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(72) Inventors:
• **TAKAHASHI, Kazutama**
Kobe-shi
Hyogo 651-2271 (JP)
• **YAMAGUCHI, Atsuhito**
Kobe-shi
Hyogo 651-2271 (JP)

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(74) Representative: **Intès, Didier Gérard André et al**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cedex 07 (FR)

(71) Applicant: **Nabtesco Corporation**
Tokyo 105-0022 (JP)

(54) **PLUG DOOR DEVICE**

(57) A plug door apparatus (1) includes a fixed base (2) fixed to the main body of a vehicle, a slide base (3) provided on the fixed base (2) to be movable in vehicle width directions, a door driver (4) provided in the slide base (3), axis components (5a, 5b) provided at connecting members connecting the door driver (4) with the doors

(104a, 104b), and guide portions (6a, 6b) which are rotatably provided on the fixed base (2) to guide the axis components (5a, 5b). When the doors are opened or closed, the guide portions (6a, 6b) contact the axis components (5a, 5b) to guide the axis components (5a, 5b) to move them in a vehicle width direction.

FIG. 6 (a)

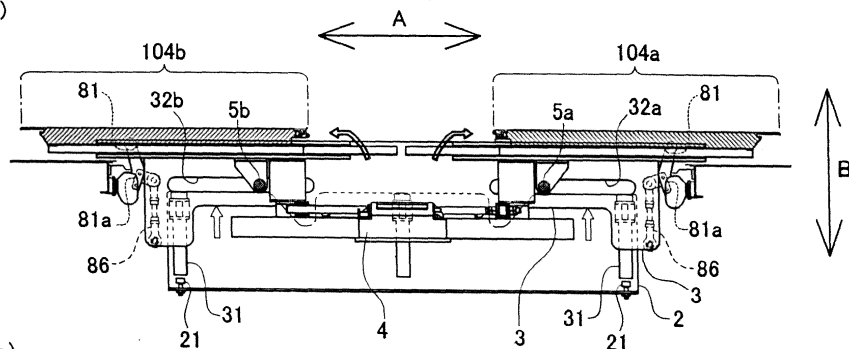
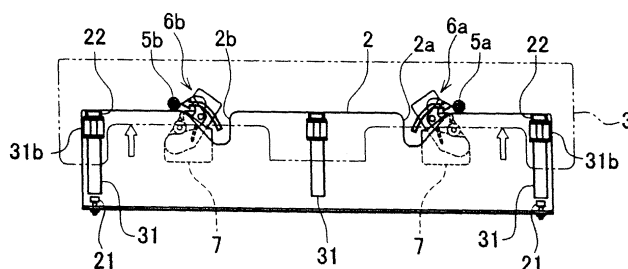


FIG. 6 (b)



Description

TECHNICAL FIELD

[0001] The present invention relates to a plug door apparatus which is used for an entrance of a vehicle and allows a door to open or close and to conduct plugging (i.e. to move in a vehicle width direction).

BACKGROUND ART

[0002] Patent Document 1 recites a conventional plug door apparatus.

This plug door apparatus is arranged so that a guide groove which allows a door to move in the outward direction or inward direction and to slide in a front-back direction is formed in a fixed base which is fixed to a vehicle. The guide groove includes a parallel groove portion in parallel to the side wall of the vehicle and a ramped groove portion which is continued from the parallel groove portion and is inclined with respect to the side wall. As the door is arranged to move along the guide groove, the door is opened by using a door driver exerting a force to the door in a front-back direction of the vehicle, in such a way that the closed door is moved toward the outside of the side wall of the vehicle and then slid along the outer surface of the side wall.

[Prior Art Documents]

[Patent Documents]

[0003]

[Patent Document 1] Japanese Unexamined Patent Publication No. 2005-61065

[Patent Document 2] Japanese Unexamined Patent Publication No. 2006-316524

[Patent Document 3] Japanese Unexamined Patent Publication No. 2008-121244

[0004] (1) The plug door apparatus recited in Patent Document 1, however, is disadvantageous in that, since the ramped groove portion inclined with respect to the vehicle side wall is formed in the fixed base, the fixed base must be sufficiently wide in the vehicle width direction. This results in the upsizing of the plug door apparatus.

[0005] (2) In the plug door apparatus of Patent Document 1, furthermore, the door is connected to a component transferring the driving force from the door driver at the anterior door end side. When the door is opened or closed, the anterior door end side of the door is moved in the outward direction or inward direction so that an upper arm on the posterior door end side is swung in a vehicle width direction by the door. For this reason, when the door is not rigid enough, the upper arm may not sufficiently rotate on account of reasons such as the warping

of the door. In such a case, the posterior door end side of the door may contact the vehicle main body. In particular, when the door is connected to the driver at the upper part of the anterior door end side of the door, the lower part of the posterior door end side of the door, which is far from the junction, is susceptible to contact the vehicle main body. A conceivable solution to this problem of contact between the posterior door end side and the vehicle main body is to connect the door with the door driver at a part of the door which is close to the posterior door end side. However, in this case, to prevent the width of the entrance from being narrowed as compared to the conventional arrangement, it is necessary to provide components, such as the door driver and the junction between the door driver and the door, across a wide range of the door surface in the front-back directions of the vehicle. This also induces upsizing of the plug door apparatus.

DISCLOSURE OF THE INVENTION

[0006] In consideration of the problems above, an object of the present invention is to provide a compact plug door apparatus.

[0007] The plug door apparatus of the present invention has the following features to achieve the object above. In other words, the plug door apparatus of the present invention includes the following features singly or in combination.

[0008] The plug door apparatus of the present invention for achieving the object above includes: a fixed base fixed to a main body of a vehicle; a slide base provided on the fixed base to be movable in a width direction of the vehicle (hereinafter, vehicle width direction); a door driver which is provided in the slide base and moves a door in a front-back direction of the vehicle via a connecting member; an axis component connected to the connecting member; and a guide portion which is rotatably provided on the fixed base and, when the door is opened, rotates while contacting the axis component so as to guide the axis component so that the axis component moves in one width direction of the vehicle, whereas, when the door is closed, rotates while contacting the axis component so as to guide the axis component so that the axis component moves in the other width direction of the vehicle.

[0009] According to this structure, the guide portion rotates while contacting the axis component, so as to guide the axis component in a vehicle width direction. The operation of the guide portion therefore follows the movement of the door in a vehicle width direction. This makes it possible to downsize the space occupied by the guide portion in the vehicle width direction, in accordance with the state of the movement of the door in the vehicle width direction. As a result, the opening, closing, and plugging are carried out by the door driver which applies a force to the door in a front-back direction of the vehicle, and also the plug door apparatus is downsized.

[0010] The above-described plug door apparatus is

preferably arranged so that the slide base is provided on one of an upper side or a lower side of the fixed base and the guide portion is provided on the other side of the fixed base.

[0011] According to this arrangement, the slide base and the guide portion arranged to be movable relative to the fixed base are provided to be closer to the fixed base. This facilitates the downsizing of the entirety of the apparatus.

[0012] The above-described plug door apparatus is preferably arranged so that the guide portion includes a first link rotatably provided on the fixed base and a second link rotatably provided on the first link and having a roller portion, a roller guide fixed to the fixed base to guide the roller portion is further provided, (a) when the door is opened, the first link receives a force from the axis component via the second link and rotates for a predetermined angle so as to move the axis component in one width direction of the vehicle, the roller guide guides the roller portion such that the second link is kept contacting the axis component while the first link is rotating for the predetermined angle, and then guides the roller portion so that the second link does not obstruct the movement of the axis component, after the first link rotates for the predetermined angle, (b) when the door is closed, the first link receives a force from the axis component and rotates so as to move the axis component in the other width direction of the vehicle.

[0013] According to this arrangement, it is possible to realize, by a simple structure, the guide portion which guides the axis component toward one side in the vehicle width direction when closing the door, and guides the axis component toward the other side in the vehicle width direction when opening the door.

[0014] The above-described plug door apparatus is preferably arranged to include a biasing member which is provided between the first link and the second link and biases the second link to cause the roller portion to move close to the roller guide.

[0015] This structure prevents the roller portion from moving away from the roller guide because the roller portion is biased toward the roller guide. This makes it possible to certainly move the roller portion along the roller guide.

[0016] The above-described plug door apparatus is preferably arranged so that the slide base has a groove portion extending in the front-back direction of the vehicle, and the axis component is inserted into the groove portion and moves along the groove portion when the door is opened or closed.

[0017] According to this structure, the movement of the axis component in the vehicle width direction is stopped by the edge of the groove portion of the slide base. This makes it possible to keep the door within a predetermined range in the vehicle width direction, even if a force in the vehicle width direction is exerted to the door.

[0018] The above-described plug door apparatus is

preferably arranged to include a double-speed rail in which a pinion is provided between two opposing racks, wherein, the two racks are disposed to extend in the front-back direction of the vehicle, one of the racks being connected to the slide base whereas the other one of the racks being connected to the door, and the pinion is connected to the connecting member.

[0019] According to this structure, only by moving the connecting member for a predetermined distance by the door driver, it is possible to move the door for a distance twice as long as the predetermined distance. This reduces spaces required for moving the connecting member.

[0020] The above-described plug door apparatus is preferably arranged so that the slide base is supported by a plurality of linear guides provided on the fixed base to be movable in the width directions of the vehicle.

[0021] According to this structure, since the slide base is connected to the fixed base at plural positions in the vehicle front-back directions as a plurality of linear guides are provided, it is possible to prevent the deformation of the slide base. Furthermore, it becomes possible to cause the slide base to linearly and stably move in a vehicle width direction.

[0022] The above-described plug door apparatus is preferably arranged so that the door driver includes a rack-and-pinion mechanism for moving the connecting member and a planetary gear mechanism which transfers a rotational driving force from a drive source to the rack-and-pinion mechanism.

[0023] According to this structure, the planetary gear mechanism allows the rotational driving force from the drive source to be transferred to not only the rack-and-pinion mechanism for opening and closing the door but also another mechanism. For example, when the door is fully closed, the driving force from the drive source can be used for driving a locking mechanism for preventing the movement of the door, via the planetary gear mechanism.

[0024] The above-described plug door apparatus is preferably arranged to include a rotation arm connected to the main body of the vehicle to be rotatable about a vertical axis and also connected to the door which is opened and closed, wherein, the rotation arm is connected to the slide base to be rotated in accordance with the movement of the slide base.

[0025] According to this arrangement, since the rotation arm is connected to the slide base, the rotation arm certainly rotates even if the door is not excessively rigid. Furthermore, since the warping of the door is negligible, the rotation arm certainly rotates even if a connecting member for the connection with the door driver is provided at the anterior door end side of the door. Therefore, the components such as the door driver and the connecting member for the connection with the door are provided in a narrow area in the front-back directions of the vehicle. This ensures the downsizing of the plug door apparatus.

[0026] The above-described plug door apparatus is preferably arranged to include as the rotation arm, a lower

rotation arm which is connected to the upper rotation arm connected to the upper part of the door and is also connected to the lower part of the door, wherein the rotation axis of the upper rotation arm is connected to the rotation axis of the lower rotation arm.

[0027] According to this structure, one of the upper rotation arm and the lower rotation arm is certainly rotated by rotating the remaining one of them.

[0028] According to the present invention, the opening, closing, and plugging are carried out by the door driver which applies a force to the door in a front-back direction of the vehicle, and also the plug door apparatus is downsized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

Fig. 1 is a schematic diagram showing the overall structure of a plug door apparatus 1 according to an embodiment of the present invention.

Fig. 2 is an enlarged schematic diagram of the upper part of the plug door apparatus 1 shown in Fig. 1.

Fig. 3 is a schematic cross section of the plug door apparatus 1 taken along the X-X line in Fig. 2.

Fig. 4 is a view which shows a state where the guide portion is removed from the apparatus shown in Fig. 3.

Fig. 5 is a schematic diagram of the plug door apparatus 1 of Fig. 1 viewed from above.

Fig. 6 is a schematic diagram which corresponds to Fig. 5 and shows a state where the door is opening.

Fig. 7 is a schematic diagram which corresponds to Fig. 5 and shows a state where the door is fully opened.

Fig. 8 includes enlarged schematic diagrams of a plug mechanism, showing (a) full-closed state, (b) a state during plugging, and (c) a state immediately after the completion of plugging.

Fig. 9 is an enlarged schematic diagram of a part of the plug door apparatus 1 of Fig. 1 around the lower rotation arm 82.

Fig. 10 is a schematic cross section of the plug door apparatus 1 taken along the Y-Y line in Fig. 9.

Fig. 11 shows a plug door apparatus of a variation.

BEST MODE FOR CARRYING OUT THE INVENTION

[0030] Hereinafter, a state in which doors 104a and 104b are fully closed will be referred to as "full-closed state", whereas a state in which the doors are fully opened will be referred to as "full-opened state". Furthermore, a position of each component in the full-closed state will be referred to as "full-closed position", whereas a position of each component in the full-opened state will be referred to as "full-opened position".

[Overall Structure]

[0031] As shown in Fig. 1, a vehicle side wall 101 is provided with an entrance 102 (whose width will be referred to as S1). Above the entrance 102 is fixed a frame 103 which extends in the front-back directions. It is noted that the "front-back directions" are directions in parallel to the traveling direction of the vehicle and are indicated by the arrows A in Fig. 1. In Fig. 1, the direction toward the right side of the figure is the direction toward the front side of the vehicle, whereas the direction toward the left side of the figure is the direction toward the rear side of the vehicle.

In addition to the above, a pair of doors 104a and 104b are provided to cover the entrance 102. The doors 104a and 104b constitute a double door, and are opened and closed by a plug door apparatus 1. The doors 104a and 104b are arranged to substantially seal the entrance 102 in the full-closed state.

[0032] As shown in Fig. 2, the plug door apparatus 1 includes a fixed base 2 fixed to the main body of the vehicle, a slide base 3 provided on the fixed base 2, a door driver 4 by which the doors 104 are driven, axis components 5a and 5b moved in the front-back directions of the vehicle by the door driver 4, and guide portions 6a and 6b guiding the axis components 5a and 5b.

[0033] As shown in Fig. 2 and Fig. 3, to the frame 103 is fixed an upper plate member 103b via a bracket 103a. To this upper plate member 103b are fixed connecting plate members 103c and 103d. The fixed base 2 is fixed to the connecting plate members 103c and 103d. As a result, the fixed base 2 is fixed so as not to move relative to the frame 103 (vehicle main body). In addition to this, the fixed base 2 is arranged so that the straight edge portion on the outer side in the vehicle width direction is in parallel to the front-back directions of the vehicle. It is noted that on the edge portion of the fixed base 2 on the outer side in the vehicle width direction are formed recesses 2a and 2b curving toward the inner side in the vehicle width direction (see Fig. 5(b)).

[0034] The "vehicle width direction" above is the directions orthogonal to both the front-back directions of the vehicle and the vertical directions, and are indicated by the arrows B in Fig. 3, Fig. 5, or the like. In Fig. 3, the right side of the figure is the inner side of the vehicle whereas the left side of the figure is the outer side of the vehicle.

[0035] As shown in Fig. 3, the slide base 3 is arranged to include a plate member which is substantially L-shaped in cross section taken along a line orthogonal to the front-back directions of the vehicle. This plate member is constituted by a bottom plate portion 32 extending substantially in horizontal directions and a back plate portion 33 extending substantially in vertical directions.

[0036] As shown in Fig. 5, the slide base 3 is symmetrically shaped in the front-back directions of the vehicle. The bottom plate portion 32 of the slide base 3 is provided with grooves 32a and 32b (groove portions) extending in

parallel to the front-back directions of the vehicle. These grooves 32a and 32b penetrate the bottom plate portion 32.

[0037] As shown in Fig. 2, the slide base 3 is provided above the fixed base 2 via linear guides 31 which are in parallel to the vehicle width direction. The three linear guides 31 are provided at around the both edges of the fixed base 2 and at around the central part of the fixed base 2 in the front-back directions of the vehicle. As shown in Fig. 3, each of the linear guides 31 is provided with a rail 31a fixed to the upper surface of the fixed base 2 and extending in the vehicle width direction and a sliding member 31b slidable along the rail 31a. The sliding member 31b is fixed to the lower surface of the bottom plate portion 32 of the slide base 3.

The slide base 3 is therefore movable in the vehicle width direction relative to the fixed base 2.

[0038] As shown in Fig. 3 and Fig. 5, the movement of the slide base 3 toward the inner side in the vehicle width direction is stopped when the slide base 3 contacts a stopper 21 of the fixed base 2. The movement of the slide base 3 toward the outer side in the vehicle width direction is stopped when the slide base 3 contacts a stopper 22 of the sliding member 31b.

[Door Driving Mechanism]

[0039] As shown in Fig. 3, a main body 41 of the door driver 4 is fixed to the back plate portion 33 of the slide base 3. Also, as shown in Fig. 2, a pair of racks 42a and 42b extend from the main body 41 in the front-back directions of the vehicle. The main body 41 is provided with an unillustrated electric motor which is a direct drive motor rotatable forward and backward. As the motor is driven, a pinion 42c engaged with the pair of racks 42a and 42b is rotated via a planetary gear mechanism G, with the result that the racks 42a and 42b move in opposite directions, respectively.

[0040] The racks 42a and 42b are connected to first brackets 43a and 43b (connecting members) at the leading ends, respectively. The first brackets 43a and 43b are further connected to second brackets 44a and 44b and rail pinions 46a and 46b of double-speed rails 45a and 45b, respectively. More specifically, via later-described supporting rails 49 (see Fig. 3) of double-speed rails 45a and 45b, the first brackets 43a and 43b, the second brackets 44a and 44b, and the rail pinions 46a and 46b are connected with one another. To the second brackets 44a and 44b, axis components 5a and 5b are fixed to extend downward, respectively.

[0041] In other words, the rack 42a, the first bracket 43a, the second bracket 44a, and the rail pinion 46a are connected to one another so as not to change the relative positions thereof. Similarly, the rack 42b, the first bracket 43b, the second bracket 44b, and the rail pinion 46b are connected to one another so as not to change the relative positions thereof. The first brackets 43a and 43b are connected to locking axis components 91a and 91b with

which a locking mechanism 90 can be engaged.

[0042] The double-speed rail 45a is provided to extend in the front-back direction of the vehicle, and includes a rail pinion 46a, two racks (upper rack 47a and a lower rack 48a) vertically opposing each other, and a supporting rail 49 which rotatably supports the pinion 46a and slidably sandwiching the upper rack 47a and the lower rack 48a in the vehicle width direction (see Fig. 3). The upper rack 47a is connected to the door 104a and moved with the door 104a. The lower rack 48a is fixed to the upper surface of the slide base 3 and moved with the slide base 3. Therefore, as the rail pinion 46a is moved in a front-back direction of the vehicle together with the supporting rail 49, the upper rack 47a is moved in the same direction as the rail pinion 46a for a distance twice as long as the moving distance of the rail pinion 46a.

The double-speed rail 45b is arranged in a similar manner. That is to say, the upper rack 47b of the double-speed rail 45b is fixed to the door 104b, whereas the lower rack 48b is fixed to the slide base 3. Therefore the door 104b is moved in a front-back direction by moving the rail pinion 46b in a front-back direction.

[0043] As such, the pinion 42c of the door driver 4 rotates forward (clockwise in Fig. 2) and the rack 42a moves toward the front of the vehicle (i.e. toward the right side in Fig. 2), with the result that the axis component 5a and the door 104a move toward the front. At the same time, the rack 42b moves toward the rear of the vehicle (i.e. toward the left side in Fig. 2), with the result that the axis component 5b and the door 104b move toward the rear. In short, as the pinion 42c of the door driver 4 rotates forward, the doors 104a and 104b opened. On other hand, as the pinion 42c rotates backward (anticlockwise in Fig. 2), the doors 104a and 104b closed.

[0044] It is noted that, the for front-side door 104a of the vehicle the arrangement for the rear-side door 104b are substantially symmetrical with each other, the descriptions below will chiefly deal with the arrangement for the front-side door 104a, and the arrangement for the rear-side door 104b will not be detailed below.

[0045] As shown in Fig. 2, the axis component 5a is fixed to the second bracket 44a interlocked with the rack 42a, to extend downward from the second bracket 44a. Also, as shown in Fig. 3, at around the lower end of the axis component 5a are provided two rollers (upper roller 51 and lower roller 52). The rollers 51 and 52 provided to be rotatable about the axis component 5a.

[Plug Mechanism]

[0046] Fig. 8 is an enlarged schematic diagram of the plug mechanism (the guide portion 6a, the roller guide 7, and the axis component 5a) shown in Fig. 5(b), and illustrates the operations of the axis component 5a and the portion 6a when the door 104a is opening. In Fig. 8, (a) shows the full-closed state, (b) shows the state during the plugging, and (c) shows the state immediately after the completion of the plugging.

[0047] The plug mechanism for the plugging of the doors 104a and 104b is arranged to include the guide portion 6a, the roller guide 7, and the axis component 5a. As shown in Fig. 3 and Fig. 8, to the lower surface of the fixed base 2 is fixed the roller guide 7. The guide portion 6a includes a first link 61 and a second link 62. The guide portion 6a is provided on the lower side of the fixed base 2.

[0048] As shown in Fig. 8, the first link 61 is a substantially rectangular parallelepiped plate member whose one end is rotatable with respect to the fixed base 2. More specifically, the first link 61 is provided to be rotatable about a substantially vertical first rotation axis 63. At around the periphery of the other end of the first link 61, a first notch portion 61a is formed to be able to house the lower roller 52 of the axis component 5a.

[0049] The second link 62 is a plate member rotatably provided on the first link 61. More specifically, the second link 62 is connected to a second rotation axis 64 which is provided around the first notch portion 61a of the first link 61 and extends substantially vertically. At the periphery of the second link 62, a second notch portion 62a is provided to be able to house the upper roller 51 of the axis component 5a. The second link 62 is provided with a roller 65 (roller member) which is rotatable about a vertical axis. The roller 65 is attached to a rotation axis 66 which protrudes upward from the second link 62, and is arranged to be substantially as high as the roller guide 7 fixed to the fixed base 2.

[0050] As shown in Fig. 8(a), when the doors 104a and 104b are in the full-closed state, in plan view, the axis component 5a is circumscribed by the first notch portion 61a of the first link 61 and the second notch portion 62a of the second link 62. More specifically, the first link 61 is retained to cause the opening side of the first notch portion 61a to face the outer side of the vehicle width direction, whereas the second link 62 is retained to cause the opening side of the second notch portion 62a to face away from the first rotation axis 63. As a result, the movement of the axis component 5a away from the inside of the first notch portion 61a in the first link 61 is stopped by the second link 62.

In the full-closed state, the roller 65 of the second link 62 is on the outer side in the vehicle width direction as compared to the second notch portion 62a, whereas the second rotation axis 64 of the second link 62 is on the inner side in the vehicle width direction as compared to the second notch portion 62a.

[0051] Between the first link 61 and the second link 62 is provided a helical spring 67 (biasing member). One end of the helical spring 67 is provided to be substantially equidistant from the second rotation axis 64 and the roller 65 on the second link 62, whereas the other end is provided to be close to the first rotation axis 63 on the first link 61. With this, the second link 62 is biased by the helical spring 67 to rotate in the direction of releasing the restriction of the axis component 5a (i.e. the direction indicated by the arrow Rb1 in Fig. 8). In other words, the

second link 62 is biased by the helical spring 67 so that the roller 65 moves toward the roller guide 7.

[0052] The roller guide 7 includes a slope 71 guiding the roller 65 and a curved surface 72 continued from the slope 71 and guiding the roller 65.

[0053] The slope 71 is a plane which is formed to be closer to the outer side in the vehicle width direction toward the direction in which the door 104a is opened (hereinafter, this direction will be referred to as opening direction and is denoted by the arrow A1 in Fig. 8). The roller guide 7 is fixed to the lower surface of the fixed base 2 such that, in plan view, a part of the roller guide 7 including the slope 71 overlaps the recess 2a of the fixed base 2.

[0054] The curved surface 72 is a curved surface which is continued from the slope 71 and extending toward the inner side in the vehicle width direction while forming a substantially S shape. This curved surface 72 protrudes in the opening direction at a part close to the outer side in the vehicle width direction, and protrudes in the closing direction (which is opposite to the opening direction and is denoted by the arrow A2 in Fig. 8) at a part close to the inner side in the vehicle width direction.

[0055] The most protruding part of the roller guide 7 in the vehicle width direction is a part where the slope 71 is continuously connected to the curved surface 72. The roller guide 7 is provided on the fixed base 2 in such a way that the most protruding part toward the outer side in the vehicle width direction is positioned either to be substantially identical in position with the end face of the fixed base 2 or to be on the inner side in the vehicle width direction as compared to the end face of the fixed base 2. In other words, the roller guide 7 is provided so as not to protrude toward the outside in the vehicle width direction as compared to the fixed base 2.

[Rotation Arm]

[0056] As shown in Fig. 1, on the both sides of the upper part of the entrance 102 and on the both sides of the lower side of the entrance 102, an upper rotation arm 81 and a lower rotation arm 82 are provided to rotate and guide the doors in the vehicle width direction. It is noted that, since the driving mechanism of the rotation arm on the vehicle front side and the driving mechanism of the rotation arm on the vehicle rear side are arranged to be symmetrical with each other, the following will only describe the driving mechanism of the rotation arm on the vehicle front side and the driving mechanism of the rotation arm on the vehicle rear side will not be detailed.

[0057] As shown in Fig. 1, the upper rotation arm 81 is fixed to a connecting axis 83 extending in a substantially vertical direction. The connecting axis 83 is rotatably fixed to the brackets extending from the upper and lower edges of the entrance 102.

As shown in Fig. 2 and Fig. 4, at the leading end of the upper rotation arm 81 is provided a roller 84 which is rotatable about a rotation axis extending substantially vertically upward. The door 104a is provided with an up-

per rail 85 which extends in the vehicle front-back directions. As shown in Fig. 4, the upper rail 85 has a groove which is open downward and extends in the vehicle front-back directions.

The roller 84 is inserted into the groove of the upper rail 85 from below and is arranged to be movable along the upper rail 85.

[0058] Furthermore, as shown in Fig. 4 and Fig. 5, a connecting rod 86 is provided between the upper rotation arm 81 and the slide base 3. One end of the connecting rod 86 is provided to be rotatable about a substantially vertical axis with respect to the bracket 81a fixed at the central portion of the upper rotation arm 81 in the longitudinal direction, whereas the other end is provided to be rotatable about a substantially vertical axis with respect to the slide base 3.

[0059] Now, the lower rotation arms 82 provided at the lower part of the doors 104a and 104b will be described. Fig. 9 is an enlarged schematic diagram of the lower rotation arm 82 and its surrounding of the plug door apparatus 1 shown in Fig. 1. Fig. 10 is a schematic cross section of the plug door apparatus 1 taken along the Y-Y line in Fig. 9.

[0060] As shown in Fig. 9 and Fig. 10, the lower rotation arm 82 is fixed to the lower part of the connecting axis 83. Therefore the lower rotation arm 82 rotates as the upper rotation arm 81 rotates. Furthermore, in the same manner as the arrangement of the upper portion of the door 104a, the lower rotation arm 82 is provided with, at its leading end, a roller 87 which is rotatable about a rotation axis extending substantially vertically upward. This roller 87 is inserted from below to the groove of a lower rail 88 which is provided on the door 104a to extend in the front-back directions of the vehicle, and is arranged to be movable along the lower rail 88.

[Operation of Plug Door Apparatus]

[0061] The following will describe the operation of the plug door apparatus 1 with reference to Fig. 5 to Fig. 8.

<Operation to Open Door>

[0062] As shown in Fig. 5 and Fig. 8(a), when the door is in the full-closed state, the axis component 5a (schematically indicated by half-tone dot meshing in Fig. 5 to Fig. 8) is inside the recess 2a of the fixed base 2 in plan view. This axis component 5a is engaged with both the first notch portion 61a of the first link 61 and the second notch portion 62a of the second link 62 (i.e., the axis component is positioned inside the notch portions).

[0063] As the motor (not illustrated) of the door driver 4 is driven so that the pinion 42c is rotated forward, the pair of racks 42a and 42b receive a driving force in the opening direction. The driving force in the opening direction is transferred to the axis component 5a via the first bracket 43a, the supporting rail 49, and the second bracket 44a. In other words, the axis component 5a moves in

the opening direction (indicated by the arrow A1 in Fig. 8) so as to bias the second link 62 in the same direction.

[0064] In this regard, as shown in Fig. 8 (a), the rotation of the second link 62 relative to the first link 61 (i.e. the rotation in the direction of the arrow Rb1) is stopped when the roller 65 contacts the slope 71 of the roller guide 7. For this reason, the second link 62 rarely rotates relative to the first link 61, and hence the first link 61 receives, via the second rotation axis 64, a rotational force about the first rotation axis 63 (i.e. the rotational force in the direction indicated by the arrow Ra1). As a result, as shown in Fig. 8(b), the roller 65 moves along the slope 71 and the first link 61 rotates about the first rotation axis 63.

[0065] Fig. 8 (b) shows a state where the first link 61 has rotated for a predetermined angle in the direction of the arrow Ra1 and the roller 65 has moved to the edge of the slope 71. As shown in Fig. 8 (b), while the first link 61 is rotating in the direction of Ra1, the roller 65 of the second link 62 moves along the slope 71 of the roller guide 7. At this point, since the second link 62 is drawn to the slope 71 side by the helical spring 67, the roller 65 does not move away from the slope 71. Furthermore, in plan view, the state where the axis component 5a is circumscribed by the first notch portion 61a of the first link 61 and the second notch portion 62a of the second link 62 is maintained.

[0066] As the axis component 5a further moves in the opening direction from the state shown in Fig. 8(b), the contact point between the roller 65 and the roller guide 7 moves from the slope 71 to the curved surface 72. As a result, the roller 65 is drawn toward the inner side in the vehicle width direction along the curved surface 72 and the second link 62 rotates in the direction of Rb1 relative to the first link 61. In other words, as shown in Fig. 8(c), the restriction of the axis component 5a by the second link 62 is released.

[0067] Now, in the full-closed state, the first link 61 is disposed so that the first notch portion 61a is on the outer side in the vehicle width direction as compared to the first rotation axis 63. The present embodiment is arranged such that, in plan view the straight line connecting the center of the axis component 5a housed in the first notch portion 61a with the center of the first rotation axis 63 and the straight line which passes through the first rotation axis 63 and is in parallel to the front-back directions of the vehicle form an angle (i.e. an angle indicated by in Fig. 8(a)) of 5 to 10 degrees.

Moreover, in the full-closed state, the second link 62 is disposed so that the roller 65 is provided on the outer side in the vehicle width direction as compared to the center of the axis component 5a and the second rotation axis 64 is provided on the inner side in the vehicle width direction as compared to the center of the axis component 5a.

The arrangement above allows the biasing force from the axis component 5a to be efficiently used for the rotation of the first link 61.

[0068] When the first link 61 rotates as above, a force toward the outer side in the vehicle width direction is exerted to the axis component 5a. Similarly, a force toward the outer side in the vehicle width direction is exerted to the other axis component 5b. For this reason, the door driver 4 connected to the axis component 5a and the axis component 5b also receives a force toward the outer side in the vehicle width direction, and the slide base 3 to which the door driver 4 is fixed also receives a force toward the outer side in the vehicle width direction.

[0069] As a result, the door driver 4 and the slide base 3 are guided by the linear guide 31 and move toward the outer side in the vehicle width direction. As such, as shown in Fig. 6, the doors 104a and 104b are moved in the opening direction while being moved toward the outer side in the vehicle width direction.

[0070] Thereafter, as shown in Fig. 7, the axis component 5a does not receive a force in the vehicle width direction from the guide portion 6a, and hence the axis component 5a is linearly moved in the opening direction by the driving of the door driver 4. In other words, the door 104a linearly moves to the full-opened position in the opening direction.

In so doing, the axis component 5a moves along the periphery of the fixed base 2 which periphery extends in the vehicle front-back directions. Therefore, since the axis component 5a contacts the periphery of the fixed base 2 even if an external force toward the inner side in the vehicle width direction is applied to the door 104a, the slide base 3 is not pushed toward the inner side in the vehicle width direction.

The axis component 5a moves along the groove 32a of the slide base 3. For this reason, even if an external force is applied to the door 104a toward the outer side in the vehicle width direction, the movement of the axis component 5a toward the outer side in the vehicle width direction is stopped by the edge of the groove 32a. This prevents the door from excessively moving toward the outer side in the vehicle width direction. Furthermore, since the movement of the slide base 3 toward the outer side in the vehicle width direction is stopped by the stopper 22, the slide base 3 is not moved by an external force toward the outer side in the vehicle width direction. The movement of the axis component 5b in the vehicle width direction is also restricted by the groove 32b.

<Operation to Close Door>

[0071] When the door is closed, the operation opposite to the above-described operation to open the door is carried out.

[0072] That is to say, as the unillustrated motor of the door driver 4 is driven so that the pinion 42c is rotated backward, a driving force toward the closing direction is applied to the pair of racks 42a and 42b. The driving force in the closing direction is transferred to the axis component 5a, and the axis component 5a linearly moves toward the guide portion 6a in the closing direction (i.e. the

direction indicated by the arrow A2 in Fig. 8).

[0073] when the door is open, as shown in Fig. 8(c), the helical spring 67 exerts a rotating force to the second link 62 in the direction of Rb1. In other words, a tensile force is exerted from the helical spring 67 to the second link 62 such that the roller 65 is positioned on the curved surface 72 of the roller guide 7. In the present embodiment, the roller 65 is housed in the recess 72a which has a substantially identical arc shape as the outer circumference of the roller 65 of the curved surface 72. With this, the first link 61 and the second link 62 are stably retained at predetermined positions. More specifically, the second link 62 is retained at a position where the axis component 5a having linearly moved in the closing direction contacts the inner edge of the second notch portion 62a. Also, the first link 61 is retained at a position where the axis component 5a having linearly moved in the closing direction is housed in the first notch portion 61a.

[0074] Therefore, the axis component 5a contacts the inner edge of the second notch portion 62a of the second link 62 after moving for a predetermined distance in the closing direction from the full-opened position (see Fig. 8(c)), so as to bias the second link 62. In so doing, since the second link 62 rotates in the direction indicated by the arrow Rb2 against the force of the helical spring 67, the linear movement of the axis component 5a in the closing direction is not obstructed. During the rotation of the second link 62, the roller 65 moves along the curved surface 72 of the roller guide 7. It is noted that, during the rotation of the second link 62, the first link 61 rarely rotates and is retained at or at around a predetermined position.

[0075] The axis component 5a then moves in the closing direction until contacting the inner edge of the first notch portion 61a of the first link 61, so as to bias the first link 61 in the closing direction. As a result, the first link 61 rotates in the direction of the arrow Ra2 and the axis component 5a is guided toward the inner side in the vehicle width direction. In other words, the axis component 5a is guided into the recess 2a of the fixed base 2.

[0076] The door 104a moves in the same manner as the axis component 5a. In other words, the door 104a linearly moves from the full-opened position in the closing direction, and is then drawn toward the inner side in the vehicle width direction at around the full-closed position so as to be shifted to the full-closed position. The closing operation of the door 104b is identical with that of the door 104a.

[Operation of Rotation Arm When Door Is Closed/Opened]

[0077] The following will describe the operation of the rotation arm when the door is opened or closed.

[0078] As described above, when the door starts to move in the opening direction from the full-closed position, the slide base 3 moves toward the outer side in the

vehicle width direction. As a result of this, as shown in Fig. 5 and Fig. 6, the connecting rod 86 whose one end is connected to the slide base 3 also moves toward the outer side in the vehicle width direction, so as to bias the upper rotation arm 81 to push it toward the outer side in the vehicle width direction. The upper rotation arm 81 biased by the connecting rod 86 rotates while exerting a biasing force to around the posterior door end of the door 104a via the upper rail 85, toward the outer side in the vehicle width direction (see Fig. 4).

[0079] Furthermore, because of the rotation of the upper rotation arm 81, the lower rotation arm 82 is rotated by the connecting axis 83 in the same direction. In other words, the lower rotation arm 82 rotates while exerting a biasing force to around the posterior door end of the door 104a via the lower rail 88, toward the outer side in the vehicle width direction.

[0080] As a result, the door 104a is biased toward the outer side in the vehicle width direction at around the upper end and lower end of the posterior door end, and the door 104a is therefore moved toward the outer side in the vehicle width direction.

[0081] When the door is closed, as described above, the slide base 3 moves toward the inner side in the vehicle width direction at around the full-closed position. As a result, the connecting rod 86 whose one end is connected to the slide base 3 is also moved in the inner side in the vehicle width direction, so as to bias the upper rotation arm 81 to draw it toward the inner side in the vehicle width direction. The upper rotation arm 81 biased by the connecting rod 86 rotates while exerting a drawing force to around the posterior door end of the door 104a via the upper rail 85, toward the inner side in the vehicle width direction.

[0082] Furthermore, because of the rotation of the upper rotation arm 81, the lower rotation arm 82 is rotated by the connecting axis 83 in the same direction, so as to exert a biasing force toward the inner side in the vehicle width direction to around the lower end of the posterior door end of the door 104a via the lower rail 88.

[0083] As a result, the door 104a is biased toward the inner side in the vehicle width direction at around the upper end and lower end of the posterior door end, and is therefore moved toward the inner side in the vehicle width direction.

[0084] It is noted that, in the opening and closing operations, the roller 84 at the leading end of the upper rotation arm 81 and the roller at the leading end of lower rotation arm 82 roll along the upper rail 85 and the lower rail to move relative to the door 104a, in accordance with the movement of the door 104a in the opening or closing direction.

[Locking Operation]

[0085] As shown in Fig. 2, in the present embodiment, a locking mechanism 90 is provided to prevent the first brackets 43a and 43b from moving (i.e. prevent the doors

104a and 104b from moving) in the opening direction when the door is in the full-closed state, by being engaged with the locking axis components 91a and 91b. The locking mechanism 90 is provided in the main body 41 of the door driver 4 and is switched between a locking state and a locking release state as described below.

[0086] The output shaft of an unillustrated motor in the door driver 4 is capable of transferring a driving force to the pinion 42c and the locking mechanism 90 via the planetary gear mechanism G.

The planetary gear mechanism G includes a sun gear G1 which is rotatably supported, planetary gears G2 provided on the outer circumference of the sun gear G1 and each rotates on its own and revolves along the outer circumference of the sun gear G1 while being engaged with the sun gear G1, an internal gear G3 having internal teeth engaging externally with the planetary gears G2, and a carrier C which rotatably supports the planetary gears G2. The sun gear G1, the internal gear G3, and the carrier C are arranged so that their rotation axes correspond to one another and each of them is freely rotatable relative to the remaining ones. The rotation axes of these three components also correspond to the rotation axis of the pinion 42c of the rack-and-pinion mechanism.

[0087] The sun gear G1 is connected to the output shaft of a motor. It is noted that a speed reducer may be suitably connected according to need.

The internal gear G3 is connected to the pinion 42c by an unillustrated bolt or the like.

The carrier C is connected to the locking mechanism 90. The carrier C receives, during the door closing operation, a predetermined biasing force which restrains the rotation of the carrier C caused by the revolution of the planetary gears G2.

[0088] Because of this arrangement, basically the carrier C does not rotate until the door reaches the full-closed position in the closing operation. When the door reaches the full-closed position, the rotation of the internal gear G3 stops because the door no longer moves in the closing direction. Therefore the driving force of the motor is transferred to the carrier C. As a result, the carrier C rotates against the predetermined biasing force, and hence the locking mechanism 90 shifts to the locking state.

[0089] On the other hand, when the door is moved from the full-closed position to the opening direction, at the start of the movement in the opening direction, the locking mechanism 90 in the locking state prevents the locking axis components 91a and 91b from moving. Therefore the internal gear G3 does not rotate. For this reason, the carrier C rotates in the direction opposite to the rotation in the closing operation. As a result, the locking mechanism 90 shifts to the locking release state. The carrier C is arranged so that its rotation is stopped at a position reached after the rotation for a predetermined angle. For this reason, after the rotation of the carrier C is stopped, the driving force of the motor is transferred to the internal gear G3, with the result that the door moves in the opening direction.

[0090] The locking mechanism 90 may be differently constructed as long as the mechanism cooperates with the rotation of the carrier C to stop the movement of the locking axis components 91a and 91b in the opening direction and releases the stopping action when the carrier C reversely rotates, when the door is at the full-closed position. For example, it is possible to use known locking mechanisms recited in Patent Documents 2 and 3.

[0091] As described above, the plug door apparatus 1 according to the present embodiment includes a fixed base 2 fixed to a frame 103, a slide base 3 which is provided on the fixed base 2 to be movable in vehicle width direction, a door driver 4 which is provided in the slide base 3 and moves the doors 104a and 104b in a front-back direction of a vehicle via first brackets 43a and 43b, axis components 5a and 5b fixed to the first brackets 43a and 43b, and guide portions 6a and 6b which are rotatably provided on the fixed base 2 and, when the doors 104a and 104b are opened, rotate while contacting the axis components 5a and 5b so as to guide the axis components 5a and 5b to move toward the outer side in the vehicle width direction, and when the doors 104a and 104b are closed, rotate while contacting the axis components 5a and 5b so as to guide the axis components 5a and 5b to move toward the inner side in the vehicle width direction.

[0092] According to this arrangement, the guide portions 6a and 6b rotate while contacting the axis components 5a and 5b so as to guide the axis components 5a and 5b in a vehicle width direction. The guide portions 6a and 6b therefore move in accordance with the movement of the doors 104a and 104b in the vehicle width direction. According to this arrangement, when the doors 104a and 104b are drawn toward the inner side in the vehicle width direction, it is possible to prevent the guide portions 6a and 6b from excessively jut toward the outer side in the vehicle width direction. Therefore, the space occupied by the guide portions 6a and 6b is reduced. As a result, the opening and closing operations and the plugging are realized by the door driver 4 which exerts a force to the doors 104a and 104b in the front-back direction of the vehicle, and the plug door apparatus 1 is downsized.

[0093] It is noted that the subject application is not limited to the arrangement in which, in the closing operation, the doors are drawn toward the inner side in the vehicle width direction to closely contact the periphery of the entrance. For example, in the closing operation, the doors may be pushed toward the outer side in the vehicle width direction to closely contact the periphery of the entrance.

[0094] In the meanwhile, the slide base 3 is provided below the fixed base 2, whereas the guide portions 6a and 6b are provided above the fixed base 2.

[0095] According to this arrangement, it is possible to provide the slide base 3 and the guide portions 6a and 6b, which are arranged to be movable relative to the fixed base 2, to be closer to the fixed base 2. This further ensures the downsizing of the entire apparatus. That is to say, when both of the slide base 3 and the

guide portions 6a and 6b are provided on one side of the fixed base 2, it is necessary to suitably position the slide base 3 and the guide portions 6a and 6b so as not to interfere each other when moved. In so doing, an unnecessary space is often formed. In this regard, since the slide base 3 and the guide portions 6a and 6b are separately provided above and below the fixed base, it is unnecessary to take into account of the interference and hence an excessively large space is not required for disposing the components.

[0096] Furthermore, since the slide base 3 and the guide portions 6a and 6b are provided to be closer to the fixed base 2, the connection of the slide base 3 and the guide portions 6a and 6b with the fixed base 2 becomes stable. This makes it possible to stabilize the operations of the slide base 3 and the guide portions 6a and 6b.

[0097] It is noted that the guide portion may be provided above the fixed base 2 and the slide base may be provided below the fixed base 2.

[0098] In addition to the above, the guide portion 6a (also the guide portion 6b) includes a first link 61 rotatably provided on the fixed base 2, a second link 62 rotatably provided on the first link 61 and having a roller 65, and a roller guide 7 fixed to the fixed base 2 and guiding the roller 65.

When the doors are opened, the first link 61 receives a force from the axis component 5a via the second link 62, so as to rotate for a predetermined angle to move the axis component 5a toward the outer side in the vehicle width direction. While the first link 61 moves for the predetermined angle, the roller guide 7 guides the roller 65 so that the second link 62 keeps contacting the axis component 5a. After the rotation of the first link 61 for the predetermined angle, the second link 62 guides the roller 65 in such a way as not to obstruct the movement of the axis component 5a.

On the other hand, when the door are closed, the first link 61 receives a force from the axis component 5a so as to rotate to move the axis component 5a toward the inner side in the vehicle width direction.

[0099] According to the arrangement above, it is possible to realize, by a simple structure, the guide portion 6a which guides the axis component 5a toward the outer side in the vehicle width direction when closing the doors and guides the axis component 5a toward the inner side in the vehicle width direction when opening the doors.

[0100] In addition to the above, a helical spring 67 is provided between the first link 61 and the second link 62 to bias the second link 62 in such a way as to cause the roller 65 to move close to the roller guide 7.

[0101] This arrangement restrains the roller 65 from moving away from the roller guide 7 because the roller 65 is biased toward the roller guide 7. This ensures the movement of the roller 65 along the roller guide 7.

[0102] Furthermore, the elasticity of the helical spring 67 keeps the first link 61 and the second link 62 to be at predetermined positions. In other words, it is possible to retain the first link 61 and the second link 62 so that the

opening sides of the notch portions 61a and 61b to jut toward the outside in the width directions as compared to the fixed base 2 and the opening sides of the notch portion 61a and 61b to face toward the opening direction (as shown in Fig. 8(c)).

This makes it possible to, in the closing operation, certainly guide the axis component 5a into the notch portions 61a and 61b of the first link 61 and the second link 62.

[0103] It is noted that the second link is not necessarily biased by the helical spring. Another type of elastic member may be used, or a biasing force may be generated by a magnet or the like.

[0104] The slide base 3 has grooves 32a and 32b extending along the front-back directions of the vehicle, the axis components 5a and 5b are inserted into the grooves 32a and 32b, and the axis components 5a and 5b move along the grooves 32a and 32b when the doors 104a and 104b are opened or closed.

[0105] According to this arrangement, the movement of the axis components 5a and 5b in the vehicle width direction is stopped at the edges of the grooves 32a and 32b. This makes it possible to certainly retain the doors 104a and 104b within a predetermined range in the vehicle width direction, even if a force in a vehicle width direction is exerted to the doors 104a and 104b.

[0106] In addition to the above, the first brackets 43a and 43b used for transferring the driving force of the door driver 4 to the doors are connected to the doors 104a and 104b via the double-speed rails 45a and 45b. For this reason, only by moving the first brackets 43a and 43b for a predetermined distance by the door driver 4, it is possible to move the doors 104a and 104b for a distance twice as long as the predetermined distance. This reduces spaces required for moving the first brackets 43a and 43b and the second brackets 44a and 44b and the axis components 5a and 5b moving in accordance with the movement of the first brackets 43a and 43b.

[0107] In addition to the above, since the slide base 3 is supported by the three linear guides 31 of the fixed base 2 to be movable in the vehicle width direction, the connection between the slide base 3 and the fixed base 2 is stable. This prevents the slide base 3 from being deformed. Furthermore, it becomes easy to keep the slide base 3 to stably and linearly move in the vehicle width direction.

[0108] The door driver 4 includes a rack-and-pinion mechanism constituted by racks 42a and 42b and a pinion 42c for moving the first brackets 43a and 43b and a planetary gear mechanism G which transfers a rotational driving force from a motor as a driving source to the rack-and-pinion mechanism.

Furthermore, a locking mechanism 90 is included to lock the movement of the doors 104a and 104b.

The planetary gear mechanism G is arranged to be able to transfer the rotational driving force from the motor to the rack-and-pinion mechanism and the locking mechanism 90.

[0109] This arrangement allows the door driver 4 which

uses the motor as a driving source to carry out the opening and closing operations, the plugging, and the locking to lock the movement of the doors.

[0110] In addition to the above, the plug door apparatus 1 according to the present embodiment includes upper rotation arms 81 and lower rotation arms 82 which are connected to the both sides of the upper part and the both side of the lower part of the entrance 102 to be rotatable about vertical axes and are connected to the doors 104a and 104b which are opened and closed.

The upper rotation arm 81 is connected to the slide base 3 via the connecting rod 86 to rotate in accordance with the movement of the slide base 3. The lower rotation arm 82 is connected to the upper rotation arm 81 via the connecting axis 83 and rotates in accordance with the movement of the slide base 3.

[0111] According to this arrangement, since the upper rotation arm 81 is connected to the slide base 3 via the connecting rod 86, the driving force is transferred from the door driver 4 without the intermediary of the doors 104a and 104b. That is to say, it is possible to certainly rotate the upper rotation arm 81 without arranging the doors 104a and 104b to have excessively high strength. The lower rotation arm 82 is connected to the slide base 3 via the connecting rod 86, the upper rotation arm 81, and the connecting axis 83. Therefore the lower rotation arm 82 is certainly rotated by moving the slide base 3.

[0112] It is noted that the subject application is not limited to the arrangement in which the door driver 4 is connected to the doors 104a and 104b by the double-speed rails 45a and 45b. The first brackets 43a and 43b of the door driver 4 may be directly fixed to the doors 104a and 104b. In such a case, the structure becomes simple: however, the moving distance of the racks 42a and 42b of the door driver 4 is doubled as compared to the case of using the double-speed rails. In addition to the above, the upper rotation arm 81 and the lower rotation arm 82 are certainly rotated even if the first brackets 43a and 43b or the like are fixed on the anterior door end side of the doors 104a and 104b. Therefore, the components such as the door driver 4, the first brackets 43a and 43b, and the second brackets 44a and 44b are provided in a narrow area around the center of the entrance 102 in the front-back directions of the vehicle. As a result, the plug door apparatus is downsized.

[0113] Furthermore, since the upper rotation arm 81 and the lower rotation arm 82 are fixed to the same connecting axis 83, it is possible to certainly rotate the lower rotation arm 82 by rotating the upper rotation arm 81 by a biasing force from the slide base 3.

[0114] Note that various design variations can be made in the present invention without departing from the scope of the claims, and the present invention is not limited to the above-described embodiment

[0115] For example, a variation may be implemented as below. The present invention is not limited to the arrangement in which the guide portions 6a and 6b which rotate so as to guide the axis components 5a and 5b are

included. As shown in Fig. 11, a plug mechanism which guides axis components 5a and 5b by a guide groove 221 provided in a fixed base 220 may be adopted.

The guide groove 221 includes a parallel groove portion 221a formed to be in parallel to the front-back directions of the vehicle and a ramped groove portion 221b which is continued from the parallel groove portion 221a and oblique with respect to the vehicle side wall.

According to this structure, when the opening operation is carried out, the axis components 5a and 5b are guided by the ramped groove portion 221b so that the slide base 230 and the door driver 240 are pushed toward the outer side in the vehicle width direction, with the result that the doors 104a and 104b move in the opening direction while being pushed toward the outer side in the vehicle width direction. In so doing, the upper rotation arm 81 certainly rotates for a predetermined angle as it is biased from the slide base 230 toward the outer side in the vehicle width direction via the connecting rod 86.

On the other hand, when the closing operation is carried out, the axis components 5a and 5b at the full-opened position are guided by the parallel groove portion 203a and move, and then guided by the ramped groove portion 221b and drawn toward the inner side in the vehicle width direction at around the full-closed position. As a result, the slide base 230 and the door driver 240 are drawn toward the inner side in the vehicle width direction, and hence the doors 104a and 104b move in the closing direction while being drawn toward the inner side in the vehicle width direction. In so doing, the upper rotation arm 81 certainly rotates for a predetermined angle as it is biased from the slide base 230 toward the inner side in the vehicle width direction via the connecting rod 86.

REFERENCE NUMERALS

[0116]

1	PLUG DOOR APPARATUS	
2	FIXED BASE	
3	SLIDE BASE	
4	DOOR DRIVER	
5a,5b	AXIS COMPONENT	
6a,6b	GUIDE PORTION	
61	FIRST LINK	
62	SECOND LINK	
65	ROLLER	
7	ROLLER GUIDE	
81	UPPER ROTATION ARM	
82	LOWER ROTATION ARM	

Claims

1. A plug door apparatus comprising:

a fixed base fixed to a main body of a vehicle;
a slide base provided on the fixed base to be

movable in a width direction of the vehicle;
a door driver which is provided in the slide base and moves a door in a front-back direction of the vehicle via a connecting member;
an axis component connected to the connecting member; and
a guide portion which is rotatably provided on the fixed base and, when the door is opened, rotates while contacting the axis component so as to guide the axis component so that the axis component moves in one width direction of the vehicle, whereas, when the door is closed, rotates while contacting the axis component so as to guide the axis component so that the axis component moves in the other width direction of the vehicle.

2. The plug door apparatus according to claim 1, wherein, the slide base is provided on one of an upper side or a lower side of the fixed base and the guide portion is provided on the other side of the fixed base.

3. The plug door apparatus according to claim 1 or 2, wherein, the guide portion includes a first link rotatably provided on the fixed base and a second link rotatably provided on the first link and having a roller portion, a roller guide fixed to the fixed base to guide the roller portion is further provided,

(a) when the door is opened,
the first link receives a force from the axis component via the second link and rotates for a predetermined angle so as to move the axis component in one width direction of the vehicle,
the roller guide guides the roller portion such that the second link is kept contacting the axis component while the first link is rotating for the predetermined angle, and then guides the roller portion so that the second link does not obstruct the movement of the axis component, after the first link rotates for the predetermined angle,
(b) when the door is closed,
the first link receives a force from the axis component and rotates so as to move the axis component in the other width direction of the vehicle.

4. The plug door apparatus according to claim 3, further comprising:

a biasing member which is provided between the first link and the second link and biases the second link to cause the roller portion to move close to the roller guide.

5. The plug door apparatus according to any one of claims 1 to 4, wherein,

the slide base has a groove portion extending in the front-back direction of the vehicle, and the axis component is inserted into the groove portion and moves along the groove portion when the door is opened or closed.

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6. The plug door apparatus according to any one of claims 1 to 5, further comprising:

a double-speed rail in which a pinion is provided between two opposing racks, wherein, the two racks are disposed to extend in the front-back direction of the vehicle, one of the racks being connected to the slide base whereas the other one of the racks being connected to the door, and the pinion is connected to the connecting member.

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7. The plug door apparatus according to any one of claims 1 to 6, wherein, the slide base is supported by a plurality of linear guides provided on the fixed base to be movable in the width directions of the vehicle.

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8. The plug door apparatus according to any one of claims 1 to 7, wherein, the door driver includes a rack-and-pinion mechanism for moving the connecting member and a planetary gear mechanism which transfers a rotational driving force from a drive source to the rack-and-pinion mechanism.

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9. The plug door apparatus according to any one of claims 1 to 8, further comprising:

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a rotation arm connected to the main body of the vehicle to be rotatable about a vertical axis and also connected to the door which is opened and closed, wherein, the rotation arm is connected to the slide base to be rotated in accordance with the movement of the slide base.

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10. The plug door apparatus according to claim 9, further comprising:

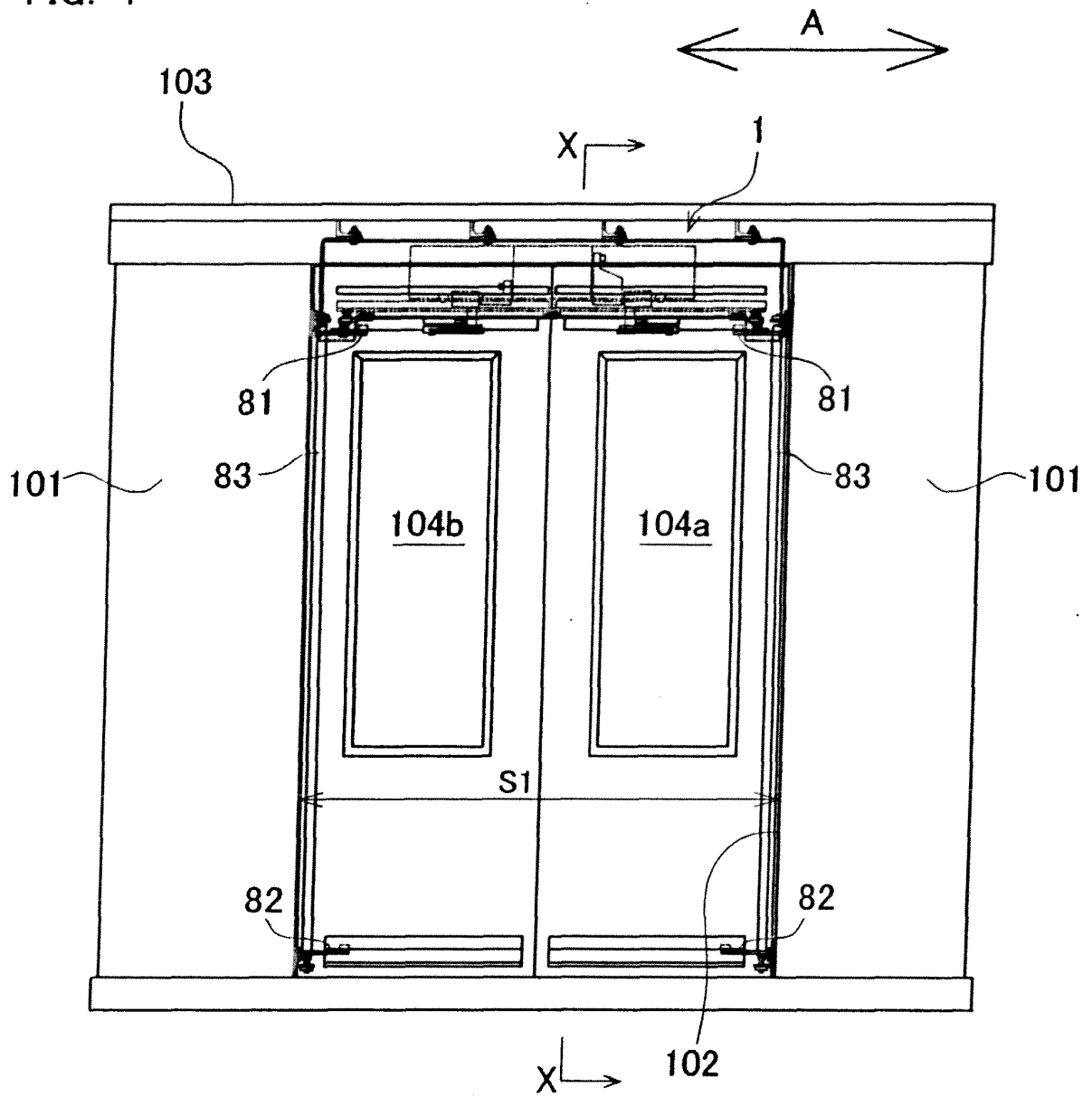
45

as the rotation arm, a lower rotation arm which is connected to the upper rotation arm connected to the upper part of the door and is also connected to the lower part of the door, wherein, the rotation axis of the upper rotation arm is connected to the rotation axis of the lower rotation arm.

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FIG. 1



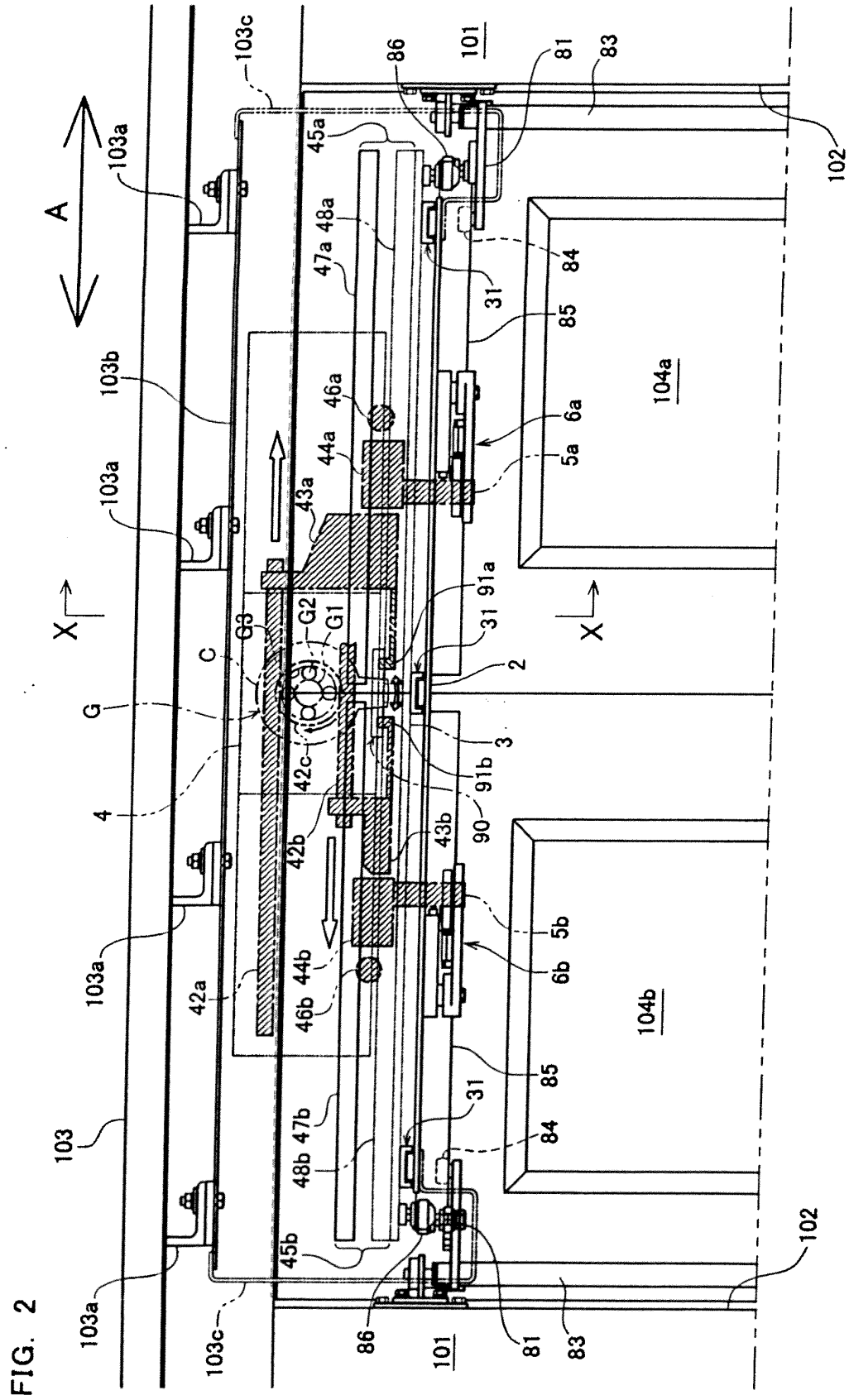


FIG. 3

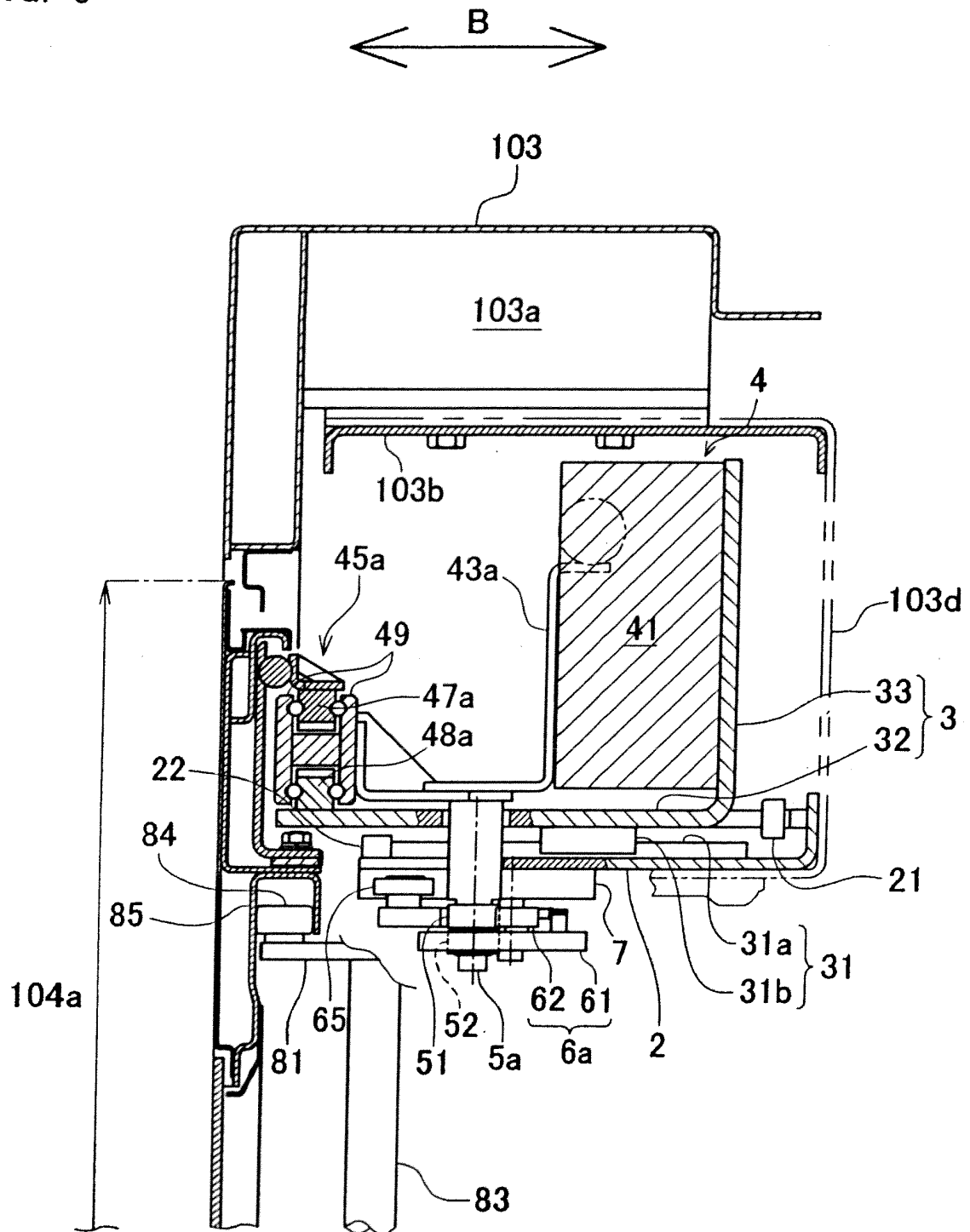
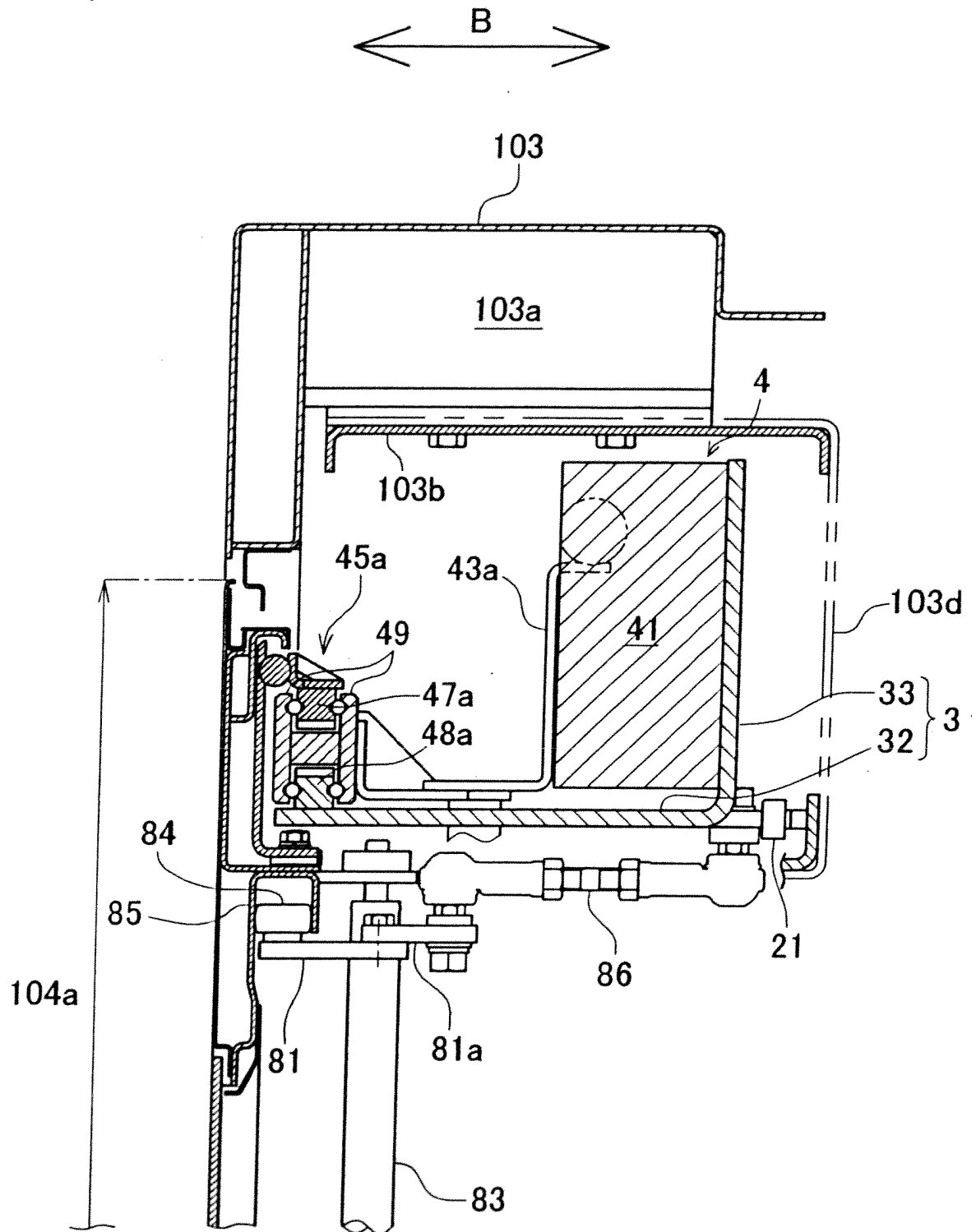


FIG. 4



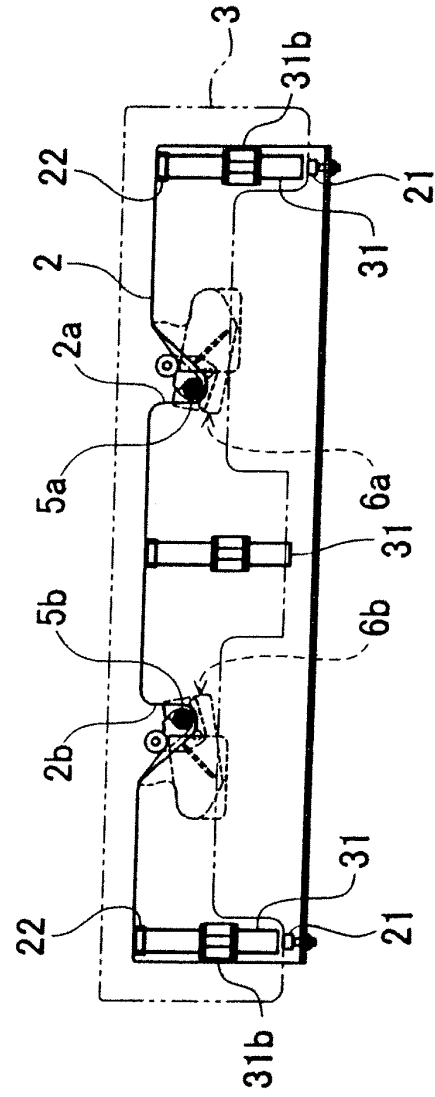
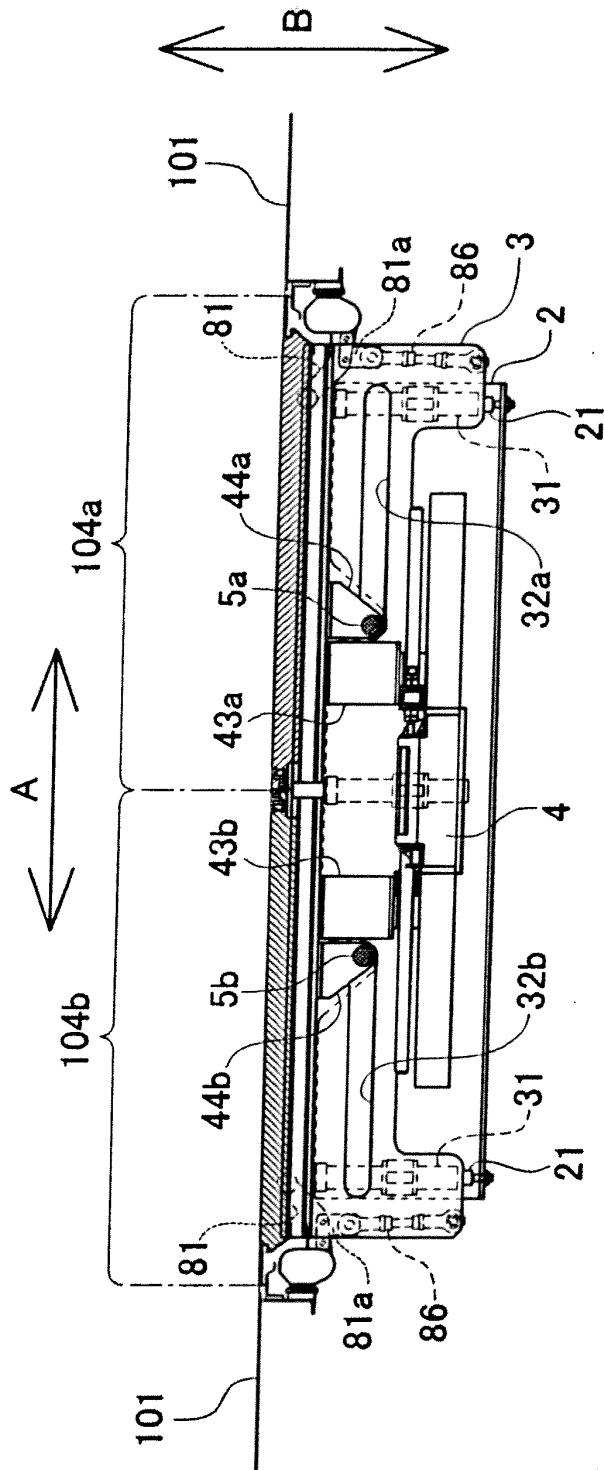


FIG. 6 (a)

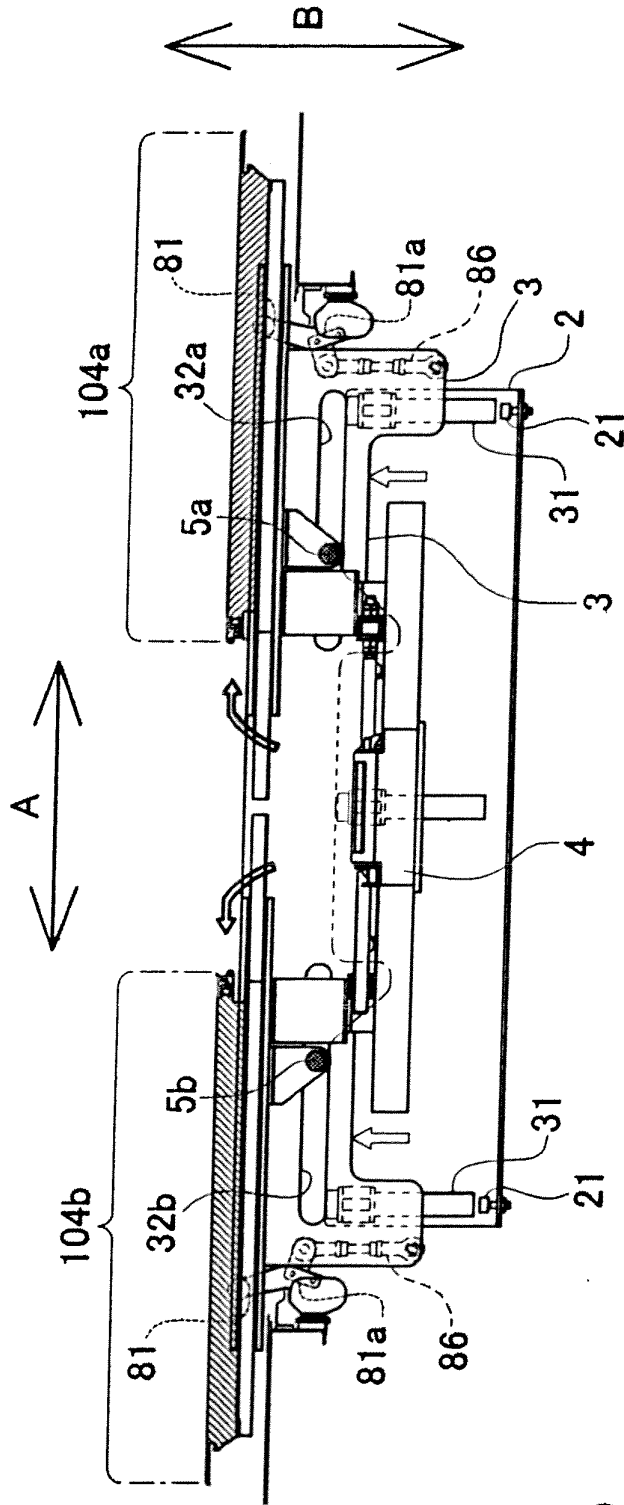


FIG. 6 (b)

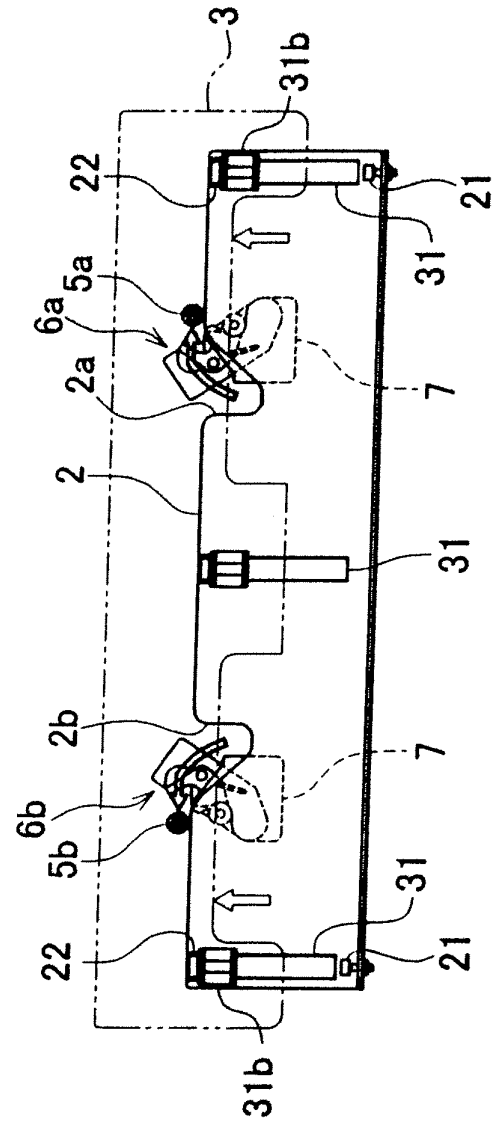


FIG. 7 (a)

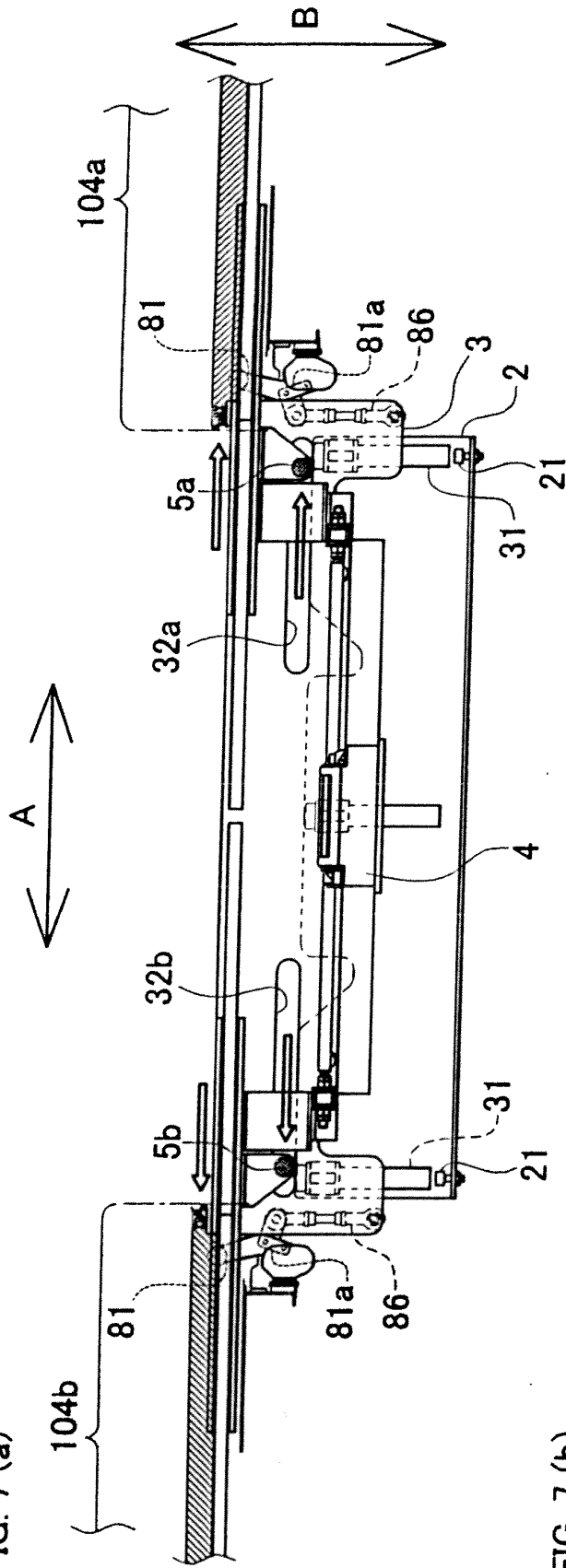


FIG. 7 (b)

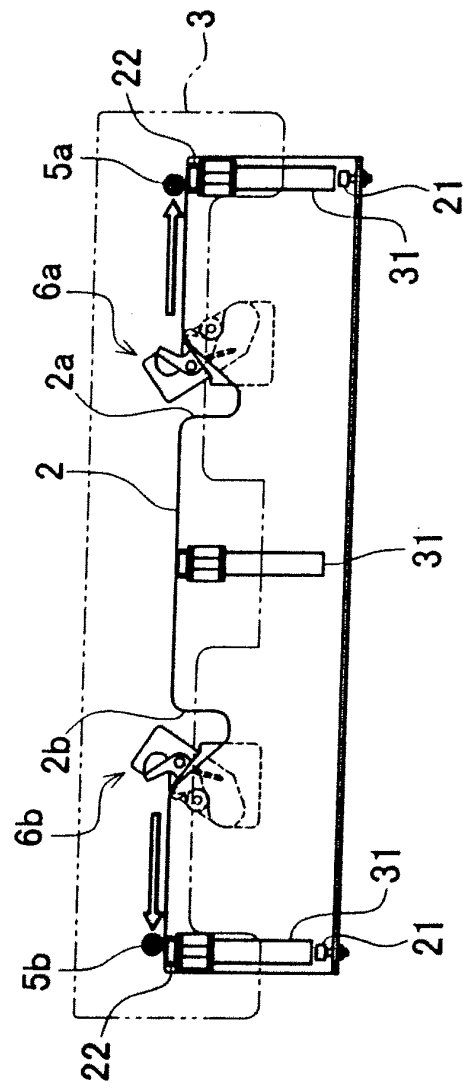


FIG. 8 (a)

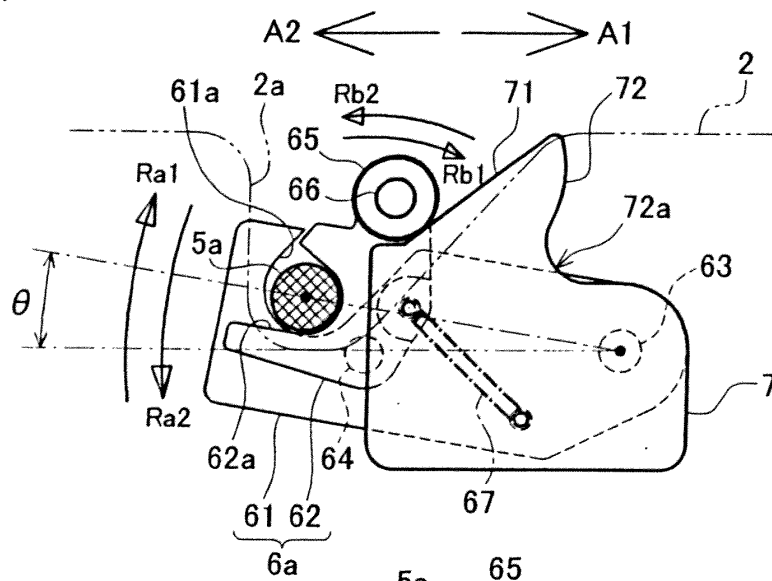


FIG. 8 (b)

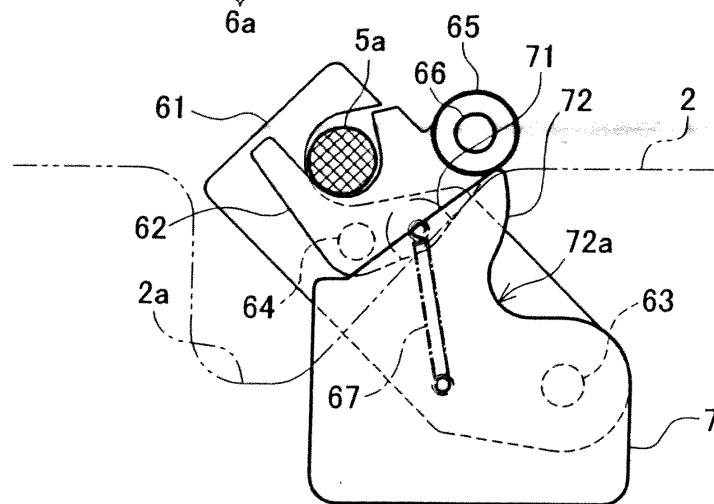


FIG. 8 (c)

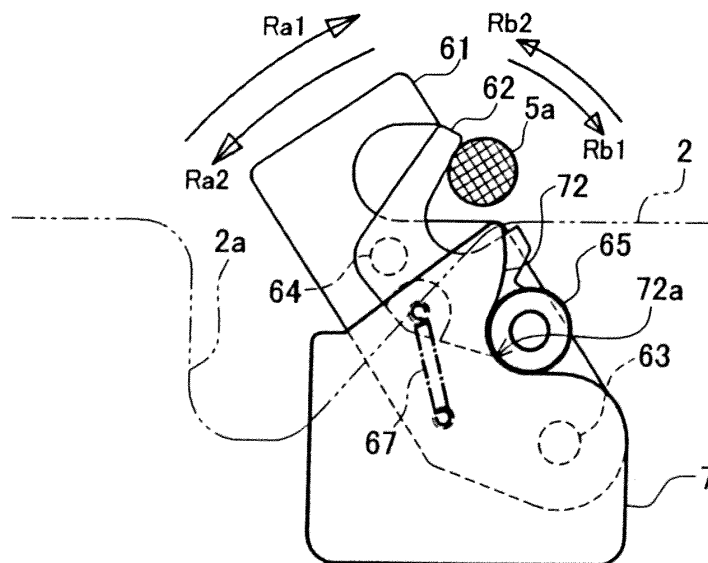


FIG. 9

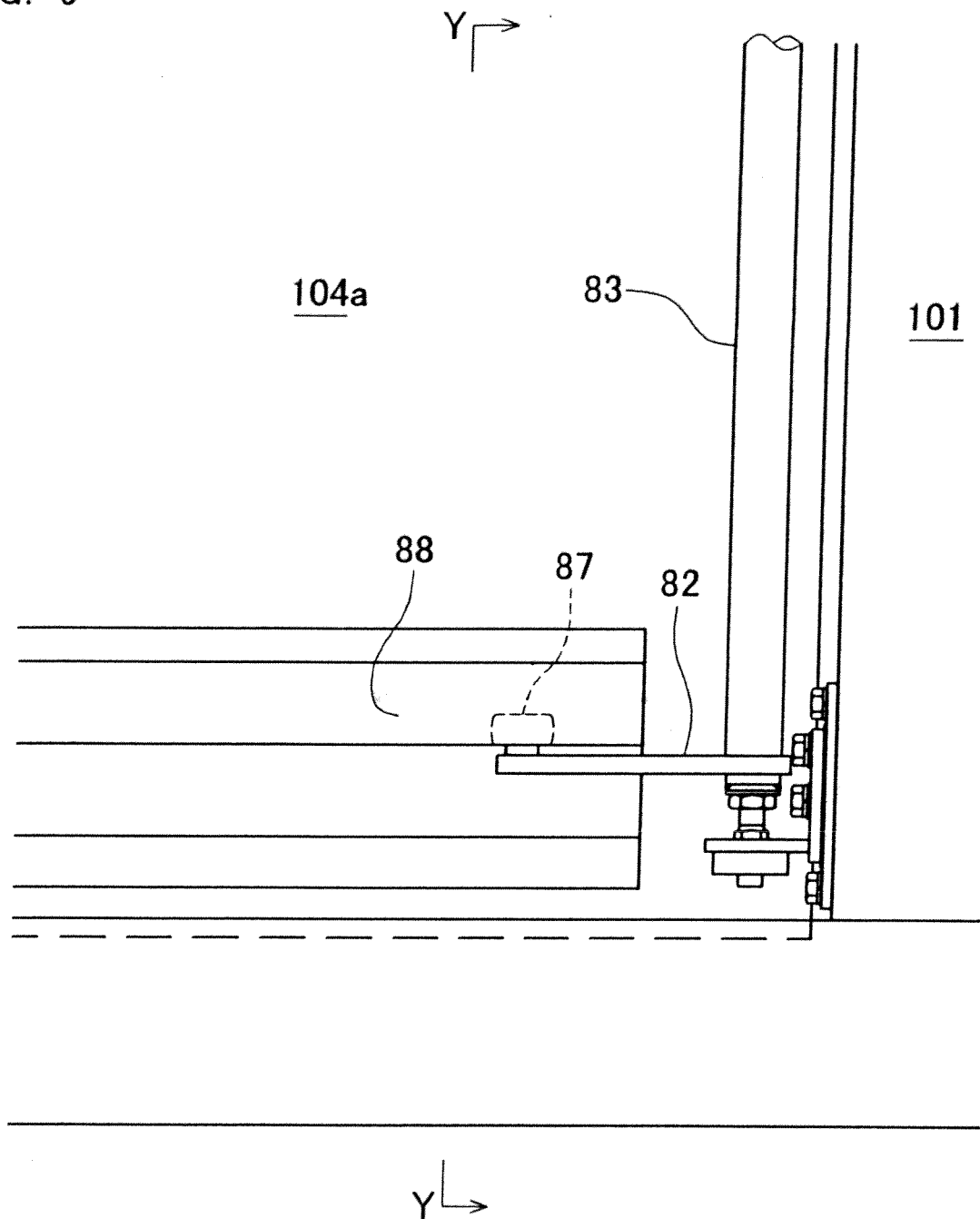


FIG. 10

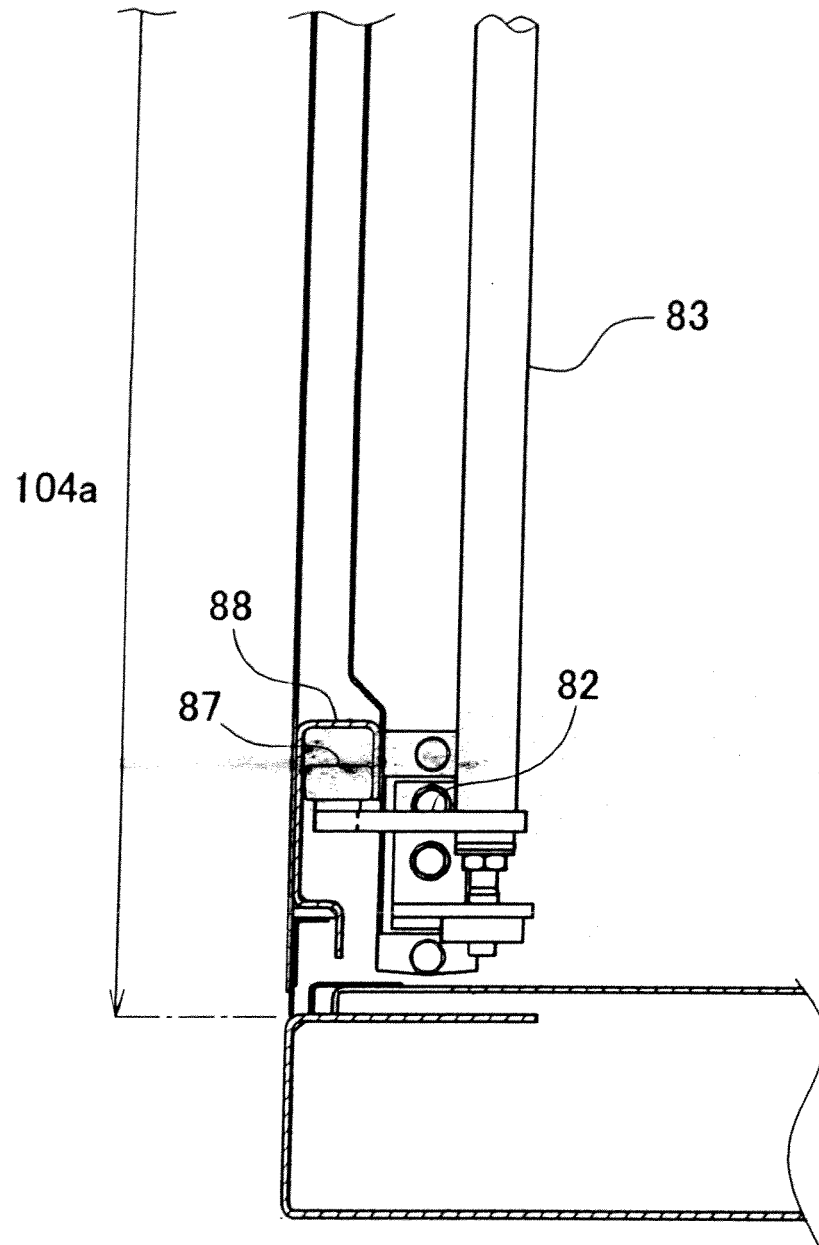
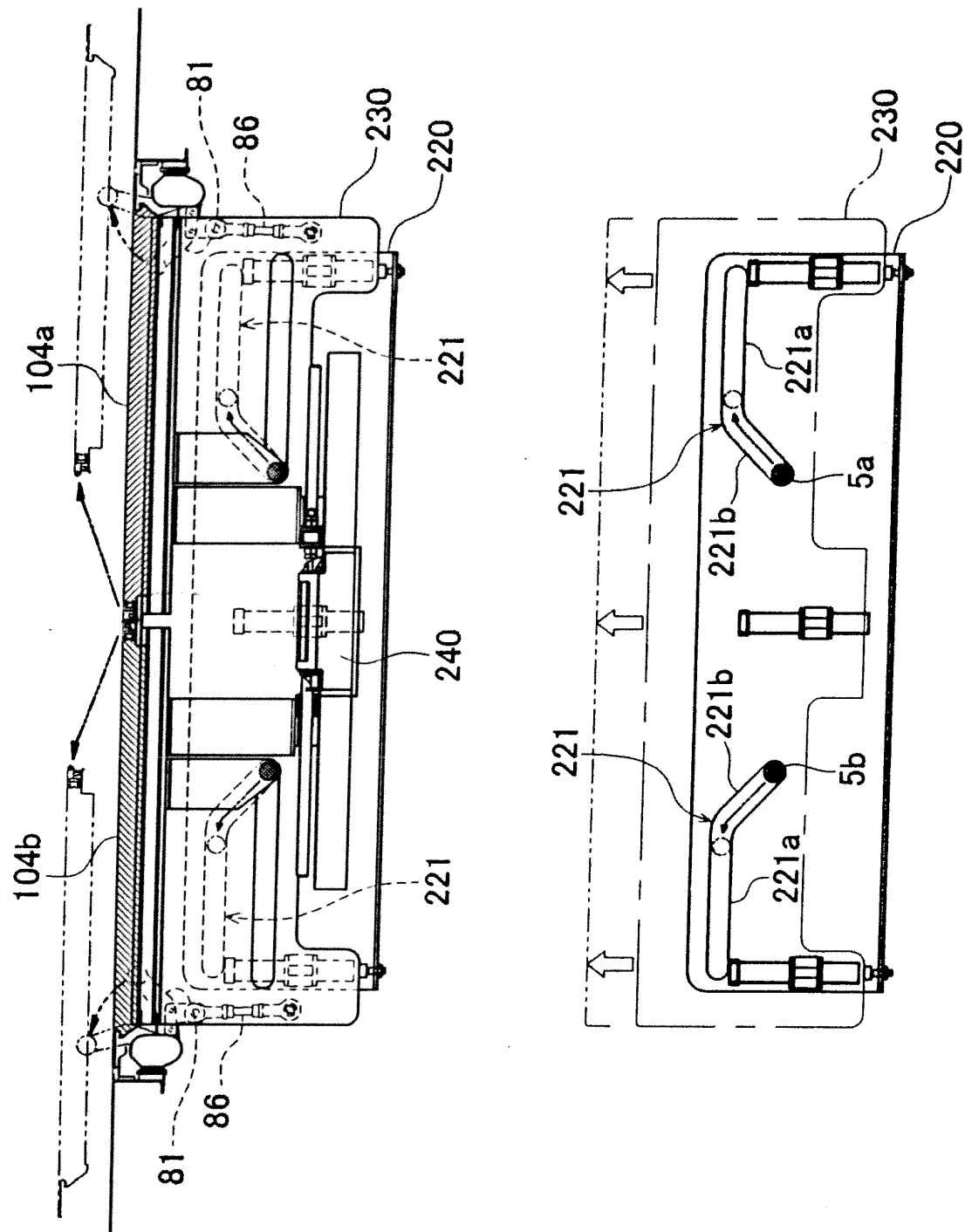


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/066616

A. CLASSIFICATION OF SUBJECT MATTER

E05D15/10(2006.01)i, B61D19/02(2006.01)i, E05F11/53(2006.01)i, E05F15/14(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E05D15/10, B61D19/02, E05F11/53, E05F15/14

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2005-61065 A (Nabtesco Corp.), 10 March 2005 (10.03.2005), paragraphs [0028] to [0103]; all drawings & HK 1071412 A & CN 1580476 A	1-10
A	JP 2008-121244 A (Nabtesco Corp.), 29 May 2008 (29.05.2008), paragraphs [0024] to [0079]; all drawings & EP 2079894 A & WO 2008/056620 A1	1-10
A	JP 2006-316524 A (Nabtesco Corp.), 24 November 2006 (24.11.2006), paragraphs [0020] to [0061]; all drawings & EP 1721802 A1 & KR 10-2006-0117268 A & CN 1861970 A	1-10

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

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Date of the actual completion of the international search
16 October, 2009 (16.10.09)Date of mailing of the international search report
27 October, 2009 (27.10.09)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/066616

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-190199 A (Mitsuba Corp.), 21 August 2008 (21.08.2008), paragraphs [0019] to [0060]; all drawings (Family: none)	1-10

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005061065 A [0003]
- JP 2006316524 A [0003]
- JP 2008121244 A [0003]