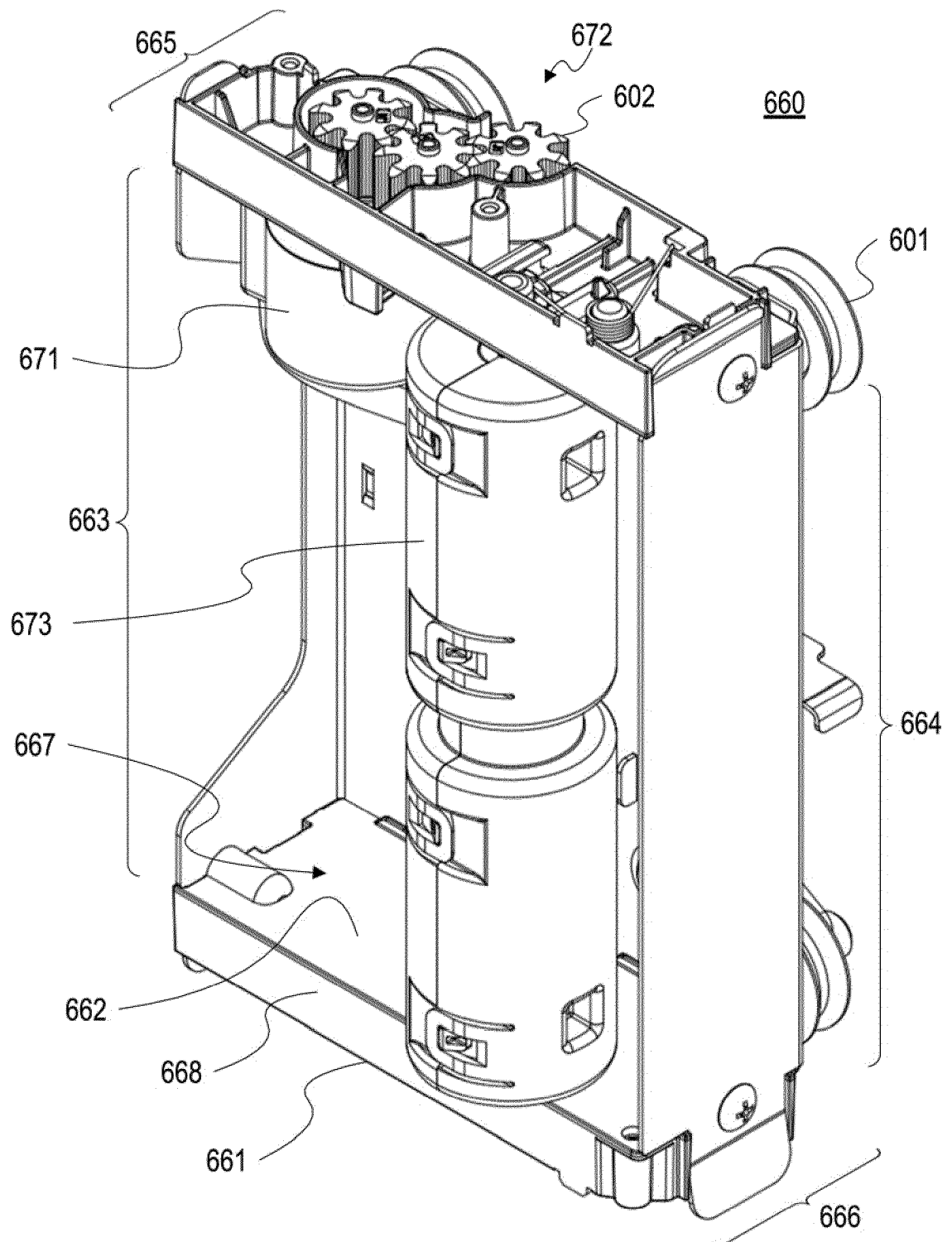


Fig. 8

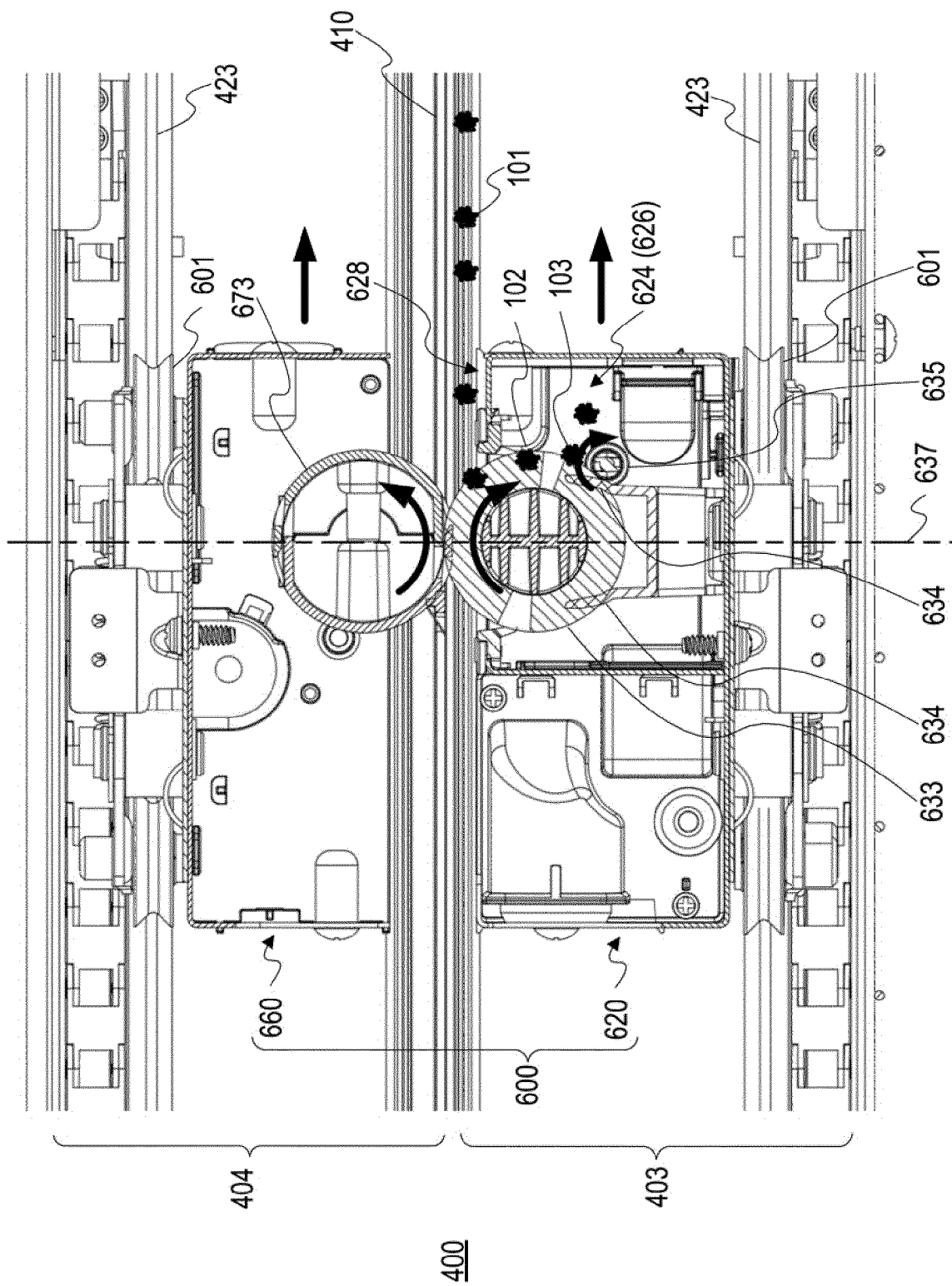


Fig. 9

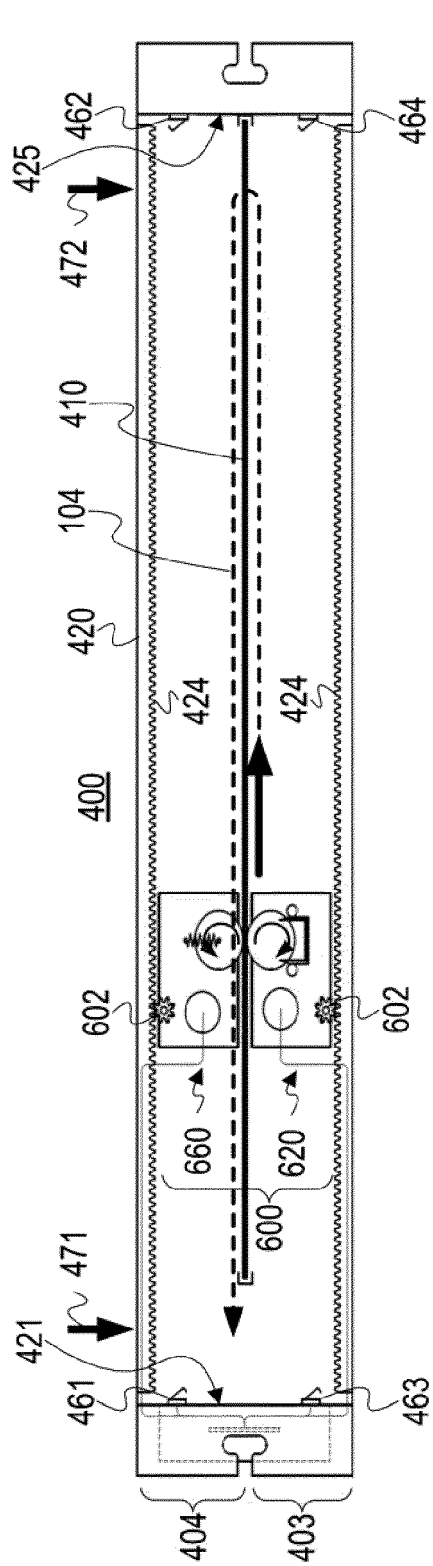


Fig. 10

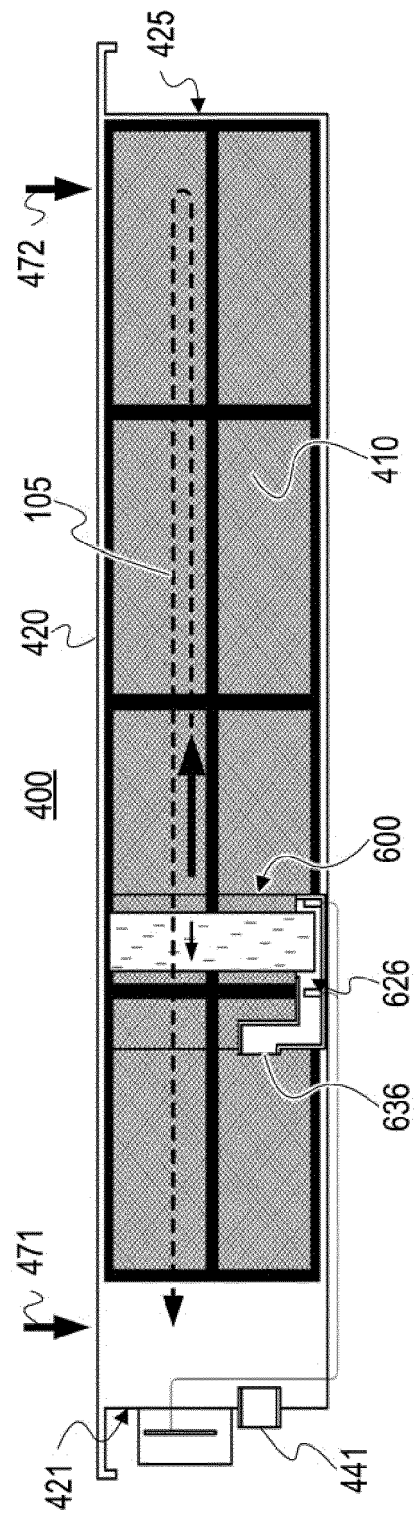


Fig. 11

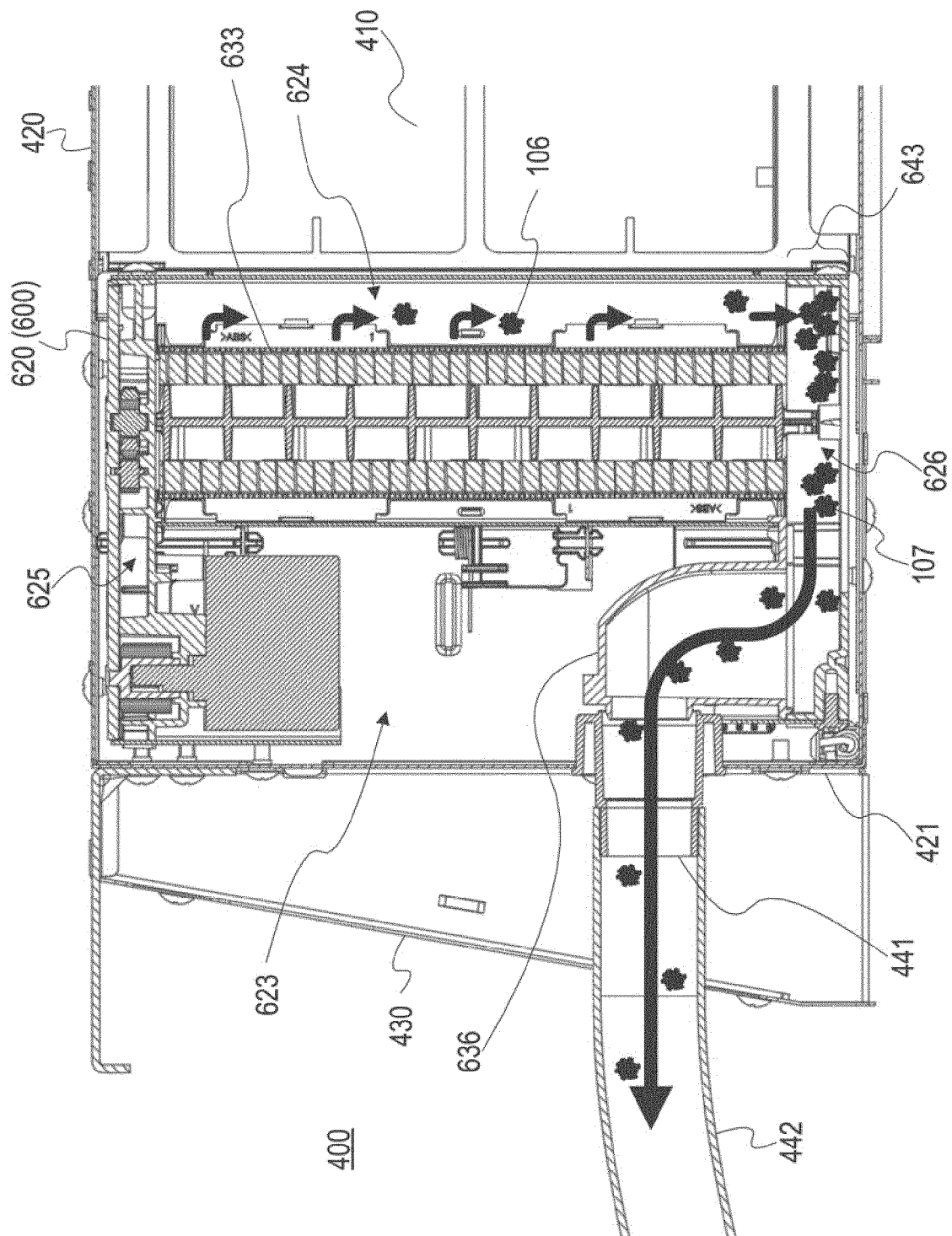


Fig. 12

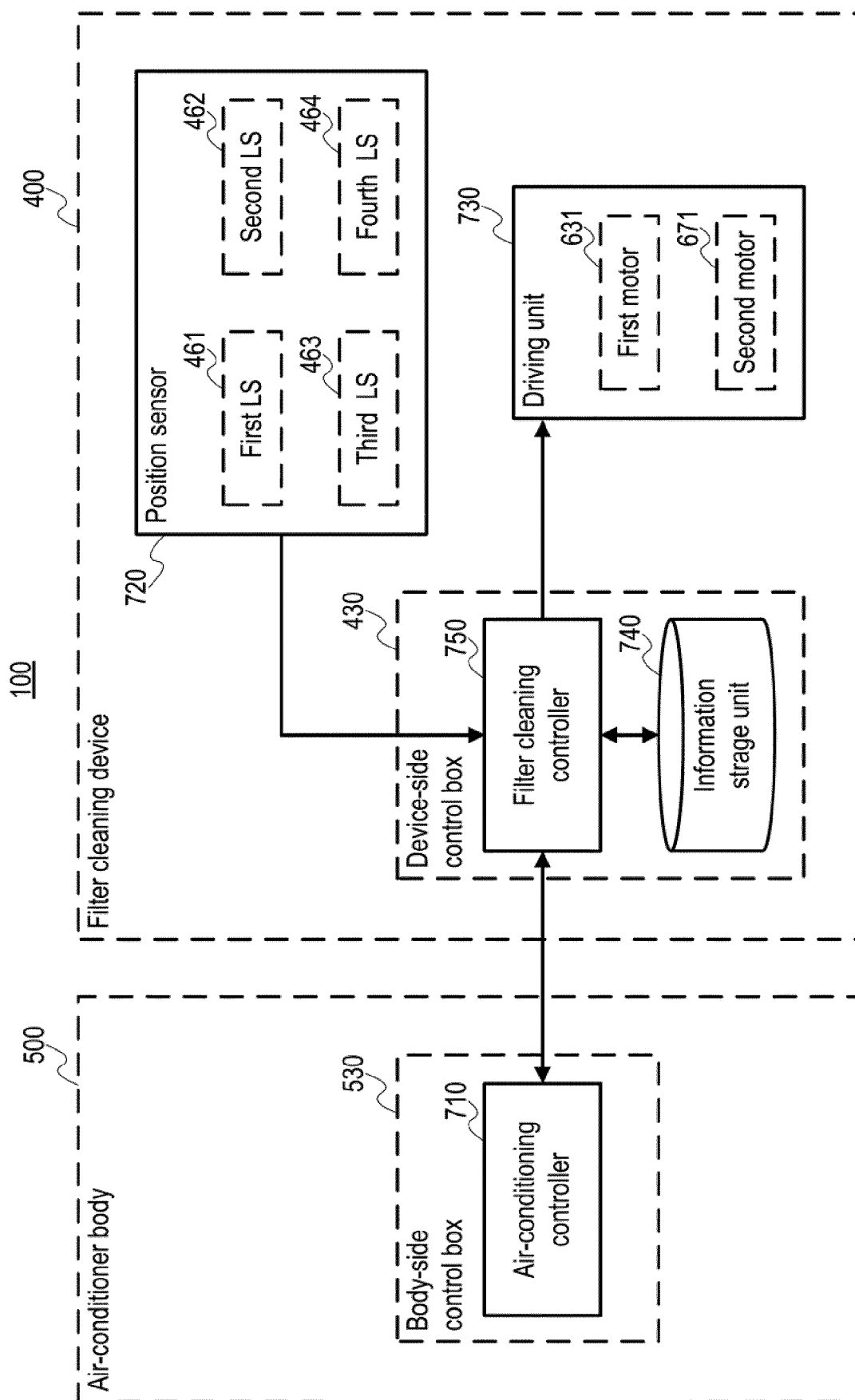


Fig. 13

810a

811	812	813
Item	Default setting	Setting adjustment
First motor (Brush unit)	Pulse rate: 235pps Default velocity: 15.4mm/sec Nonstop traveling ...	-
Second motor (Cylinder unit)	Pulse rate: 600pps Default velocity: 15.4mm/sec Nonstop traveling ...	-

Fig. 14

810b

811		812		813	
Item		Default setting		Setting adjustment	
First motor (Brush unit)		Pulse rate: 200pps Default velocity: 13.1mm/sec Nonstop traveling ...		-	
Second motor (Cylinder unit)		Pulse rate: 500pps Default velocity: 12.8mm/sec Nonstop traveling ...		-	

Fig. 15

810c

811 Item	812 Default setting	813 Setting adjustment
First motor (Brush unit)	Pulse rate: 200pps Default velocity: 13.1mm/sec Nonstop traveling ...	Stop interval Is1: 16.6sec Stop time Ls1: 0.4sec
Second motor (Cylinder unit)	Pulse rate: 500pps Default velocity: 12.8mm/sec Nonstop traveling ...	-

Fig. 16

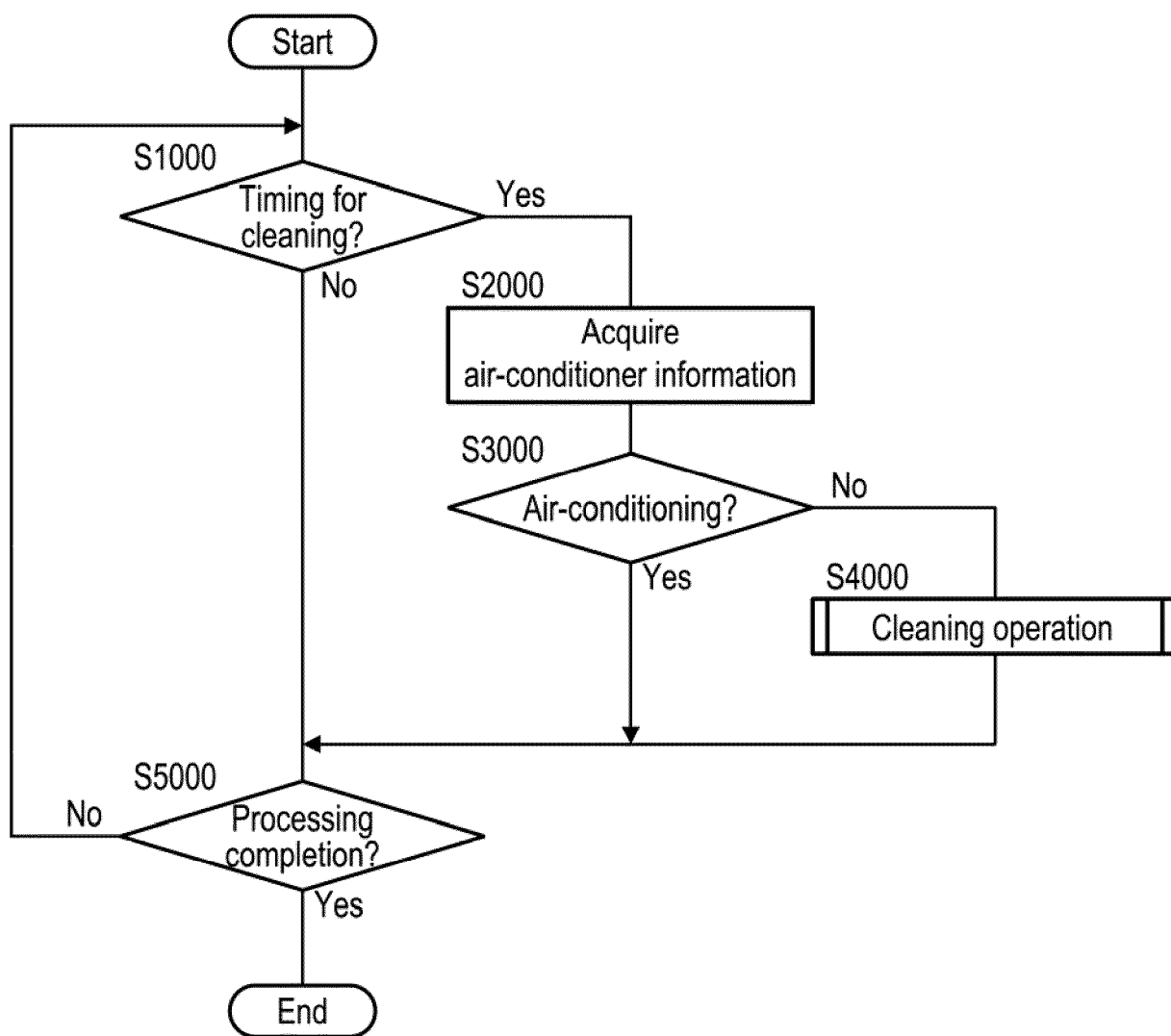


Fig. 17

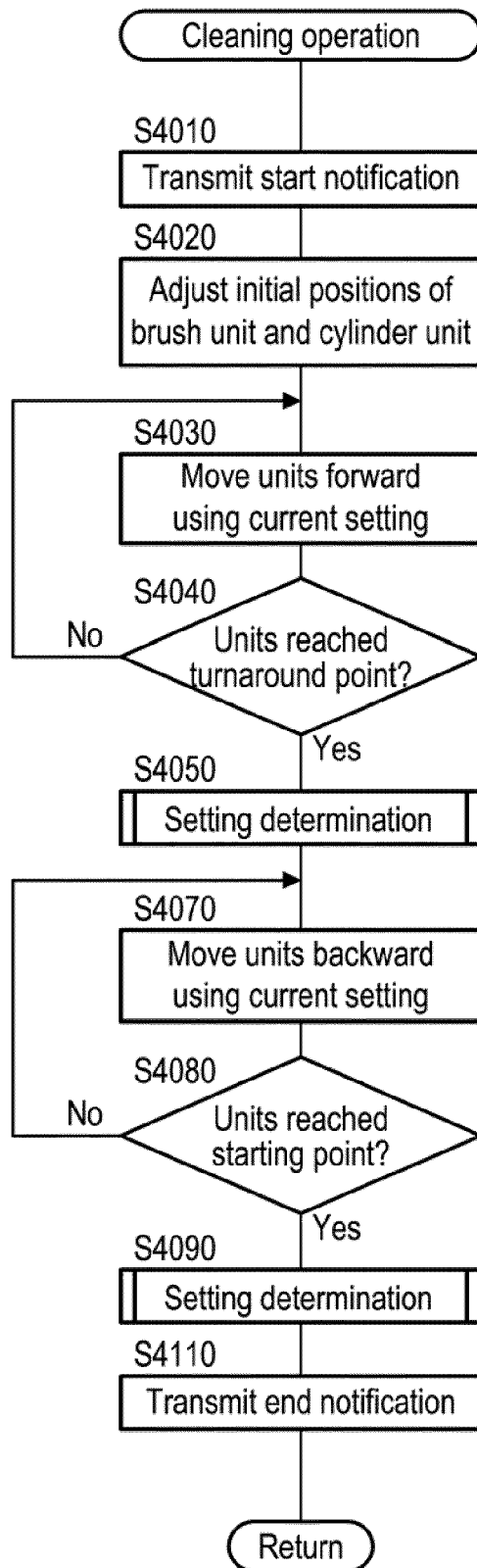


Fig. 18

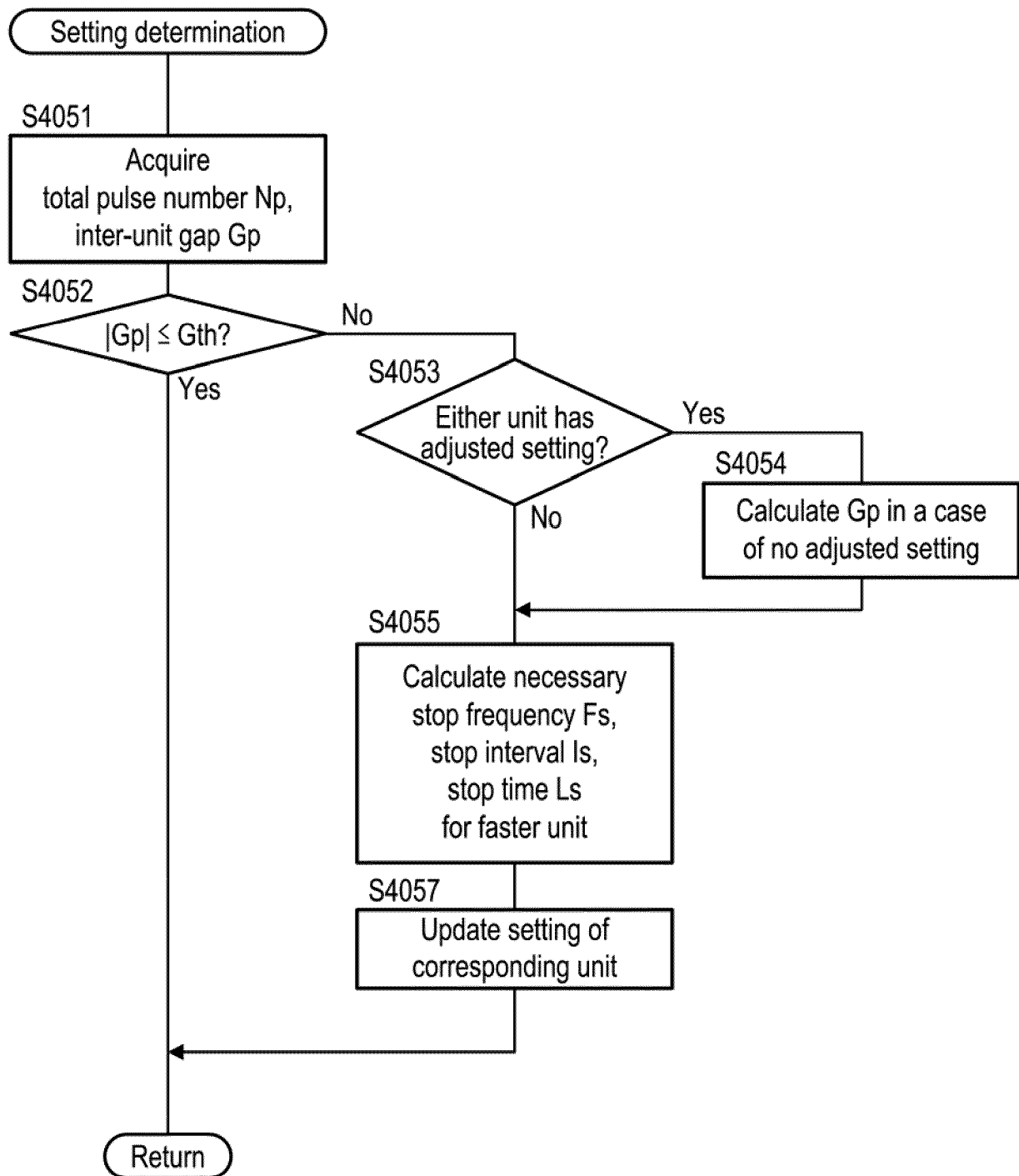


Fig. 19

810d

811 Item	812 Default setting	813 Setting adjustment
First motor (Brush unit)	Pulse rate: 200pps Default velocity: 13.1mm/sec Nonstop traveling ...	<u>Stop interval</u> Is1: 10.10sec <u>Stop time</u> Ls1: 0.4sec
Second motor (Cylinder unit)	Pulse rate: 500pps Default velocity: 12.8mm/sec Nonstop traveling ...	-

Fig. 20

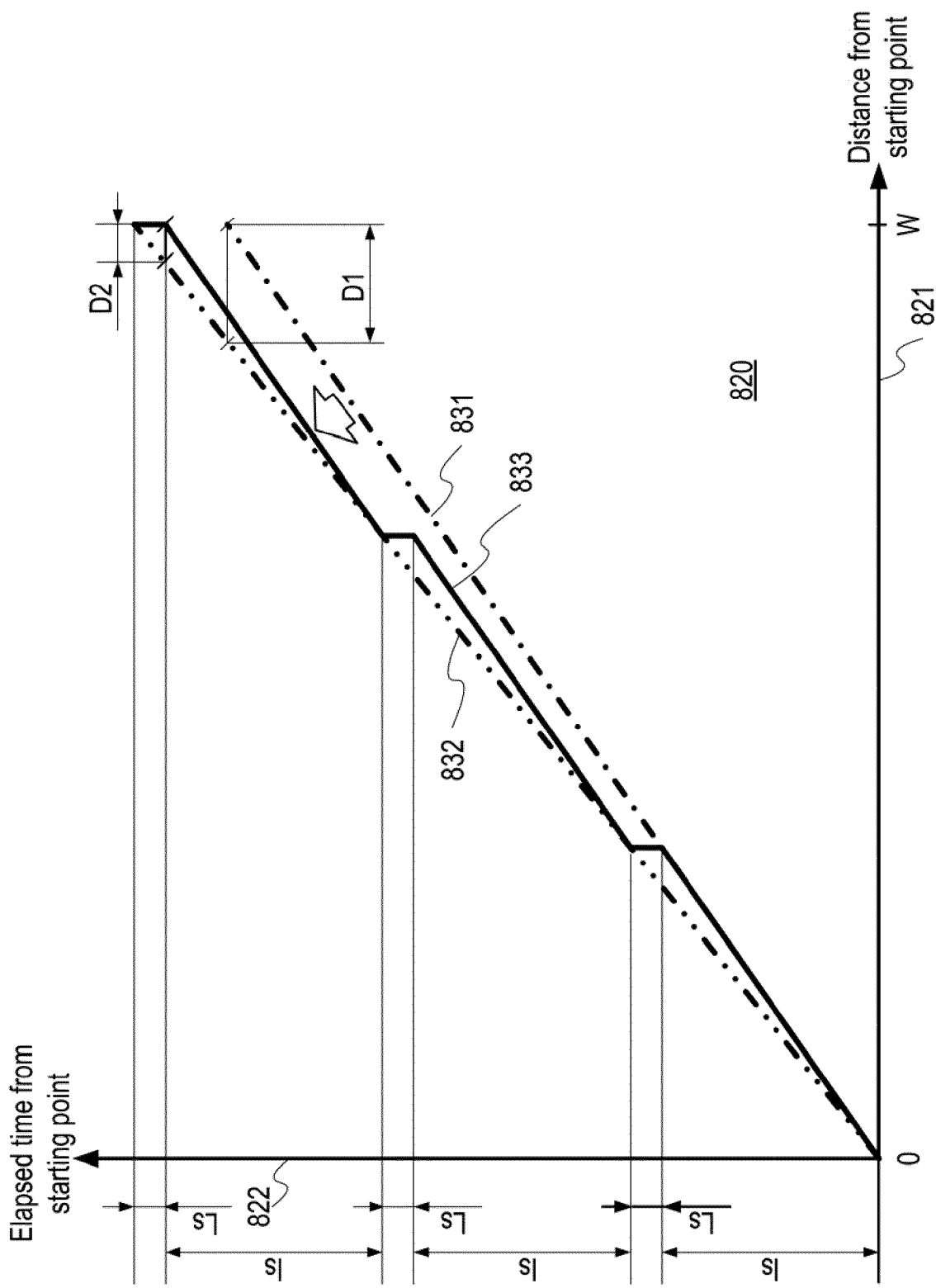


Fig. 21



EUROPEAN SEARCH REPORT

 Application Number
 EP 17 15 5704

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			F24F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 July 2017	Examiner Djemour, Anna
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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