



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.05.2022 Bulletin 2022/21

(51) International Patent Classification (IPC):
E05D 15/10^(2006.01) E05F 15/646^(2015.01)

(21) Application number: **21201204.1**

(52) Cooperative Patent Classification (CPC):
E05F 15/646; E05D 15/1044; E05D 2015/1055; E05Y 2201/22; E05Y 2201/404; E05Y 2201/62; E05Y 2201/626; E05Y 2201/64; E05Y 2201/684; E05Y 2201/686; E05Y 2800/266; E05Y 2900/51

(22) Date of filing: **06.10.2021**

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

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(30) Priority: **13.11.2020 JP 2020189535**
26.03.2021 JP 2021053515

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(54) **PLUG DOOR DEVICE**

(57) A plug door device (1) relating to an embodiment includes a stationary base (3), a slidable base (4) slidable in a width direction relative to the stationary base (3) when acted upon by a driving force from a drive source (6), and a movement alignment mechanism (100, 200, 300) for controlling the front and rear ends of the slidable base (4) in a front-rear direction to move in the width direction toward the same side and by the same amount. The movement alignment mechanism (100, 200, 300) includes two stationary shaft members (101, 251, 301), two rotatable members (102, 202, 302), and a shaft (103, 203, 303). The stationary shaft members (101, 251, 301) are spaced away from each other in the front-rear direction and extend in a height direction. The rotatable mem-

bers (102, 202, 302) each include a contact arm (111, 211, 311) in contact with the slidable base (4) and a transmission arm (113, 213, 313) having a transmission shaft member (112, 212, 312) spaced away from a corresponding one of the stationary shaft members (101, 251, 301). The contact arm (111, 211, 311) and the transmission arm (113, 213, 313) are rotatable integrally with the corresponding stationary shaft member (101, 251, 301) around the corresponding stationary shaft member (101, 251, 301). The front and rear ends of the shaft (103, 203, 303) are connected to the transmission shaft members (112, 212, 312) of the two rotatable members (102, 202, 302).

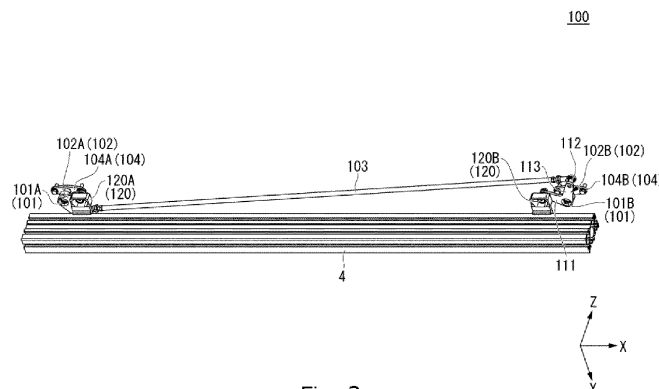


Fig. 2

Description**TECHNICAL FIELD**

[0001] The present invention relates to a plug door device.

BACKGROUND

[0002] In the conventional art, plug door devices are known for actuating a door in a plugging manner. Here, "to actuate a door in a plugging manner" means moving the door in the front-rear direction of a railway vehicle while moving the door in the width direction of the railway vehicle. For example, Patent Literature 1 discloses a plug door device including an upper guide rail provided above a doorway of a vehicle body, a lower guide rail provided below the doorway, and a door engine for driving an upper portion of a door. The upper guide rail is configured to guide the upper portion of the door. The lower guide rail is configured to guide the lower portion of the door. The door engine is coupled to the upper portion of the door. In the case of such a plug door device, the door engine moves only the upper portion of the door, and the lower portion of the door follows the moving upper portion of the door. The plug door device moves the door along the inner or outer surface of the vehicle body in the above manner. A known alternative plug door device, on the other hand, includes a stationary base fixedly attached to a vehicle body and a slidable base slidable in the width direction of the vehicle relative to the stationary base when acted upon by a driving force from one or more drive sources. A door is attached to the slidable base. In the case of the plug door device of this type, the slidable base exerts a force against the driving force from the drive sources (for example, a motor reaction force). Accordingly, there may be a discrepancy, in terms of the direction and amount of the movement in the width direction, between the respective ends of the slidable base in the front-rear direction of the vehicle (between the front and rear ends of the slidable base), depending on the number and location of the drive sources installed. Here, to align the amount of the movement in the width direction of one of the front and rear ends of the slidable base with the amount of the movement in the width direction of the other end, a cooperation shaft extending in the front-rear direction and a coupling mechanism including a link are provided. The coupling mechanism couples together the cooperation shaft and the front and rear ends of the slidable base.

RELEVANT REFERENCES**LIST OF RELEVANT PATENT LITERATURE**

[0003] Patent Literature 1: Japanese Patent Application Publication No. 2004-168089

SUMMARY

[0004] When the link rotates around the cooperation shaft extending in the front-rear direction, however, a sufficient space is required in the height direction to allow the link to rotate. The conventional plug door devices can be further improved. More specifically, they can be reduced in size in the height direction.

[0005] The present invention is intended to overcome the above problem, and one object thereof is to provide a plug door device that can achieve a reduced size in the height direction.

[0006] To solve the above problems, aspects of the present invention are configured as follows.

(1) A plug door device relating to an aspect of the present invention includes a stationary base fixedly attached to a body of a vehicle, a slidable base having a door of the vehicle attached thereto, where the slidable base is slidable in a width direction of the vehicle relative to the stationary base when acted upon by a driving force from a drive source, and a movement alignment mechanism for controlling front and rear ends of the slidable base in a front-rear direction of the vehicle to move in the width direction of the vehicle toward the same side and by the same amount. The movement alignment mechanism includes two stationary shaft members provided on one of the body and the slidable base, where the stationary shaft members are spaced away from each other in the front-rear direction of the vehicle and the stationary shaft members extend in a height direction of the vehicle, two rotatable members each including a contact arm in contact with the other of the body and the slidable base and a transmission arm including a transmission shaft member spaced away from a corresponding one of the stationary shaft members, where the contact arm and the transmission arm are rotatable integrally with the corresponding stationary shaft member around the corresponding stationary shaft member, and a shaft having a first end connected to the transmission shaft member of one of the rotatable members and a second end connected to the transmission shaft member of the other of the rotatable members, where the shaft extends in the front-rear direction of the vehicle. Here, the terms "same" and "alignment" mean that quantities or qualities are perfectly the same and also allows a difference as long as the difference does not adversely affect the movement in the width direction of the vehicle.

[0007] With the above-described design, as the slidable base moves in the width direction, the rotatable members rotate around the stationary shaft members extending in the height direction, so that no space is required in the height direction to allow the rotatable members to rotate. As a result, the plug door device can achieve a

reduced size in the height direction. The front and rear ends of the shaft are connected to the transmission shaft members of the two rotatable members. With such a design, when compared with a case where the middle portion of the shaft is connected to the transmission shaft members, the shaft can be favorably arranged between the transmission shaft members of the two rotatable members and, at the same time, the shaft can be permitted to move within a wide range.

[0008] (2) In the plug door device of (1), the two stationary shaft members may be fixedly attached to the body via the stationary base, and wherein the contact arms of the rotatable members may be in contact with the slidable base.

[0009] (3) In the plug door device of (2), the slidable base may be provided with guide members for guiding the contact arms as the contact arms move in the front-rear direction of the vehicle.

[0010] (4) In the plug door device of (3), the guide members may each have a rail extending along the front-rear direction of the vehicle, and the contact arms may each include a roller rollable along the rail.

[0011] (5) In the plug door device of any one of (1) to (4), the contact arm and the transmission arm of each rotatable member may extend orthogonally to each other when seen in the height direction of the vehicle.

[0012] (6) A plug door device relating to an aspect of the present invention includes a stationary base fixedly attached to a body of a vehicle, a slidable base having a door of the vehicle attached thereto, where the slidable base is slidable in a width direction of the vehicle relative to the stationary base when acted upon by a driving force from a drive source, and a movement alignment mechanism for controlling front and rear ends of the slidable base in a front-rear direction of the vehicle to move in the width direction of the vehicle toward the same side and by the same amount. The movement alignment mechanism includes two stationary shaft members provided on the stationary base, where the stationary shaft members are spaced away from each other in the front-rear direction of the vehicle and the stationary shaft members extend in a height direction of the vehicle, two rotatable members each including a contact arm in contact with the slidable base and a transmission arm including a transmission shaft member spaced away from a corresponding one of the stationary shaft members, where the contact arm and the transmission arm are rotatable integrally with the corresponding stationary shaft member around the corresponding stationary shaft member, and a shaft having a first end connected to the transmission shaft member of one of the rotatable members and a second end connected to the transmission shaft member of the other of the rotatable members, where the shaft extends in the front-rear direction of the vehicle. The slidable base is provided with guide members for guiding the contact arms of the rotatable members as the contact arms move in the front-rear direction of the vehicle, the guide members each have a rail extending along the

front-rear direction of the vehicle, and the contact arms each include a roller rollable along the rail, and the contact arm and the transmission arm of each rotatable member extend orthogonally to each other when seen in the height direction of the vehicle.

[0013] With the above-described design, as the slidable base moves in the width direction, the rotatable members rotate around the stationary shaft members extending in the height direction, so that no space is required in the height direction to allow the rotatable members to rotate. As a result, the plug door device can achieve a reduced size in the height direction. In addition, since the two stationary shaft members are fixedly attached to the stationary base, the two stationary shaft members can be fixedly attached to the vehicle body at a predetermined position via the stationary base. Furthermore, the slidable base is provided with the guide members for guiding the contact arms as the contact arms move in the front-rear direction, so that the guide members can guide the contact arms as the contact arms move in the front-rear direction. In this manner, the movement of the slidable base in the width direction can be converted into the rotation of the rotatable members. In addition, the guide members each have the rail extending in the front-rear direction, and the contact arms each include the roller rollable along the rail. With such a design, the rollers can reduce the friction between the contact arms and the rails. As a result, the movement of the slidable base in the width direction can be smoothly converted into the rotation of the rotatable members. Furthermore, the shaft is connected at the front and rear ends thereof to the transmission shaft members of the two rotatable members. With such a design, when compared with a case where the middle portion of the shaft is connected, the shaft can be favorably arranged between the transmission shaft members of the two rotatable members and, at the same time, the shaft can be permitted to move within a wide range. In addition, when seen in the height direction, the contact arm and the transmission arm extend orthogonally to each other. Accordingly, when seen in the height direction, the distance between the axis of the transmission shaft member and an imaginary straight line, which runs through the center of the contact portion of the contact arm and the axis of the stationary shaft member when seen in the height direction, is maximized. With such a design, the movement alignment mechanism can maximize the amount of the movement of the front and rear ends of the slidable base, while making the amounts of the movement the same between the front and rear ends of the slidable base.

[0014] (7) A plug door device relating to an aspect of the present invention includes a stationary base fixedly attached to a body of a vehicle, a slidable base having a door of the vehicle attached thereto, where the slidable base is slidable in a width direction of the vehicle relative to the stationary base when acted upon by a driving force from a drive source, and a movement alignment mechanism for controlling front and rear ends of the slidable

base in a front-rear direction of the vehicle to move in the width direction of the vehicle toward the same side and by the same amount. The movement alignment mechanism uses rotational power acting within a plane orthogonal to a height direction of the vehicle.

[0015] With the above-described design, the movement alignment mechanism uses the rotational power acting within the plane orthogonal to the height direction, so that no space is required in the height direction to use the rotational power. As a result, the plug door device can achieve a reduced size in the height direction.

[0016] (8) The plug door device of any one of (1) to (6) may include a swingable arm mechanism for guiding the door as the door moves, where the door is movable in the width direction and the front-rear direction of the vehicle via the slidable base. The swingable arm mechanism may include two pillars provided on the body of the vehicle, where the pillars are spaced away from each other in the front-rear direction of the vehicle and the pillars extend in a height direction of the vehicle, two upper arms supporting an upper portion of the door, where the upper arms are rotatable integrally with the pillars around the pillars, and two lower arms supporting a lower portion of the door, where the lower arms are rotatable integrally with the pillars around the pillars. The movement alignment mechanism may include the pillars serving as the stationary shaft members, the rotatable members including the upper arms, and the shaft having the first end connected to one of the pillars and the second end connected to the other of the pillars, where the shaft extends in the front-rear direction of the vehicle.

[0017] (9) The plug door device of (7) may include a swingable arm mechanism for guiding the door as the door moves, where the door is movable in the width direction and the front-rear direction of the vehicle via the slidable base. The swingable arm mechanism may include two pillars provided on the body, where the pillars are spaced away from each other in the front-rear direction of the vehicle and the pillars extend in a height direction of the vehicle, two upper arms supporting an upper portion of the door, where the upper arms are rotatable integrally with the pillars around the pillars, and two lower arms supporting a lower portion of the door, where the lower arms are rotatable integrally with the pillars around the pillars. The movement alignment mechanism may include the two pillars configured to apply the rotational power acting within the plane, two pillar-side bevel gears rotatable integrally with the pillars around the pillars, two link-side bevel gears engaged respectively with the two pillar-side bevel gears, and a link shaft member having a first end connected to one of the link-side bevel gears and a second end connected to the other of the link-side bevel gears, where the link shaft member extends in the front-rear direction of the vehicle.

[0018] (10) The plug door device of (7) may include a swingable arm mechanism for guiding the door as the door moves, where the door is movable in the width direction and the front-rear direction of the vehicle via the

slidable base. The swingable arm mechanism may include two pillars provided on the body, where the pillars are spaced away from each other in the front-rear direction of the vehicle and the pillars extend in a height direction of the vehicle, two upper arms supporting an upper portion of the door, where the upper arms are rotatable integrally with the pillars around the pillars, and two lower arms supporting a lower portion of the door, where the lower arms are rotatable integrally with the pillars around the pillars. The movement alignment mechanism may include the two pillars configured to apply the rotational power acting within the plane, two pillar-side gears rotatable integrally with the pillars around the pillars, an intermediate gear engaged with one of the pillar-side gears, and a toothed belt engaged with the other of the two pillar-side gears and the intermediate gear.

ADVANTAGEOUS EFFECTS

[0019] The present invention can provide a plug door device capable of achieving a reduced size in the height direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Fig. 1 is a perspective view showing a plug door device relating to a first embodiment.

Fig. 2 is a perspective view showing a movement alignment mechanism of the first embodiment and surrounding parts.

Fig. 3 is a perspective view showing one of the front and rear ends of the movement alignment mechanism of the first embodiment in a front-rear direction and surrounding parts.

Fig. 4 is a perspective view showing the other of the front and rear ends of the movement alignment mechanism of the first embodiment and surrounding parts.

Fig. 5 is a plan view showing one of the front and rear ends of the movement alignment mechanism of the first embodiment and surrounding parts.

Fig. 6 is a plan view showing the other of the front and rear ends of the movement alignment mechanism of the first embodiment and surrounding parts.

Fig. 7 illustrates how the movement alignment mechanism of the first embodiment works.

Fig. 8 illustrates the advantageous effects of the movement alignment mechanism of the first embodiment.

Fig. 9 shows a comparative example.

Fig. 10 is a bottom view showing a plug door device relating to a second embodiment.

Fig. 11 is a front view showing a swingable arm mechanism of the second embodiment and surrounding parts.

Fig. 12 is a perspective view showing the upper por-

tion of the swingable arm mechanism of the second embodiment and surrounding parts.

Fig. 13 is a perspective view showing the lower portion of the swingable arm mechanism of the second embodiment and surrounding parts.

Fig. 14 is a perspective view showing one of the portions of the swingable arm mechanism of the second embodiment in a front-rear direction.

Fig. 15 is a bottom view showing one of the front and rear ends of a movement alignment mechanism of the second embodiment and surrounding parts.

Fig. 16 is a bottom view showing the other of the front and rear ends of the movement alignment mechanism of the second embodiment and surrounding parts.

Fig. 17 illustrates how the movement alignment mechanism of the second embodiment works.

Fig. 18 is a bottom view showing a shaft constituting a movement alignment mechanism of a third embodiment and surrounding parts.

Fig. 19 is a front view showing the shaft of the third embodiment and surrounding parts.

Fig. 20 schematically illustrates a movement alignment mechanism of a fourth embodiment.

Fig. 21 schematically illustrates a movement alignment mechanism of a fifth embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Embodiments of the present disclosure will now be described with reference to the attached drawings. The following embodiments are described with reference to an example plug door device including a double leaf sliding door to open or close the doorway of a railway vehicle (vehicle). In the following description, terms such as "parallel," "orthogonal," "center" and "coaxial" describe relative or absolute positions. These terms are not only strictly used but also allow some tolerances and relative differences in angle and distance as long as the same effects can be still produced. In the drawings used for the following description, members are shown to different scales into recognizable sizes.

<First Embodiment>

[0022] Fig. 1 is a perspective view showing a plug door device relating to a first embodiment. Fig. 2 is a perspective view showing a movement alignment mechanism of the first embodiment and surrounding parts. As shown in Fig. 1, a plug door device 1 includes a pair of doors 2, a stationary base 3, a slidable base 4, a drive source 6 and a movement alignment mechanism 100. In Fig. 1, the doors 2 are indicated by the two-dot chain line. Figs. 1 and 2 show the movement alignment mechanism 100 with the doors 2 being fully closed.

[0023] In the following description, an XYZ orthogonal coordinate system is used as required. The X direction

coincides with the front-rear direction of the vehicle. The Y direction coincides with the width direction of the vehicle. The Z direction is orthogonal to the X and Y directions and indicates the height direction (gravitational direction) of the vehicle. The following description is made with the arrows shown in the drawings indicating the X, Y and Z directions and the head side and the tail side respectively indicating the positive (+) side and the negative (-) side. The outside and the inside in the width direction are respectively denoted as the +Y side and the -Y side. The upper side and the lower side in the gravitational direction are respectively denoted as the +Z side and the -Z side.

[0024] The plug door device 1 supports the doors 2 such that the external surface of the doors 2 are flush with the external surface of the side wall of the vehicle body when the doors 2 are fully closed. The doors 2 each include a door leaf 10 and a door hunger 11 coupled to the door leaf 10. The doors 2 are attached to the slidable base 4. The door hungers 11 are supported by the slidable base 4 such that the door hungers 11 are movable in the front-rear direction (X direction) relative to the slidable base 4. The plug door device 1 of the first embodiment has no swingable arm mechanism for guiding the doors 2 as the doors 2 move in the width direction (Y direction) and the front-rear direction.

[0025] The stationary base 3 is fixedly attached to the body of the vehicle. The body forms the framework of the vehicle. The stationary base 3 is positioned above a doorway 15 of the vehicle. The stationary base 3 extends in the front-rear direction crossing over the upper edge of the doorway 15. Rail bases 9 extending in the width direction are coupled to the front and rear ends of the stationary base 3.

[0026] The slidable base 4 is slidable in the width direction relative to the stationary base 3 with the driving force from the drive source 6, thereby moving the doors 2 in the width direction. The slidable base 4 is positioned below the stationary base 3. The slidable base 4 extends in the front-rear direction along the upper edge of the doorway 15. The front and rear ends of the slidable base 4 are movable in the width direction along the rail bases 9.

[0027] The drive source 6 is configured to output the driving force to move the doors 2. For example, the drive source 6 is a motor. The output shaft of the motor rotates around an axis extending along the front-rear direction. For example, the output shaft of the motor is rotatable in two opposite directions (in positive and negative directions) around the axis extending along the front-rear direction. The drive source 6 is connected to a movable power source cable 29 or, a cableveyor (registered trademark). The drive source 6 is supported by the slidable base 4 via a power transmission mechanism 30. The drive source 6 is movable in the width direction as the slidable base 4 moves in the width direction.

[0028] The power transmission mechanism 30 includes a power conversion mechanism 31 for changing the direction of the driving force from the drive source 6 and an endless belt 32 extending along the front-rear

direction. The power conversion mechanism 31 converts the rotation of the output shaft of the motor around the axis extending along the front-rear direction into rotation around an axis extending along the width direction. The power conversion mechanism 31 includes a gear 33 rotatable around the axis extending along the width direction. A pulley 34 is provided at a position away in the front-rear direction from the gear 33. The pulley 34 is rotatable around an axis parallel to the rotational axis of the gear 33 (extending along the width direction).

[0029] The belt 32 bridges the gear 33 and the pulley 34. The belt 32 is movable cooperatively as the gear 33 rotates and moves (circulates) around the gear 33 and the pulley 34. The belt 32 is connected to the door hangers 11. The door hangers 11 move in the front-rear direction as the belt 32 moves.

[0030] A coupling member 35 is attached to the belt 32. The coupling member 35 moves as the belt 32 moves. The coupling member 35 supports a roller (not shown). The roller rolls along the opening/closing path (not shown) of the doors 2 while being guided along a guide rail (not shown), when the doors 2 open or close. In Fig. 1, the reference number 7 indicates a restraining member for restraining the roller when the doors 2 are fully closed. The reference number 8 indicates a lock mechanism for holding the restraining member 7 at the position where the restraining member 7 restrains the roller. The following describes, as an example, how a door is actuated in a plugging manner, or how the door is moved in the front-rear direction of a vehicle while moving the door in the width direction of the vehicle.

[0031] From among the doors 2, the door 2 on the -X side is connected, via the door hunger 11, to the upper portion of the belt 32 together with the coupling member 35. The door 2 on the +X side is connected, via the door hunger 11, to the lower portion of the belt 32. The belt 32 bridges the gear 33 and the pulley 34, which are spaced away from each other in the front-rear direction. The upper and lower portions of the belt 32 move oppositely in the front-rear direction. Accordingly, as the belt 32 moves, the -X-side door 2 and the coupling member 35 move oppositely to the +X-side door 2 in the front-rear direction.

[0032] The doors 2 move from the fully closed position shown in Fig. 1 (where the external surface of the vehicle body side wall is flush with the external surface of the doors 2) to the fully open position, as the driving force from the drive source 6 is transmitted to the belt 32, which is connected to the door hangers 11 and the coupling member 35, and the door hangers 11 and the coupling member 35 then move. At the fully open position, the doors 2 open (fully open) the doorway 15 and are positioned outside the vehicle. According to the example shown in Fig. 1, the -X-side door 2 first moves from the fully closed position outward in the width direction (specifically, obliquely relative to the width direction) and then moves linearly toward the -X side, to reach the fully open position. On the other hand, the +X-side door 2 first

moves from the fully closed position outward in the width direction (specifically, obliquely relative to the width direction) and then moves linearly toward the +X side, to reach the fully open position.

[0033] Although not shown, the opening/closing path provided by the guide rail is divided into a linear portion extending along the front-rear direction and an inclined portion inclined relative to the linear portion. When the doors close from the fully open position, the roller first moves linearly along the linear portion and then moves inwardly in the width direction (specifically, obliquely relative to the width direction) along the inclined portion. Here, the roller is supported on the slidable base 4 via the coupling member 35, the belt 32 and the like. With such a design, as the roller moves along the inclined portion, the slidable base 4 moves in the width direction. The slidable base 4 supports the door leaves 10 via the door hangers 11 and the like. With such a design, as the slidable base 4 moves in the width direction, the door leaves 10 move in the width direction.

[0034] In the above description, the doors are driven using the power transmission mechanism 30 including the belt 32, or using the belt system. The present invention, however, is not limited to such. As an alternative example, the doors may be driven using the screw system. Specifically, a motor rotates a screw shaft corresponding to a bolt, so that the doors attached to a ball nut corresponding to a nut are opened or closed. As an yet another alternative example, the doors may be driven using the rack and pinion system. Specifically, a motor rotates a pinion of a rack and pinion mechanism, so that the doors attached to a rack rail are opened or closed. For example, the door driving system may depend on required specifications.

[0035] The movement alignment mechanism 100 controls the front and rear ends of the slidable base 4 to move in the width direction in the same direction and by the same amount. Here, "to move in the width direction in the same direction and by the same amount" means "to move in the width direction toward the same side by the same amount". As shown in Fig. 2, the movement alignment mechanism 100 includes two stationary shaft members 101 spaced away from each other in the front-rear direction and extending in the height direction (Z direction), two rotatable members 102 respectively rotatable around the stationary shaft members 101, a rod-shaped shaft 103.

[0036] The following description focuses on the description of one (the -X side) of the front and rear ends of the movement alignment mechanism 100 and the surrounding parts. The other (the +X side) of the front and rear ends of the movement alignment mechanism 100 and the surrounding parts are configured in the same manner as the -X side end and the surrounding parts except for the positions of the constituent elements and the direction of the movement (the direction of the rotation) and are thus not described in detail. Fig. 3 is a perspective view showing one (the -X side) of the front and

rear ends of the movement alignment mechanism 100 of the first embodiment and the surrounding parts. Fig. 4 is a perspective view showing the other (the +X side) of the front and rear ends of the movement alignment mechanism 100 of the first embodiment and the surrounding parts. Fig. 5 is a plan view showing one (the -X side) of the front and rear ends of the movement alignment mechanism 100 of the first embodiment and the surrounding parts. Fig. 6 is a plan view showing the other (the +X side) of the front and rear ends of the movement alignment mechanism 100 of the first embodiment and the surrounding parts. Figs. 3 to 6 show the movement alignment mechanism 100 with the doors 2 being fully closed. In the drawings, the symbol "A" is appended to the reference numerals of the constituent elements at one (the -X side) of the front and rear ends of the movement alignment mechanism 100, and the symbol "B" is appended to the reference numerals of the constituent elements at the other end (the +X side). The symbols "A" and "B", however, are omitted unless they are particularly distinguished.

[0037] As shown in Fig. 1, the stationary shaft members 101 are provided on the vehicle body via the stationary base 3. The stationary shaft members 101 are coupled to the stationary base 3 via fixture members 104 extending in the front-rear direction. Each of the fixture members 104 is attached to the stationary base 3 using a plurality of (for example, two, in the present embodiment) bolts 105 that are next to each other in the front-rear direction with a corresponding one of the stationary shaft members 101 being sandwiched therebetween.

[0038] As shown in Fig. 5, the rotatable members 102 are L-shaped as seen in the height direction. The rotatable members 102 each have an arm base portion 110, a contact arm 111, and a transmission arm 113. The arm base portion 110 is coaxially arranged with the stationary shaft member 101. The contact arm 111 is in contact with the slidable base 4. The transmission arm 113 including a transmission shaft member 112 spaced away from the stationary shaft member 101. For example, the arm base portion 110, the contact arm 111 and the transmission arm 113 may be formed as a single unit piece and made of the same material.

[0039] The arm base portion 110 is shaped like a tube extending in the height direction along the stationary shaft member 101. As shown in Fig. 3, the arm base portion 110 is positioned below the fixture member 104. The arm base portion 110 surrounds the stationary shaft member 101. For example, a bearing may be provided between the inner periphery of the arm base portion 110 and the stationary shaft member 101 for supporting the stationary shaft member 101 rotatably.

[0040] The contact arm 111 extends radially outward (outward in the direction orthogonal to the arm base portion 110) from the lower portion of the arm base portion 110. As shown in Fig. 5, the contact arm 111 is tapered radially outward from the arm base portion 110 as seen in the height direction.

[0041] The slidable base 4 is provided with guide members 120 for guiding the contact arms 111 as the contact arms 111 move in the front-rear direction. The guide members 120 are shaped like a rectangle long in the width direction as seen in the height direction. The +Y-side end of each guide member 120 is attached to the upper edge of the slidable base 4 using a plurality of (for example, two, in the present embodiment) bolts 121 arranged next to each other in the front-rear direction.

[0042] The -Y-side portion of the guide member 120 has an elongated hole 122 formed therein, which is open in the height direction and long in the front-rear direction. The elongated hole 122 is shaped like an oval when seen in the height direction. The guide member 120 has a rail 123 extending along the front-rear direction. The rail 123 is constituted by the pair of inner wall surfaces of the elongated hole 122 that face each other in the width direction. The inner wall surfaces extend in the front-rear direction and parallel to each other, when seen in the height direction. The length of the inner wall surfaces in the front-rear direction is greater than the outer diameter of a roller 115.

[0043] It is not limited to the elongated hole 122 that can be formed in the guide member 120. For example, a groove extending in the front-rear direction may be formed in the guide member 120. The shape of the elongated hole 122 as seen in the height direction is not limited to an oval. For example, the elongated hole 122 may be rectangularly shaped when seen in the height direction. For example, the hole, groove and the like formed in the guide member 120 can depend on required specifications.

[0044] The contact arm 111 includes a roller 115 rotatable along the rail 123. As shown in Fig. 3, the roller 115 is positioned below the contact arm 111. The roller 115 is coupled to the tip end of the contact arm 111 (the most distant portion from the arm base portion 110) such that the roller 115 is rotatable around an axis extending in the height direction. The roller 115 is shaped like a circle when seen in the height direction.

[0045] The transmission arm 113 extends radially outward from the lower portion of the arm base portion 110 but originates from a different portion than the contact arm 111 does. As shown in Fig. 5, the transmission arm 113 is tapered from the arm base portion 110 radially outward as seen in the height direction.

[0046] The contact arm 111 and the transmission arm 113 extend orthogonally to each other when seen in the height direction. For example, when seen in the height direction, the angle Aa formed between the contact arm 111 and the transmission arm 113 is approximately 90 degrees. Here, the angle Aa refers to the angle formed, when seen in the height direction, between (i) an imaginary straight line running through the axis of the stationary shaft member 101 and the rotational center of the roller 115 (the center of the tip end of the contact arm 111) and (ii) an imaginary straight line running through the axis of the stationary shaft member 101 and the axis

of the transmission shaft member 112.

[0047] The transmission shaft member 112 extends parallel to the stationary shaft member 101 (in the height direction). The lower end of the transmission shaft member 112 is coupled to the tip end of the transmission arm 113 (the most distant portion from the arm base portion 110) (see Fig. 4).

[0048] As shown in Fig. 2, the shaft 103 extends in the front-rear direction. A first one of the front and rear ends of the shaft 103 is connected to the transmission shaft member 112 of one of the two rotatable members 102 (see Figs. 5 and 6). A second one of the front and rear ends of the shaft 103 is connected to the transmission shaft member 112 of the other of the two rotatable members 102. The shaft 103 extends linearly to bridge the transmission shaft members 112 of the two rotatable members 102. The ends of the shaft 103 are rotatable around the transmission shaft members 112. For example, the shaft 103 may be provided with an adjuster member 116 (see Fig. 5) for adjusting the distance between the transmission shaft members 112 of the two rotatable members 102.

[0049] The shaft 103 is rigid enough to satisfactorily transmit the rotational force exerted by one of the two rotatable members 102 to the other rotatable member 102. For example, the shaft 103 can be a metal shaft member. For example, the shaft 103 is preferably a member that can be ideally deemed to be rigid. The shaft 103 may not be a member that is never deformed by a force of any level but a member that may experience some deformation when acted upon by a force of a predetermined level or more.

[0050] The stationary shaft members 101 of the two rotatable members 102 are aligned with each other in the front-rear direction when seen in the height direction (see Figs. 5 and 6). When the doors are fully closed, the rollers 115 of the two rotatable members 102 are positioned on the -Y side of the stationary shaft members 101 as seen in the height direction (see Figs. 5 and 6). When the doors are fully closed, the roller 115 of the rotatable member 102A is positioned on the +X side of the stationary shaft member 101 as seen in the height direction (see Fig. 5). On the other hand, the roller 115 of the rotatable member 102B is positioned on the -X side of the stationary shaft member 101 as seen in the height direction (see Fig. 6), when the doors are fully closed. When the doors are fully closed, the transmission shaft member 112 of the rotatable member 102A is positioned on the +Y side of the stationary shaft member 101 as seen in the height direction (see Fig. 5). On the other hand, the transmission shaft member 112 of the rotatable member 102B is positioned on the -Y side of the stationary shaft member 101 as seen in the height direction (see Fig. 6), when the doors are fully closed.

[0051] Fig. 7 illustrates how the movement alignment mechanism 100 of the first embodiment works. Fig. 7 is a top view of the movement alignment mechanism 100 of the first embodiment. Fig. 7 shows an example case

where the slidable base 4 moves outward in the width direction (toward the +Y side: in the plug-out direction) (move as indicated by the arrow Wd shown in Fig. 7) as the doors are opened from the fully closed state. For example, the case shown in Fig. 7 corresponds to a case where the doors move outward in the width direction from the fully closed position so that the doors are positioned outside the vehicle.

[0052] As shown in Fig. 7, as the slidable base 4 moves outward in the width direction, the rollers 115 of the two rotatable members 102 are pushed toward the +Y side by the -Y-side inner wall surfaces of the rails 123 of the guide members 120. Subsequently, the rotatable member 102A rotates anti-clockwise around the stationary shaft member 101A as seen from above (as indicated by the arrow Ra), and the rotatable member 102B rotates clockwise around the stationary shaft member 101B as seen from above (as indicated by the arrow Rb). This means that the rotatable members 102A and 102B rotate oppositely respectively around the stationary shaft members 101A and 101B.

[0053] The following more specifically describes how the movement alignment mechanism 100 works with reference to an example case where, as the slidable base 4 moves outward in the width direction, the roller 115 of the rotatable member 102A is first pushed toward the +Y side by the -Y-side inner wall surface of the rail 123 of the guide member 120A. In this case, the rotatable member 102A rotates anti-clockwise around the stationary shaft member 101A as seen from above (as indicated by the arrow Ra). This causes the transmission shaft member 112 of the rotatable member 102A to pull the shaft 103 toward the -X side. As a result, the shaft 103 pulls the transmission shaft member 112 of the rotatable member 102B toward the -X side. The rotatable member 102B then rotates clockwise around the stationary shaft member 101B as seen from above (as indicated by the arrow Rb). In other words, when the roller 115 of the rotatable member 102A is pushed toward the +Y side earlier than is the roller 115 of the rotatable member 102B, the rotatable members 102A and 102B rotate oppositely respectively around the stationary shaft members 101A and 101B.

[0054] The following more specifically describes how the movement alignment mechanism 100 works with reference to a different example case where, as the slidable base 4 moves outward in the width direction, the roller 115 of the rotatable member 102B is first pushed toward the +Y side by the -Y-side inner wall surface of the rail 123 of the guide member 120B. In this case, the rotatable member 102B rotates clockwise around the stationary shaft member 101B as seen from above (as indicated by the arrow Rb). This causes the transmission shaft member 112 of the rotatable member 102B to push the shaft 103 toward the -X side. As a result, the shaft 103 pushes the transmission shaft member 112 of the rotatable member 102A toward the -X side. Accordingly, the rotatable member 102A rotates anti-clockwise around the station-

ary shaft member 101A as seen from above (as indicated by the arrow Ra). In other words, when the roller 115 of the rotatable member 102B is pushed toward the +Y side earlier than is the roller 115 of the rotatable member 102A, the rotatable members 102A and 102B rotate oppositely respectively around the stationary shaft members 101A and 101B.

[0055] The following describes how the doors are actuated in a plugging manner in a direction opposite to the example shown in Fig. 7, or an example case where the slidable base 4 moves inward in the width direction (toward the -Y side: in the plug-in direction) (moves in the opposite direction to the direction indicated by the arrow Wd shown in Fig. 7) as the doors are closed from the fully open state.

[0056] As the slidable base 4 moves inward in the width direction, the rollers 115 of the two rotatable members 102 are pushed toward the -Y side by the +Y-side inner wall surfaces of the rails 123 of the guide members 120. Subsequently, the rotatable member 102A rotates clockwise around the stationary shaft member 101A as seen from above (in the opposite direction to the direction indicated by the arrow Ra in Fig. 7), and the rotatable member 102B rotates anti-clockwise around the stationary shaft member 101B as seen from above (in the opposite direction to the direction indicated by the arrow Rb in Fig. 7). This means that the rotatable members 102A and 102B rotate oppositely respectively around the stationary shaft members 101A and 101B.

[0057] The following more specifically describes how the movement alignment mechanism 100 works with reference to an example case where, as the slidable base 4 moves inward in the width direction, the roller 115 of the rotatable member 102A is first pushed toward the -Y side by the +Y-side inner wall surface of the rail 123 of the guide member 120A. In this case, the rotatable member 102A rotates clockwise around the stationary shaft member 101A as seen from above (in the direction opposite to the direction indicated by the arrow Ra in Fig. 7). This causes the transmission shaft member 112 of the rotatable member 102A to push the shaft 103 toward the +X side. As a result, the shaft 103 pushes the transmission shaft member 112 of the rotatable member 102B toward the +X side. The rotatable member 102B then rotates anti-clockwise around the stationary shaft member 101B as seen from above (in the direction opposite to the direction indicated by the arrow Rb in Fig. 7). In other words, when the roller 115 of the rotatable member 102A is pushed toward the -Y side earlier than is the roller 115 of the rotatable member 102B, the rotatable members 102A and 102B rotate oppositely respectively around the stationary shaft members 101A and 101B.

[0058] The following more specifically describes how the movement alignment mechanism 100 works with reference to a different example case where, as the slidable base 4 moves inward in the width direction, the roller 115 of the rotatable member 102B is first pushed toward the -Y side by the +Y-side inner wall surface of the rail 123

of the guide member 120B. In this case, the rotatable member 102B rotates anti-clockwise around the stationary shaft member 101B as seen from above (in the direction opposite to the direction indicated by the arrow Rb in Fig. 7). This causes the transmission shaft member 112 of the rotatable member 102B to pull the shaft 103 toward the +X side. As a result, the shaft 103 pulls the transmission shaft member 112 of the rotatable member 102A toward the +X side. In this case, the rotatable member 102A rotates clockwise around the stationary shaft member 101A as seen from above (in the direction opposite to the direction indicated by the arrow Ra in Fig. 7). In other words, when the roller 115 of the rotatable member 102B is pushed toward the -Y side earlier than is the roller 115 of the rotatable member 102A, the rotatable members 102A and 102B rotate oppositely respectively around the stationary shaft members 101A and 101B.

[0059] As described above, as the slidable base 4 moves in the width direction to actuate the doors in a plugging manner (in the plugging-out and plugging-in directions), the rotatable members 102A and 102B rotate oppositely respectively around the stationary shaft members 101A and 101B in the first embodiment.

[0060] Fig. 8 illustrates the advantageous effects of the movement alignment mechanism 100 of the first embodiment. Fig. 9 shows a comparative example. Figs. 8 and 9 show, as an example, how the slidable base 4 moves outward in the width direction (in the plug-out direction) as the doors are opened from the fully closed state. Fig. 9 also shows the movement alignment mechanism 100 of the first embodiment.

[0061] As shown in Fig. 9, if the -X-side end of the slidable base 4 moves in the plug-out direction with a delay Dy (a stroke delay) relative to the +X-side end, the slidable base 4 is inclined at an angle Ad indicated in Fig. 9. If the slidable base 4 is inclined relative to the front-rear direction while moving in the width direction to actuate the doors in a plugging manner, the slidable base 4 may stagnate in the rail bases 9 (see Fig. 1). Here, "to stagnate" means that a movable part such as a slidable part becomes unmovable and is prevented from smoothly moving.

[0062] To address this issue, the present embodiment is designed as described above. As the slidable base 4 moves in the width direction to actuate the doors in a plugging manner, the rotatable members 102A and 102B rotate oppositely respectively around the stationary shaft members 101A and 101B. With such a design, there is no discrepancy, in terms of the direction and amount of the movement in the width direction, between the front and rear ends of the slidable base 4, as shown in Fig. 8. The present embodiment can correct for the movement delay Md, which is shown in Fig. 9, thereby reducing the inclination angle Ad of the slidable base 4 to zero. As described above, the present embodiment can prevent the slidable base 4 from being inclined relative to the front-rear direction while moving in the width direction to

actuate the doors in a plugging manner, so that the slidable base 4 can avoid stagnating.

[0063] As described above, the plug door device 1 relating to the present embodiment includes the stationary base 3 fixedly attached to the vehicle body of the vehicle, the slidable base 4 having the doors 2 of the vehicle attached thereto, where the slidable base 4 is slidable in the width direction of the vehicle relative to the stationary base 3 by the driving force from the drive source 6, and the movement alignment mechanism 100 for controlling the front and rear ends of the slidable base 4 to move in the width direction toward the same side and by the same amount. The movement alignment mechanism 100 includes the two stationary shaft members 101, the two rotatable members 102, and the shaft 103. The stationary shaft members 101 are provided on the stationary base 3, spaced away from each other in the front-rear direction and extend in the height direction of the vehicle. The rotatable members 102 each include the contact arm 111 in contact with the slidable base 4 and the transmission arm 113 having the transmission shaft member 112 spaced away from the stationary shaft member 101. The contact arm 111 and the transmission arm 113 are integrally rotatable around the stationary shaft member 101. The front and rear ends of the shaft 103 are connected to the transmission shaft members 112 of the two rotatable members 102. The slidable base 4 is provided with the guide members 120 for guiding the contact arms 111 as the contact arms 111 move in the front-rear direction. The guide members 120 have the rails 123 extending along the front-rear direction. The contact arms 111 include the rollers 115 rollable along the rails 123. The contact arm 111 and the transmission arm 113 extend orthogonally to each other when seen in the height direction.

[0064] With the above-described arrangement, as the slidable base 4 moves in the width direction, the rotatable members 102 rotate around the stationary shaft members 101 extending in the height direction, so that no space is required in the height direction to allow the rotatable members 102 to rotate. Accordingly, the plug door device 1 can achieve a reduced size in the height direction. Since the two stationary shaft members 101 are fixedly attached to the stationary base 3, the two stationary shaft members 101 can be fixedly provided on the vehicle body at a predetermined position via the stationary base 3. The slidable base 4 is provided with the guide members 120 for guiding the contact arms 111 as the contact arms 111 move in the front-rear direction, so that the guide members 120 can guide the contact arms 111 as the contact arms 111 move in the front-rear direction. This can convert the movement of the slidable base 4 in the width direction into the rotation of the rotatable members 102. The guide members 120 each have the rail 123 extending in the front-rear direction, and the contact arms 111 each include the roller 115 rollable along the rail 123. With such a design, the roller 115 can reduce the friction between the contact arm 111 and the rail 123. This can

smoothly convert the movement of the slidable base 4 in the width direction into the rotation of the rotatable members 102. The front and rear ends of the shaft 103 are connected to the transmission shaft members 112 of the two rotatable members 102. With such a design, when compared with a case where the middle portion of the shaft 103 is connected to the transmission shaft members, the shaft 103 can be favorably arranged between the transmission shaft members 112 of the two rotatable members 102 and, at the same time, the shaft 103 can be permitted to move within a broad range. When seen in the height direction, the contact arm 111 and the transmission arm 113 extend orthogonally to each other. Accordingly, when seen in the height direction, the distance between the axis of the transmission shaft member 112 and an imaginary straight line, which runs through the center of the contact portion of the contact arm 111 and the axis of the stationary shaft member 101 when seen in the height direction, is maximized. With such a design, the present embodiment can maximize the amount of the movement of the front and rear ends of the slidable base 4, while making the amounts of the movement the same between the front and rear ends of the slidable base 4. As the slidable base 4 moves in the width direction, the rotatable members 102 rotate around the stationary shaft members 101 extending in the height direction. This rotation applies a tensile or compressive force to the shaft 103, so that the shaft 103 can avoid being twisted.

[0065] The technical scope of the present invention is not limited to the embodiments described above but is susceptible of various modification within the purport of the present invention.

[0066] In the above-described embodiment, the two stationary shaft members 101 are both fixedly attached to the stationary base 3, and the two rotatable members 102 respectively include the contact arms 111 in contact with the slidable base 4. The present embodiment, however, is not limited to such. As an alternative example, the two stationary shaft members 101 may be both fixedly attached to the slidable base 4, and the two rotatable members 102 may respectively include the contact arms 111 in contact with the stationary base 3. For example, the two stationary shaft members 101 and the two rotatable members 102 can be arranged in various manners as required.

[0067] In the above-described embodiment, the slidable base 4 is provided with the guide members 120 for guiding the contact arms 111 as the contact arms 111 move in the front-rear direction (see Fig. 3). The present embodiment, however, is not limited to such. As an alternative example, the slidable base 4 may be practiced without the guide members 120. As an alternative example, the contact arms 111 may be directly in contact with the slidable base 4.

[0068] In the above-described embodiment, the guide members 120 have the rails 123 extending in the front-rear direction, and the contact arms 111 respectively include the rollers 115 rollable along the rails 123 (see Fig.

5). The present embodiment, however, is not limited to such. As an alternative example, the contact arms 111 may be practiced without the rollers 115. As an alternative example, each contact arm 111 may include a pin fixedly attached to the tip end of the contact arm 111 such that the pin is not allowed to rotate. As an alternative example, the contact arm 111 can be configured in various manners as required.

[0069] In the above-described embodiment, the contact arm 111 and the transmission arm 113 extend orthogonally to each other when seen in the height direction (see Fig. 5). The present embodiment, however, is not limited to such. As an alternative example, the contact arm 111 and the transmission arm 113 may extend in directions intersecting each other obliquely when seen in the height direction. For example, when seen in the height direction, the angle Aa formed between the contact arm 111 and the transmission arm 113 may be from 10 degrees to 80 degrees, or from 100 degrees to 170 degrees. For example, when seen in the height direction, the angle Aa formed between the contact arm 111 and the transmission arm 113 may not exceed 180 degrees. As an alternative example, when seen in the height direction, the angle Aa formed between the contact arm 111 and the transmission arm 113 can be adjusted as to satisfy the required specifications as long as the movement alignment mechanism 100 can still produce the above-described advantageous effects.

[0070] In the above-described embodiment, the movement alignment mechanism 100 includes the two stationary shaft members 101, the two rotatable members 102, and the shaft 103. The stationary shaft members 101 are provided on the stationary base 3, spaced away from each other in the front-rear direction and extend in the height direction of the vehicle. The rotatable members 102 each include the contact arm 111 in contact with the slidable base 4 and the transmission arm 113 having the transmission shaft member 112 spaced away from the stationary shaft member 101. The contact arm 111 and the transmission arm 113 are integrally rotatable around the stationary shaft member 101. The shaft 103 bridges the transmission shaft members 112 of the two rotatable members 102, and the front and rear ends of the shaft 103 are connected to the transmission shaft members 112 of the two rotatable members 102. The present embodiment, however, is not limited to such. As an alternative example, the movement alignment mechanism may include two swingable arms spaced away from each other in the front-rear direction and a belt, a link, a gear and the like coupling together the swingable arms.

[0071] An example plug door device may include a stationary base fixedly attached to the body of a vehicle, a slidable base having doors of the vehicle attached thereto, where the slidable base is slidable in the width direction of the vehicle relative to the stationary base by a driving force from a drive source, and a movement alignment mechanism for controlling the front and rear ends of the slidable base to move in the width direction toward

the same side and by the same amount using a rotational power acting in a plane orthogonal to the height direction of the vehicle. With the above-described design, the movement alignment mechanism uses the rotational power acting within the plane orthogonal to the height direction, so that no space is required in the height direction to use the rotational power. Accordingly, the plug door device can achieve a reduced size in the height direction.

<Second Embodiment>

[0072] According to the above-described first embodiment, the plug door device does not include a swingable arm mechanism. The present invention, however, is not limited to such. A second embodiment is different from the first embodiment in that the plug door device includes a swingable arm mechanism and some of the constituent parts of the movement alignment mechanism constitute the swingable arm mechanism. The first and second embodiments have some common features, which are denoted by the same reference numerals and are not described in detail.

[0073] Fig. 10 is a bottom view showing a plug door device relating to the second embodiment. As shown in Fig. 10, a plug door device 2001 includes the pair of doors 2, the stationary base 3, the slidable base 4, a power transmission mechanism 230, a swingable arm mechanism 250 and a movement alignment mechanism 200. Fig. 10 shows the movement alignment mechanism 200 with the doors 2 being fully closed.

[0074] The power transmission mechanism 230 includes a power conversion mechanism 231 for changing the direction of the driving force from a drive source, which is not shown, and an endless belt 232 extending along the front-rear direction. The power converting mechanism 231 converts the rotation around the output shaft of the motor into rotation around an axis extending along the height direction. The power conversion mechanism 231 includes a gear 233 rotatable around an axis extending along the height direction. A pulley 234 is provided at a position away in the front-rear direction from the gear 233 and rotatable around an axis parallel to the rotational axis of the gear 233 (extending along the height direction).

[0075] The belt 232 bridges the gear 233 and the pulley 234. The belt 232 is movable cooperatively as the gear 233 rotates and moves (circulates) around the gear 233 and the pulley 234. The belt 232 is connected to the door hangers 11. The door hangers 11 are movable in the front-rear direction as the belt 232 moves. The following describes how the doors are actuated in a plugging manner, or how the doors are moved in the front-rear direction while being moved in the width direction.

[0076] From among the doors 2, the door 2 on the -X side is connected, via the door hanger 11, to the -Y-side portion of the belt 232. The door 2 on the +X side is connected, via the door hanger 11, to the +Y-side portion of

the belt 232. The belt 232 bridges the gear 233 and the pulley 234, which are spaced away from each other in the front-rear direction. The -Y-side and +Y-side portions of the belt 232 move in opposite directions in the front-rear direction. Accordingly, as the belt 232 moves, the -X-side door 2 and the +X-side door 2 move oppositely in the front-rear direction.

[0077] As the driving force from the drive source, which is not shown, is transmitted to the belt 232 and the door hangers 11 connected to the belt 232 resultantly move, the doors 2 move from the fully closed position shown in Fig. 10 (where the external surface of the vehicle body side wall is flush with the external surface of the doors 2) to the fully open position. In the example shown in Fig. 10, the -X-side door 2 first moves outward in the width direction (specifically, obliquely relative to the width direction) from the fully closed position and then moves linearly toward the -X side, to reach the fully open position. On the other hand, the +X-side door 2 first moves outward in the width direction from the fully closed position (specifically, obliquely relative to the width direction) and then moves linearly toward the +X side, to reach the fully open position.

[0078] Fig. 11 is a front view showing a swingable arm mechanism 250 of the second embodiment and surrounding parts. Fig. 12 is a perspective view showing the upper portion of the swingable arm mechanism 250 of the second embodiment and surrounding parts. Fig. 13 is a perspective view showing the lower portion of the swingable arm mechanism 250 of the second embodiment and surrounding parts. Fig. 14 is a perspective view showing one of the portions of the swingable arm mechanism 250 of the second embodiment in the front-rear direction. In the drawings, the symbol "A" is appended to the reference numerals of the constituent elements of one (the -X side) of the portions of the swingable arm mechanism 250 in the front-rear direction, and the symbol "B" is appended to the reference numerals of the constituent elements of the other portion (the +X side). The symbols "A" and "B", however, are omitted unless they are particularly distinguished.

[0079] As shown in Fig. 11, the swingable arm mechanism 250 includes two pillars 251, two upper arms 252, and two lower arms 253. The two pillars 251 are provided on the vehicle body, spaced away from each other in the front-rear direction, and extend in the height direction. The two upper arms 252 support the upper portions of the doors 2 and are integrally rotatable around the pillars 252. The two lower arms 253 support the lower portions of the doors 2 and are integrally rotatable around the pillars 251.

[0080] The pillars 251 are shaft members extending linearly along the height direction. The pillars 251 are positioned outside the doorway in the front-rear direction. As shown in Fig. 12, the upper end of each pillar 251 is attached to the upper portion of the vehicle body via an upper bracket 258. As shown in Fig. 13, the lower end of each pillar 251 is attached to the lower portion of the

vehicle body via a lower bracket 259. The pillars 251 are supported on the brackets 258 and 259 rotatably around an axis extending in the height direction.

[0081] As shown in Fig. 14, the upper arm 252 is attached to the upper portion of the pillar 251 such that it is not allowed to rotate relative to the upper portion of the pillar 251. The upper arm 252 is divided into an arm base portion 210 coaxially arranged with the pillar 251 and a contact arm 211 arranged near the upper edge of the door 2. For example, the arm base portion 210 and the contact arm 211 may be formed as a single unit piece and made of the same material.

[0082] The arm base portion 210 is an annular member coaxially arranged with the pillar 251. The arm base portion 210 is arranged near and below a portion of the upper bracket 258 that is connected to the pillar 251. The arm base portion 210 surrounds the pillar 251. For example, a bearing may be provided between the inner periphery of the arm base portion 210 and the pillar 251 for supporting the pillar 251 rotatably.

[0083] The contact arm 211 extends radially outward (outward in the direction orthogonal to the central axis of the arm base portion 210) from the arm base portion 210. The contact arm 211 is divided into a first extension portion 211a, a second extension portion 211b, and a third extension portion 211c. The first extension portion 211a has a uniform width and extends radially outward from the arm base portion 210. The second extension portion 211b extends upward from the tip end of the first extension portion 211a. The third extension portion 211c is tapered radially outward from the tip end of the second extension portion 211b (specifically, radially outward in the direction of the extension line following the first extension portion 211a, when seen in the height direction).

[0084] The lower arm 253 is attached to the lower portion of the pillar 251 such that it is not allowed to rotate relative to the lower portion of the pillar 251. The lower arm 253 is connected near and above a portion of the lower bracket 259 that is connected to the pillar 251.

[0085] The lower arm 253 extends radially outward (outward in the direction orthogonal to the central axis of the pillar 251) from the pillar 251. The lower arm 253 is divided into a first arm portion 253a, a second arm portion 253b, a third arm portion 253c and a fourth arm portion 253d. The first arm portion 253a extends radially outward from the pillar 251. The second arm portion 253b extends downward from the tip end of the first arm portion 253a. The third arm portion 253c extends radially outward from the tip end of the second arm portion 253b (specifically, radially outward in the direction of the extension line following the first arm portion 253a when seen in the height direction). The fourth arm portion 253d extends from the tip end of the third arm portion 253c obliquely relative to the radially outward direction (specifically, the radially outward direction extending along the extension line following the third arm portion 253c when seen in the height direction).

[0086] As shown in Fig. 13, the doors 2 are provided

at the lower edge thereof with lower guide rails 260 for guiding the lower arms 253 as the lower arms 253 move in the front-rear direction. The lower guide rails 260 extend in the front-rear direction. The lower guide rails 260 are U-shaped and open downward when seen in the front-rear direction. The lower guide rails 260 are each divided into an external wall portion 261 fixedly attached to the door 2, an internal wall portion 262 arranged on the inner side in the width direction relative to the external wall portion 261, and an upper wall portion 263 connecting together the upper edge of the external wall portion 261 and the upper edge of the inner wall portion 262.

[0087] The lower arm 253 includes a roller 255 rollable along the lower guide rail 260. The roller 255 is attached to the tip end of the fourth arm portion 253d of the lower arm 253. The roller 255 is attached to the tip end of the fourth arm portion 253d such that it is rotatable around an axis extending in the height direction. The roller 255 is positioned above the tip end of the fourth arm portion 253d. The roller 255 is interposed between the external wall portion 261 and the internal wall portion 262 in the width direction.

[0088] The roller 255 is movable along the guide surface (the +Y-side internal wall surface or the -Y-side internal wall surface) of the lower guide rail 260 as the door 2 is actuated in a plugging manner. For example, as the doors 2 move outward in the width direction (specifically, obliquely relative to the width direction) from the fully closed position, the rollers 255 are pushed toward the +Y-side by the guide surfaces (the +Y-side internal wall surfaces) of the internal wall portions 262. Subsequently, the lower arm 253A rotates clockwise around the pillar 251A as seen from below (as indicated by the arrow E1 in Fig. 13), and the lower arm 253B rotates anti-clockwise around the pillar 251B as seen below (as indicated by the arrow E2 in Fig. 13). Following this, when the doors 2 move linearly outward in the front-rear direction, the rollers 255 of the two lower arms 253 roll along the guide surfaces of the lower guide rails 260. As a result, the doors 2 move outward in the front-rear direction relative to the rollers 255 and the lower arms 253 to reach the fully open position.

[0089] For example, when the doors 2 move linearly inward in the front-rear direction from the fully open position, the rollers 255 of the two lower arms 253 roll along the guide surfaces of the lower guide rail 260. Following this, as the doors 2 move inward in the width direction (specifically, obliquely relative to the width direction), the rollers 255 are pushed toward the -Y-side by the guide surfaces (the -Y-side internal wall surfaces) of the external wall portions 261. Subsequently, the lower arm 253A rotates anti-clockwise around the pillar 251A as seen from below (oppositely to the direction indicated by the arrow E1 in Fig. 13), and the lower arm 253B rotates clockwise around the pillar 251B as seen from below (oppositely to the direction indicated by the arrow E2 in Fig. 13). As a result, the doors 2 move toward the -Y side as the lower arms 253 rotate, to reach the fully closed po-

sition.

[0090] As shown in Fig. 10, the movement alignment mechanism 200 includes the two pillars 251 serving as the two stationary shaft members, two rotatable members 202 including the two upper arms 252, and a shaft 203 connected at the front and rear ends thereof to the two pillars 251 via transmission shaft members 212 of the two rotatable members 202.

[0091] The following description focuses on the description of one (the -X side) of the front and rear ends of the movement alignment mechanism 200 and the surrounding parts. The other (the +X side) of the front and rear ends of the movement alignment mechanism 200 and the surrounding parts are configured in the same manner as the -X side end and the surrounding parts except for the positions of the constituent elements and the direction of the movement (the direction of the rotation) and are thus not described in detail. Fig. 15 is a bottom view showing one (the -X side) of the front and rear ends of the movement alignment mechanism 200 of the second embodiment and surrounding parts. Fig. 16 is a bottom view showing the other (the +X side) of the front and rear ends of the movement alignment mechanism 200 of the second embodiment and surrounding parts. Figs. 15 and 16 show the movement alignment mechanism 200 with the doors 2 being fully closed. In the drawings, the symbol "A" is appended to the reference numerals of the constituent elements at one (the -X side) of the front and rear ends of the movement alignment mechanism 200, and the symbol "B" is appended to the reference numerals of the constituent elements at the other end (the +X side). The symbols "A" and "B", however, are omitted unless they are particularly distinguished.

[0092] As shown in Fig. 15, the rotatable members 202 are L-shaped as seen in the height direction. The rotatable members 202 each include an upper arm 252 and a transmission arm 213. The upper arm 252 specifically includes an arm base portion 210 coaxially arranged with the pillar 251 and a contact arm 211 arranged near the upper edge of the door 2. The transmission arm 213 includes a transmission shaft member 212 spaced away from the rotational center of the pillar 251. For example, the upper arm 252 and the transmission arm 213 may be formed as a single unit piece and made of the same material.

[0093] The slidable base 4 is provided with guide members 220 for guiding the contact arms 211 as the contact arms 211 move in the front-rear direction. The guide members 220 are shaped like a rectangle long in the front-rear direction as seen in the height direction. The +Y-side edge of each guide member 220 is attached to the lower edge of the slidable base 4 using a plurality of (for example, three, in the present embodiment) bolts 121 arranged next to each other in the front-rear direction.

[0094] Each guide member 220 has an elongated hole 222 formed therein, which is open in the height direction and long in the front-rear direction. The guide member

220 has a rail 223 extending along the front-rear direction. The rail 223 is constituted by the pair of inner wall surfaces of the elongated hole 222 that face each other in the width direction. The inner wall surfaces extend in the front-rear direction and parallel to each other, when seen in the height direction. The length of the inner wall surfaces in the front-rear direction is greater than the outer diameter of a roller 215.

[0095] The contact arm 211 includes a roller 215 rotatable along the rail 223. The roller 215 is positioned above the contact arm 211. The roller 215 is coupled to the tip end of the third extension portion 211c of the contact arm 211 (the most distant portion from the arm base portion 210) such that the roller 215 is rotatable around an axis extending in the height direction. The roller 215 is shaped like a circle when seen in the height direction.

[0096] The transmission arm 213 extends radially outward from the arm base portion 210 but originates from a different portion than the contact arm 211 does. When seen in the height direction, the transmission arm 213 is tapered from the arm base portion 210 radially outward and then swells to have a circular shape. The circular swollen portion of the transmission arm 213 overlaps annular portions at the respective ends of the shaft 203 when seen in the height direction.

[0097] The contact arm 211 and the transmission arm 213 extend orthogonally to each other when seen in the height direction. For example, when seen in the height direction, the angle α_m formed between the contact arm 211 and the transmission arm 213 is approximately 90 degrees. Here, the angle α_m refers to the angle formed between (i) an imaginary straight line running through the rotational center of the pillar 251 and the rotational center of the roller 215 (the center of the tip end of the contact arm 211) and (ii) an imaginary straight line running through the rotational center of the pillar 251 and the axis of the transmission shaft member 212, when seen in the height direction.

[0098] The transmission shaft member 212 extends parallel to the pillar 251 (in the height direction). The lower end of the transmission shaft member 212 is coupled to the tip end of the transmission arm 213 (the most distant portion from the arm base portion 210). The transmission shaft member 212 overlaps the center of the circular swollen portion of the transmission arm 213, when seen in the height direction.

[0099] As shown in Fig. 10, the shaft 203 is connected to the two pillars 251 via the transmission shaft members 212 of the two rotatable members 202 (see Figs. 15 and 16). The shaft 203 has a first end connected to one of the two pillars 251 and a second end connected to the other pillar 251. The shaft 203 extends linearly to bridge the transmission shaft members 212 of the two rotatable members 202. Each end of the shaft 203 is rotatable around a corresponding one of the transmission shaft members 212. For example, the shaft 203 may be provided with an adjuster member for adjusting the distance between the transmission shaft members 212 of the two

rotatable members 202.

[0100] The shaft 203 is rigid enough to satisfactorily transmit the rotational force exerted by one of the rotatable members 202 to the other rotatable member 202. For example, the shaft 203 can be a metal shaft member. For example, the shaft 203 is preferably a member that can be ideally deemed to be a rigid member. The shaft 203 may not be a member that is never deformed by a force of any level but a member that may experience some deformation when acted upon by a force of a predetermined level or more.

[0101] The two pillars 251 are aligned with each other in the front-rear direction when seen in the height direction. The rollers 215 of the two rotatable members 202 are positioned on the inner side of the pillars 251 in the front-rear direction, as seen in the height direction (see Figs. 15 and 16). When the doors are fully closed, the roller 215 of the rotatable member 202A is positioned on the +X side of the pillar 251A as seen in the height direction (see Fig. 15). On the other hand, the roller 215 of the rotatable member 202B is positioned on the -X side of the pillar 251B as seen in the height direction, when the doors are fully closed (see Fig. 16). The transmission shaft members 212 of the two rotatable members 202 are differently positioned in the width direction when seen in the height direction (see Figs. 15 and 16). When the doors are fully closed, the transmission shaft member 212 of the rotatable member 202A is positioned on the -Y side of the pillar 251 as seen in the height direction (see Fig. 15). On the other hand, the transmission shaft member 212 of the rotatable member 202B is positioned on the +Y side of the pillar 251 as seen in the height direction, when the doors are fully closed (see Fig. 16).

[0102] Fig. 17 illustrates how the movement alignment mechanism 200 of the second embodiment works. Fig. 17 is a bottom view showing the movement alignment mechanism 200 of the second embodiment and surrounding parts. Fig. 17 shows a case where the slidable base 4 moves outward in the width direction (in the plug-out direction) (moves as indicated by the arrow W_d shown in Fig. 17) as the doors are opened from the fully closed state. For example, the case shown in Fig. 17 corresponds to a case where the doors move outward in the width direction from the fully closed position so that the doors are positioned outside the vehicle. Fig. 17 does not show the doors, power transmission mechanism and some other constituent parts.

[0103] As shown in Fig. 17, as the doors are opened, the rollers 215 of the two rotatable members 202 are pushed toward the +Y side by the -Y-side rails 223 of the guide members 220. Subsequently, the rotatable member 202A rotates clockwise around the pillar 251A as seen from below (as indicated by the arrow R_1), and the rotatable member 202B rotates anti-clockwise around the pillar 251B as seen from below (as indicated by the arrow R_2). This means that the rotatable members 202A and 202B rotate oppositely respectively around the pillars 251A and 251B.

[0104] The following more specifically describes how the movement alignment mechanism 200 works with reference to an example case where, as the doors are opened, the roller 215 of the rotatable member 202A is first pushed toward the +Y side by the -Y-side rail 223 of the guide member 220A. In this case, the rotatable member 202A rotates clockwise around the pillar 251A as seen from below (as indicated by the arrow R1). This causes the transmission shaft member 212 of the rotatable member 202A to push the shaft 203 toward the +X side. As a result, the shaft 203 pushes the transmission shaft member 212 of the rotatable member 202B toward the +X side. The rotatable member 202B then rotates anti-clockwise around the pillar 251B as seen from below (as indicated by the arrow R2). In other words, when the roller 215 of the rotatable member 202A is pushed toward the +Y side earlier than is the roller 215 of the rotatable member 202B, the rotatable members 202A and 202B rotate oppositely respectively around the pillars 251A and 251B.

[0105] The following more specifically describes how the movement alignment mechanism 200 works with reference to a different example case where, as the doors are opened, the roller 215 of the rotatable member 202B is first pushed toward the +Y side by the -Y-side rail 223 of the guide member 220B. In this case, the rotatable member 202B rotates anti-clockwise around the pillar 251B as seen from below (as indicated by the arrow R2). This causes the transmission shaft member 212 of the rotatable member 202B to pull the shaft 203 toward the +X side. As a result, the shaft 203 pulls the transmission shaft member 212 of the rotatable member 202A toward the +X side. The rotatable member 202A then rotates clockwise around the pillar 251A as seen from below (as indicated by the arrow R1). In other words, when the roller 215 of the rotatable member 202B is pushed toward the +Y side earlier than is the roller 215 of the rotatable member 202A, the rotatable members 202A and 202B rotate oppositely respectively around the pillars 251A and 251B.

[0106] The following describes how the doors are actuated in a plugging manner in a direction opposite to the example shown in Fig. 17, or an example case where the slidable base 4 moves inward in the width direction (in the plug-in direction) (moves in the opposite direction to the direction indicated by the arrow Wd shown in Fig. 17) as the doors are closed from the fully open state.

[0107] As the doors are closed, the rollers 215 of the two rotatable members 202 are pushed toward the -Y side by the +Y-side rails 223 of the guide members 220. Subsequently, the rotatable member 202A rotates anti-clockwise around the pillar 251A as seen from below (oppositely to the direction indicated by the arrow R1 in Fig. 17), and the rotatable member 202B rotates clockwise around the pillar 251B as seen from below (oppositely to the direction indicated by the arrow R2 in Fig. 17). This means that the rotatable members 202A and 202B rotate oppositely respectively around the pillars 251A and

251B.

[0108] The following more specifically describes how the movement alignment mechanism 200 works with reference to an example case where, as the doors are closed, the roller 215 of the rotatable member 202A is first pushed toward the -Y side by the +Y-side rail 223 of the guide member 220A. In this case, the rotatable member 202A rotates anti-clockwise around the pillar 251A as seen from below (oppositely to the direction indicated by the arrow R1 in Fig. 17). This causes the transmission shaft member 212 of the rotatable member 202A to pull the shaft 203 toward the -X side. As a result, the shaft 203 pulls the transmission shaft member 212 of the rotatable member 202B toward the -X side. The rotatable member 202B then rotates clockwise around the pillar 251B as seen from below (oppositely to the direction indicated by the arrow R2 shown in Fig. 17). In other words, when the roller 215 of the rotatable member 202A is pushed toward the -Y side earlier than is the roller 215 of the rotatable member 202B, the rotatable members 202A and 202B rotate oppositely respectively around the pillars 251A and 251B.

[0109] The following more specifically describes how the movement alignment mechanism 200 works with reference to a different example case where, as the doors are closed, the roller 215 of the rotatable member 202B is first pushed toward the -Y side by the +Y-side rail 223 of the guide member 220B. In this case, the rotatable member 202B rotates clockwise around the pillar 251B as seen from below (oppositely to the direction indicated by the arrow R2 shown in Fig. 17). This causes the transmission shaft member 212 of the rotatable member 202B to push the shaft 203 toward the -X side. As a result, the shaft 203 pushes the transmission shaft member 212 of the rotatable member 202A toward the -X side. The rotatable member 202A then rotates anti-clockwise around the pillar 251A as seen from below (oppositely to the direction indicated by the arrow R1 in Fig. 17). In other words, when the roller 215 of the rotatable member 202B is pushed toward the -Y side earlier than is the roller 215 of the rotatable member 202A, the rotatable members 202A and 202B rotate oppositely respectively around the pillars 251A and 251B.

[0110] As described above, as the doors are opened or closed in a plugging manner (in the plug-out and plug-in directions), the rotatable members 202A and 202B rotate oppositely respectively around the pillars 251A and 251B in the second embodiment. Although not described in detail, the lower arms 253A and 253B rotate oppositely respectively around the pillars 251A and 251B when the doors are opened or closed.

[0111] The plug door device 2001 of the second embodiment includes the swingable arm mechanism 250 for guiding the doors 2 as the doors 2 move in the width and front-rear directions as described above. The swingable arm mechanism 250 includes the two pillars 251, the two upper arms 252, and the two lower arms 253. The pillars 251 are provided on the vehicle body, spaced

away from each other in the front-rear direction, and extend in the height direction of the vehicle. The two upper arms 252 support the upper portions of the doors 2 and are rotatable around the pillars 251 integrally with the pillars 251. The two lower arms 253 support the lower portion of the doors 2 and are rotatable around the pillars 251 integrally with the pillars 251. The movement alignment mechanism 200 includes the two pillars 251 serving as the two stationary shaft members, the two rotatable members 202 including the two upper arms 252, and the shaft 203 connected at the front and rear ends thereof to the two pillars 251 via the transmission shaft members 212 of the two rotatable members 202. The slidable base 4 is provided with the guide members 220 for guiding the upper arms 252 as the upper arms 252 move in the front-rear direction. The guide members 220 have the rails 223 extending in the front-rear direction. The upper arms 252 include the rollers 215 rollable along the rails 223. The doors 2 are provided at the lower edges thereof with the lower guide rails 260 for guiding the lower arms 253 as the lower arms 253 move in the front-rear direction. The lower guide rails 260 extend in the front-rear direction. The lower arms 253 include the rollers 255 rollable along the lower guide rails 260.

[0112] With the above-described design, when the doors 2 are opened or closed, the rotatable members 202A and 202B rotate integrally with the pillars 251 and oppositely respectively around the pillars 251, so that the front and rear ends of the slidable base 4, to which the doors 2 are attached, can move in the width direction toward the same side and by the same amount. Accordingly, the present embodiment can prevent the slidable base 4 from becoming inclined relative to the front-rear direction while moving in the width direction to actuate the doors in a plugging manner, so that the slidable base 4 can avoid stagnating. The slidable base 4 is provided with the guide members 220 for guiding the upper arms 252 as the upper arms 252 move in the front-rear direction, so that the guide members 220 can guide the upper arms 252 as the upper arms 252 move in the front-rear direction. In this manner, the movement of the slidable base 4 in the width direction can be converted into the rotation of the rotatable members 202. The guide members 220 have the rails 223 extending in the front-rear direction, and the upper arms 252 include the rollers 215 rollable along the rails 223. With such a design, the rollers 215 can reduce the friction between the upper arms 252 and the rails 223. As a result, the movement of the slidable base 4 in the width direction can be smoothly converted into the rotation of the rotatable members 202. The doors 2 are provided at the lower edges thereof with the lower guide rails 260 for guiding the lower arms 253 as the lower arms 253 move in the front-rear direction, so that the lower guide rails 260 can guide the lower arms 253 as the lower arms 253 move in the front-rear direction. As a result, the movement of the doors in the width direction can be converted into the rotation of the lower arms 253. The lower guide rails 260 extend in the front-

rear direction, and the lower arms 253 include the rollers 255 rollable along the lower guide rails 260. With such a design, the rollers 255 can reduce the friction between the lower arms 253 and the lower guide rails 260. As a result, the movement of the doors in the width direction can be smoothly converted into the rotation of the lower arms 253. The upper and lower arms 252 and 253 rotate integrally with the pillars 251 around the pillars 251, so that the upper and lower portions of the doors 2 can be actuated in a plugging manner synchronously. Since some of the constituent elements of the swingable arm mechanism 250 constitute the movement alignment mechanism 200, the existing swingable arm mechanism 250 can be effectively used. Accordingly, the present embodiment can achieve a reduced number of constituent parts when compared with a case where new dedicated constituent parts are incorporated.

<Third Embodiment>

[0113] In the above-described first embodiment, the shaft extends in the direction intersecting the front-rear direction when seen in the height direction of the vehicle. The present invention, however, is not limited to such. In the third embodiment, the shaft is arranged in a different manner than in the first embodiment. The first and third embodiments have some common features, which are denoted by the same reference numerals and are not described in detail.

[0114] Fig. 18 is a bottom view showing a shaft 303 constituting a movement alignment mechanism 300 of the third embodiment and surrounding parts. Fig. 19 is a front view showing the shaft 300 of the third embodiment and surrounding parts. In Figs. 18 and 19, the symbol "A" is appended to the reference numerals of the constituent elements at one (the -X side) of the front and rear ends of the movement alignment mechanism 300, and the symbol "B" is appended to the reference numerals of the constituent elements at the other end (the +X side). The symbols "A" and "B", however, are omitted unless they are particularly distinguished.

[0115] As shown in Fig. 18, the shaft 303 extends parallel to the front-rear direction when seen in the height direction. Rotatable members 302 are L-shaped as seen in the height direction. The rotatable members 302A and 302B have the same shape when seen in the height direction. The rotatable members 302 each have an arm base portion 310, a contact arm 311, and a transmission arm 313. The arm base portion 310 is coaxially arranged with the stationary shaft member 301. The contact arm 311 is in contact with the slidable base (not shown). The transmission arm 313 includes a transmission shaft member 312 spaced away from the rotational center of the stationary shaft member 301. The slidable base (not shown) is provided with guide members 320 for guiding the contact arms 311 as the contact arms 311 move in the front-rear direction.

[0116] The transmission arm 313 extends radially out-

ward from the arm base portion 310 but originates from a different portion than the contact arm 311 does. The transmission arms 313 of the two rotatable members 302 extend in the same direction when seen in the height direction.

[0117] As shown in Fig. 19, the transmission shaft members 312 extend parallel to the stationary shaft members 301 (in the height direction). As shown in Fig. 18, the upper end of each one of the transmission shaft members 312 is coupled to the tip end of a corresponding one of the transmission arms 313 (the most distant portion from the arm base portion 310). The transmission shaft members 312 of the two rotatable members 302 are aligned with each other in the front-rear direction when seen in the height direction.

[0118] The shaft 303 is connected at the front and rear ends (first and second ends) thereof to the transmission shaft members 312 of the two rotatable members 302. The shaft 303 extends linearly in the front-rear direction to bridge the transmission shaft members 312 of the two rotatable members 302. The ends of the shaft 303 are rotatable around the transmission shaft members 312. For example, the shaft 303 may be provided with an adjuster member for adjusting the distance between the transmission shaft members 312 of the two rotatable members 302.

[0119] As described above, the shaft 303 relating to the third embodiment extends parallel to the front-rear direction when seen in the height direction. With such a design, when compared with the case where the shaft 303 extends in the direction intersecting the front-rear direction when seen in the height direction, the shaft 303 occupies a reduced space in the width direction. As a result, the third embodiment can achieve a small-sized plug door device.

<Fourth Embodiment>

[0120] According to the above-described second embodiment, the movement alignment mechanism includes the shaft connected at the front and rear ends thereof to the two pillars via the transmission shaft members of the two rotatable members. The present invention, however, is not limited to such. The fourth embodiment is different from the second embodiment in terms of the constitution of the movement alignment mechanism. The second and fourth embodiments have some common features, which are denoted by the same reference numerals and are not described in detail.

[0121] Fig. 20 schematically illustrates a movement alignment mechanism 400 of the fourth embodiment. In Fig. 20, the symbol "A" is appended to the reference numerals of the constituent elements at one (the -X side) of the front and rear ends of the movement alignment mechanism 400, and the symbol "B" is appended to the reference numerals of the constituent elements at the other end (the +X side). The symbols "A" and "B", however, are omitted unless they are particularly distin-

guished.

[0122] As shown in Fig. 20, the movement alignment mechanism 400 includes two pillars 451, two pillar-side bevel gears 401, two link-side bevel gears 402, and a link shaft member 403. The pillars 451 are configured to apply rotational power acting within a plane orthogonal to the height direction of the vehicle. The pillar-side bevel gears 401 are rotatable integrally with the pillars 451 around the pillars 451. The link-side bevel gears 402 are engaged respectively with the pillar-side bevel gears 401. The link shaft member 403 is connected at the front and rear ends thereof to the link-side bevel gears 402. At the upper portions of the pillars 451, upper arms 452 are coupled for supporting the upper portions of the doors 2. At the lower portions of the pillars 451, lower arms (not shown) are coupled for supporting the lower portions of the doors 2.

[0123] Each pillar-side bevel gear 401 is aligned with the rotational center of a corresponding one of the pillars 451. Each pillar-side bevel gear 401 is rotatable integrally with the corresponding pillar 451 around the corresponding pillar 451. Each pillar-side bevel gear 401 is provided at the upper end of the corresponding pillar 451.

[0124] The two pillar-side bevel gears 401 each have a bevel gear, the diameter of which gradually decreases upwardly. The pillar-side bevel gears 401A and 401B have the same shape.

[0125] The link-side bevel gears 402 are positioned such that they are engaged with the pillar-side bevel gears 401. The two link-side bevel gears 402 each have a bevel gear, the diameter of which gradually decreases outwardly in the front-rear direction. The link-side bevel gear 402A has a bevel gear, the diameter of which gradually decreases toward the -X side. On the other hand, the link-side bevel gear 402B has a bevel gear, the diameter of which gradually decreases toward the +X side.

[0126] The link shaft member 403 extends in the front-rear direction. A first one of the front and rear ends of the link shaft member 403 is connected to one of the two link-side bevel gears 402. A second one of the front and rear ends of the link shaft member 403 is connected to the other of the two link-side bevel gears 402. The link shaft member 403 extends linearly in the front-rear direction to bridge the two link-side bevel gears 402. The link shaft member 403 is rotatable around an axis extending in the front-rear direction. The two link-side bevel gears 402 are rotatable integrally with the link shaft member 403 around the link shaft member 403.

[0127] In the present embodiment, one of the front and rear ends of the link shaft member 403 is connected to the link-side bevel gear 402A, which is engaged with the pillar-side bevel gear 401A, and the other of the front and rear ends of the link shaft member 403 is connected to the link-side bevel gear 402B, which is engaged with the pillar-side bevel gear 401B. For example, as the pillar-side bevel gear 401A rotates in the direction indicated by the arrow G1 in Fig. 20, the link shaft member 403 rotates in the direction indicated by the arrow G2 in Fig.

20 and the pillar-side bevel gear 401B rotates in the direction indicated by the arrow G3 in Fig. 20. This means that the pillar-side bevel gears 401A and 401B rotate oppositely respectively around the pillars 451A and 451B.

[0128] As described above, the movement alignment mechanism 400 relating to the fourth embodiment includes the two pillars 451, the two pillar-side bevel gears 401, the two link-side bevel gears 402, and the link shaft member 403. The pillars 451 are configured to apply rotational power acting within a plane orthogonal to the height direction of the vehicle. The pillar-side bevel gears 401 are rotatable integrally with the pillars 451 around the pillars 451. The link-side bevel gears 402 are engaged respectively with the pillar-side bevel gears 401. The link shaft member 403 is connected at the front and rear ends thereof to the link-side bevel gears 402.

[0129] With the above-described design, when the doors 2 are opened or closed, the pillar-side bevel gears 401 respectively rotate integrally with the pillars 451 and oppositely around the pillars 451, so that the front and rear ends of the slidable base 4, to which the doors 2 are attached, can move in the width direction toward the same side and by the same amount. Accordingly, the present embodiment can prevent the slidable base 4 from becoming inclined relative to the front-rear direction while moving in the width direction to actuate the doors in a plugging manner, so that the slidable base 4 can avoid stagnating. The pillar-side bevel gears 401 and the lower arms rotate integrally with the pillars 451 around the pillars 251, so that the upper and lower portions of the doors 2 can be actuated in a plugging manner synchronously. Since some of the constituent elements of the swingable arm mechanism constitute the movement alignment mechanism 400, the existing swingable arm mechanism can be effectively used. Accordingly, the present embodiment can achieve a reduced number of constituent parts when compared with a case where new dedicated constituent parts are incorporated.

<Fifth Embodiment>

[0130] According to the above-described second embodiment, the movement alignment mechanism includes the shaft connected at the front and rear ends thereof to the two pillars via the transmission shaft members of the two rotatable members. The present invention, however, is not limited to such. A fifth embodiment is different from the second embodiment in terms of the constitution of the movement alignment mechanism. The second and fifth embodiments have some common features, which are denoted by the same reference numerals and are not described in detail.

[0131] Fig. 21 schematically illustrates a movement alignment mechanism 500 of the fifth embodiment. In Fig. 21, the symbol "A" is appended to the reference numerals of the constituent elements at one (the -X side) of the front and rear ends of the movement alignment

mechanism 500, and the symbol "B" is appended to the reference numerals of the constituent elements at the other end (the +X side). The symbols "A" and "B", however, are omitted unless they are particularly distinguished.

[0132] As shown in Fig. 21, the movement alignment mechanism 500 includes two pillars 551, two pillar-side gears 501, an intermediate gear 502, and a toothed belt 503. The pillars 551 are configured to apply rotational power acting within a plane orthogonal to the height direction of the vehicle. The pillar-side gears 501 are rotatable integrally with the pillars 551 around the pillars 551. The intermediate gear 502 is engaged with one of the two pillar-side gears 501. The toothed belt 503 is engaged with the other of the two pillar-side gears 501 and with the intermediate gear 502. At the upper portions of the pillars 551, upper arms 552 are coupled for supporting the upper portions of the doors 2. At the lower portions of the pillars 551, lower arms (not shown) are coupled for supporting the lower portions of the doors 2.

[0133] Each pillar-side gear 501 is aligned with the rotational center of a corresponding one of the pillars 551. Each pillar-side gear 501 is rotatable integrally with the corresponding pillar 551 around the corresponding pillar 551. Each pillar-side gear 501 is provided at the upper end of the corresponding pillar 551. The two pillar-side gears 501 are differently positioned in the height direction. In the fifth embodiment, the pillar-side gear 501A is positioned below the pillar-side gear 501B.

[0134] The intermediate gear 502 is positioned such that it is engaged with the pillar-side gear 501A. The intermediate gear 502 is rotatable around an axis extending in the height direction. The length of the intermediate gear 502 in the height direction is greater than the length of the pillar-side gear 501A in the height direction. For example, the lower edge of the intermediate gear 502 may be positioned below the lower edge of the pillar-side gear 501A. For example, the upper edge of the intermediate gear 502 may be positioned above the upper edge of the pillar-side gear 501B.

[0135] The toothed belt 503 is positioned such that it is engaged with the pillar-side gear 501B and the intermediate gear 502. The toothed belt 503 is an endless belt. A plurality of teeth are formed on the inner periphery of the toothed belt 503 and next to each other in the circumferential direction of the toothed belt 503. The length of the toothed belt 503 in the height direction is less than the length of the pillar-side gear 501B in the height direction. The toothed belt 503 is accommodated in the height direction within the range of the pillar-side gear 501B. The toothed belt 503 is accommodated in the height direction within the range of the upper portion of the intermediate gear 502. The lower edge of the toothed belt 503 is positioned above the upper edge of the pillar-side gear 501A. The pillar-side gear 501B and the intermediate gear 502 are rotatable integrally with the toothed belt 503.

[0136] In the present embodiment, the toothed belt 503

bridges the intermediate gear 502 and the pillar-side gear 501B. The intermediate gear 502, which is positioned near one of the front and rear ends of the toothed belt 503, is engaged with the pillar-side gear 501A, and the other of the front and rear ends of the toothed belt 503 is engaged with the pillar-side gear 501B. For example, as the pillar-side gear 501A rotates as indicated by the arrow J1 in Fig. 21, the intermediate gear 502 rotates as indicated by the arrow J2 in Fig. 21. As a result, the toothed belt 503 moves (circulates) as indicated by the arrow J3 in Fig. 21, and the pillar-side gear 501B rotates as indicated by the arrow J4 in Fig. 21. This means that the pillar-side gears 501A and 501B rotate oppositely respectively around the pillars 551A and 551B.

[0137] As described above, the movement alignment mechanism 500 of the fifth embodiment includes the two pillars 551, the two pillar-side gears 501, the intermediate gear 502, and the toothed belt 503. The pillars 551 are configured to apply rotational power acting within a plane orthogonal to the height direction of the vehicle. The pillar-side gears 501 are rotatable integrally with the pillars 551 around the pillars 551. The intermediate gear 502 is engaged with one of the two pillar-side gears 501. The toothed belt 503 is engaged with the other of the two pillar-side gears 501 and with the intermediate gear 502.

[0138] With the above-described design, when the doors 2 are opened or closed, the pillar-side gears 501 rotate oppositely respectively integrally with the pillars 551 around the pillars 551, so that the front and rear ends of the slidable base 4, to which the doors 2 are attached, can move in the width direction toward the same side and by the same amount. Accordingly, the present embodiment can prevent the slidable base 4 from being inclined relative to the front-rear direction while moving in the width direction to actuate the doors in a plugging manner, so that the slidable base 4 can avoid stagnating. The pillar-side gears 501 and the lower arms rotate integrally with the pillars 551 around the pillars 251, so that the upper and lower portions of the doors 2 can be actuated in a plugging manner synchronously. Since some of the constituent elements of the swingable arm mechanism constitute the movement alignment mechanism 500, the existing swingable arm mechanism can be effectively used. Accordingly, the present embodiment can achieve a reduced number of constituent parts when compared with a case where new dedicated constituent parts are provided.

[0139] The technical scope of the present invention is not limited to the embodiments described above but is susceptible of various modification within the purport of the present invention.

[0140] For example, the foregoing embodiments are described with reference to an example plug door device including a double leaf sliding door to open or close the doorway of a railway vehicle. The present invention, however, is not limited to such. For example, the plug door device may be provided on vehicles other than railway vehicles. For example, the plug door device may include

a single leaf sliding door.

[0141] The elements of the embodiments described above may be replaced with known elements within the purport of the present invention. Further, the modifications described above may be combined. The foregoing embodiments disclosed herein describe a plurality of physically separate constituent parts. They may be combined into a single part, and any one of them may be divided into a plurality of physically separate constituent parts. Irrespective of whether or not the constituent parts are integrated, they are acceptable as long as they are configured to solve the problems.

LIST OF REFERENCE NUMBERS

[0142] 1...plug door device, 2...door, 3...stationary base, 4...slidable base, 6...drive source, 100...movement alignment mechanism, 101...stationary shaft member, 102...rotatable member, 103...shaft, 111...contact arm, 112...transmission shaft member, 113...transmission arm, 120...guide member, 123...rail, 200...movement alignment mechanism, 202...rotatable member, 203...shaft, 211...contact arm, 212...transmission shaft member, 213...transmission arm, 220...guide member, 223...rail, 250...swingable arm mechanism, 251...pillar, 252...upper arm, 253...lower arm, 300...movement alignment mechanism, 302...rotatable member, 303...shaft, 311...contact arm, 312...transmission shaft member, 313...transmission arm, 320...guide member, 301...stationary shaft member, 400...movement alignment mechanism, 401...pillar-side bevel gear, 402...link-side bevel gear, 403...link shaft member, 451...pillar, 452...upper arm, 500...movement alignment mechanism, 501...pillar-side gear, 502...intermediate gear, 503...toothed belt, 551...pillar, 552...upper arm, 2001...plug door device

Claims

1. A plug door device (1) comprising:

a stationary base (3) fixedly attached to a body of a vehicle;
a slidable base (4) having a door (2) of the vehicle attached thereto, the slidable base (4) being slidable in a width direction of the vehicle relative to the stationary base (3) when acted upon by a driving force from a drive source (6); and
a movement alignment mechanism (100, 200, 300) for controlling front and rear ends of the slidable base (4) in a front-rear direction of the vehicle to move in the width direction toward the same side and by the same amount, wherein the movement alignment mechanism (100, 200, 300) includes:

two stationary shaft members (101, 251,

- 301) provided on one of the body and the slidable base (4), the stationary shaft members (101, 251, 301) being spaced away from each other in the front-rear direction of the vehicle, the stationary shaft members (101, 251, 301) extending in a height direction of the vehicle;
- two rotatable members (102, 202, 302) each including a contact arm (111, 211, 311) in contact with the other of the body and the slidable base (4) and a transmission arm (113, 213, 313) including a transmission shaft member (112, 212, 312) spaced away from a corresponding one of the stationary shaft members (101, 251, 301), the contact arm (111, 211, 311) and the transmission arm (113, 213, 313) being rotatable integrally with the corresponding stationary shaft member (101, 251, 301) around the corresponding stationary shaft member (101, 251, 301); and
- a shaft (103, 203, 303) having a first end connected to the transmission shaft member (112, 212, 312) of one of the rotatable members (102, 202, 302) and a second end connected to the transmission shaft member (112, 212, 312) of the other of the rotatable members (102, 202, 302), the shaft (103, 203, 303) extending in the front-rear direction of the vehicle.
2. The plug door device (1) of claim 1,
- wherein the two stationary shaft members (101, 251, 301) are fixedly attached to the body via the stationary base (3), and
- wherein the contact arms (111, 211, 311) of the rotatable members (102, 202, 302) is in contact with the slidable base (4).
3. The plug door device (1) of claim 2, wherein the slidable base (4) is provided with guide members (120, 220, 320) for guiding the contact arms (111, 211, 311) as the contact arms (111, 211, 311) move in the front-rear direction of the vehicle.
4. The plug door device (1) of claim 3,
- wherein the guide members (120, 220, 320) each have a rail (123, 223) extending along the front-rear direction of the vehicle, and
- wherein the contact arms (111, 211, 311) each include a roller (115, 215) rollable along the rail (123, 223).
5. The plug door device (1) of any one of claims 1 to 4, wherein the contact arm (111, 211, 311) and the transmission arm (113, 213, 313) extend orthogo-

nally to each other when seen in the height direction of the vehicle.

6. A plug door device (1) comprising:

a stationary base (3) fixedly attached to a body of a vehicle;

a slidable base (4) having a door (2) of the vehicle attached thereto, the slidable base (4) being slidable in a width direction of the vehicle relative to the stationary base (3) when acted upon by a driving force from a drive source (6); and

a movement alignment mechanism (100, 200, 300) for controlling front and rear ends of the slidable base (4) in a front-rear direction of the vehicle to move in the width direction toward the same side and by the same amount, wherein the movement alignment mechanism (100, 200, 300) includes:

two stationary shaft members (101, 251, 301) provided on the stationary base (3), the stationary shaft members (101, 251, 301) being spaced away from each other in the front-rear direction of the vehicle, the stationary shaft members (101, 251, 301) extending in a height direction of the vehicle;

two rotatable members (102, 202, 302) each including a contact arm (111, 211, 311) in contact with the slidable base (4) and a transmission arm (113, 213, 313) including a transmission shaft member (112, 212, 312) spaced away from a corresponding one of the stationary shaft members (101, 251, 301), the contact arm (111, 211, 311) and the transmission arm (113, 213, 313) being rotatable integrally with the corresponding stationary shaft member (101, 251, 301) around the corresponding stationary shaft member (101, 251, 301); and

a shaft (103, 203, 303) having a first end connected to the transmission shaft member (112, 212, 312) of one of the rotatable members (102, 202, 302) and a second end connected to the transmission shaft member (112, 212, 312) of the other of the rotatable members (102, 202, 302), the shaft (103, 203, 303) extending in the front-rear direction of the vehicle,

wherein the slidable base (4) is provided with guide members (120, 220, 320) for guiding the contact arms (111, 211, 311) of the rotatable members (102, 202, 302) as the contact arms (111, 211, 311) move in the front-rear direction of the vehicle,

wherein the guide members (120, 220, 320)

each have a rail (123, 223) extending along the front-rear direction of the vehicle, wherein the contact arms (111, 211, 311) each include a roller (115, 215) rollable along the rail (123, 223), and wherein the contact arm (111, 211, 311) and the transmission arm (113, 213, 313) of each rotatable member (102, 202, 302) extend orthogonally to each other when seen in the height direction of the vehicle.

7. A plug door device (1) comprising:

a stationary base (3) fixedly attached to a body of a vehicle;
a slidable base (4) having a door (2) of the vehicle attached thereto, the slidable base (4) being slidable in a width direction of the vehicle relative to the stationary base (3) when acted upon by a driving force from a drive source (6); and
a movement alignment mechanism (100, 200, 300, 400, 500) for controlling front and rear ends of the slidable base (4) in a front-rear direction of the vehicle to move in the width direction toward the same side and by the same amount, wherein the movement alignment mechanism (100, 200, 300, 400, 500) uses rotational power acting within a plane orthogonal to a height direction of the vehicle.

8. The plug door device (1) of any one of claims 1 to 6, comprising a swingable arm mechanism (250) for guiding the door (2) as the door (2) moves, the door (2) being movable in the width direction and the front-rear direction of the vehicle via the slidable base (4),

wherein the swingable arm mechanism (250) includes:

two pillars (251) provided on the body of the vehicle, the pillars (251) being spaced away from each other in the front-rear direction of the vehicle, the pillars (251) extending in a height direction of the vehicle;
two upper arms (252) supporting an upper portion of the door (2), the upper arms (252) being rotatable integrally with the pillars (251) around the pillars (251); and
two lower arms (253) supporting a lower portion of the door (2), the lower arms (253) being rotatable integrally with the pillars (251) around the pillars (251), and

wherein the movement alignment mechanism (200) includes:

the pillars (251) serving as the stationary

shaft members (251);
the rotatable members (202) including the upper arms (252); and
the shaft (203) having the first end connected to one of the pillars (251) and the second end connected to the other of the pillars (251), the shaft (203) extending in the front-rear direction of the vehicle.

9. The plug door device (1) of claim 7, comprising a swingable arm mechanism (250) for guiding the door (2) as the door (2) moves, the door (2) being movable in the width direction and the front-rear direction of the vehicle via the slidable base (4),

wherein the swingable arm mechanism (250) includes:

two pillars (451) provided on the body, the pillars (451) being spaced away from each other in the front-rear direction of the vehicle, the pillars (451) extending in a height direction of the vehicle;
two upper arms (452) supporting an upper portion of the door (2), the upper arms (452) being rotatable integrally with the pillars (451) around the pillars (451); and
two lower arms supporting a lower portion of the door (2), the lower arms being rotatable integrally with the pillars (451) around the pillars (451), and

wherein the movement alignment mechanism (400) includes:

the two pillars (451) configured to apply the rotational power acting within the plane;
two pillar-side bevel gears (401) rotatable integrally with the pillars (451) around the pillars (451);
two link-side bevel gears (402) engaged respectively with the two pillar-side bevel gears (401); and
a link shaft member (403) having a first end connected to one of the link-side bevel gears (402) and a second end connected to the other of the link-side bevel gears (402), the link shaft member (403) extending in the front-rear direction of the vehicle.

10. The plug door device (1) of claim 7, comprising a swingable arm mechanism (250) for guiding the door (2) as the door (2) moves, the door (2) being movable in the width direction and the front-rear direction of the vehicle via the slidable base (4),

wherein the swingable arm mechanism (250) includes:

two pillars (551) provided on the body, the pillars (551) being spaced away from each other in the front-rear direction of the vehicle, the pillars (551) extending in a height direction of the vehicle;

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two upper arms (552) supporting an upper portion of the door (2), the upper arms (552) being rotatable integrally with the pillars (551) around the pillars (551); and

two lower arms supporting a lower portion of the door (2), the lower arms being rotatable integrally with the pillars (551) around the pillars (551), and

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wherein the movement alignment mechanism (500) includes:

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the two pillars (551) configured to apply the rotational power acting within the plane;

two pillar-side gears (501) rotatable integrally with the pillars (551) around the pillars (551);

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an intermediate gear (502) engaged with one of the pillar-side gears (501); and

a toothed belt (503) engaged with the other of the two pillar-side gears (501) and the intermediate gear (502).

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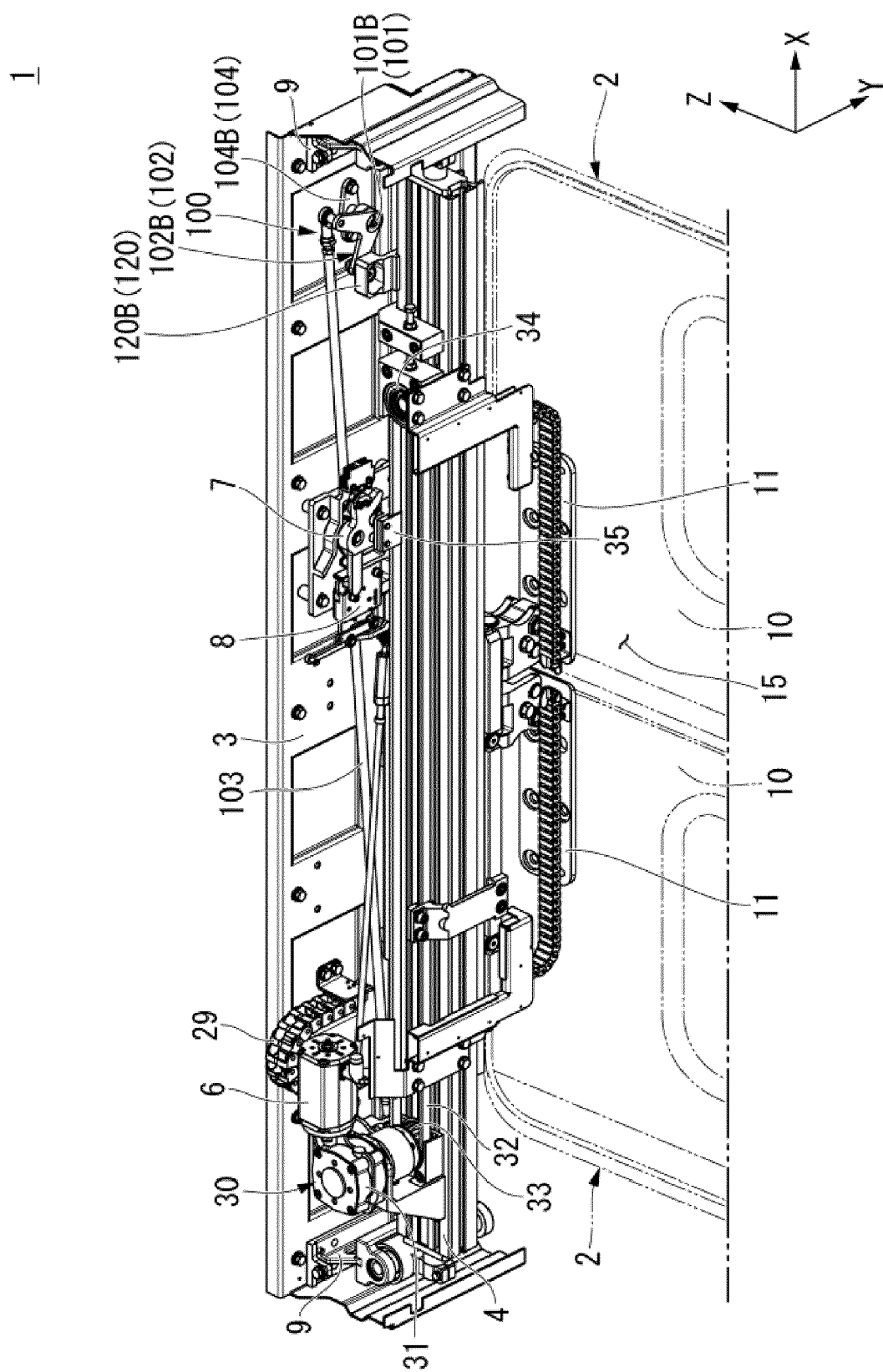


Fig. 1

100

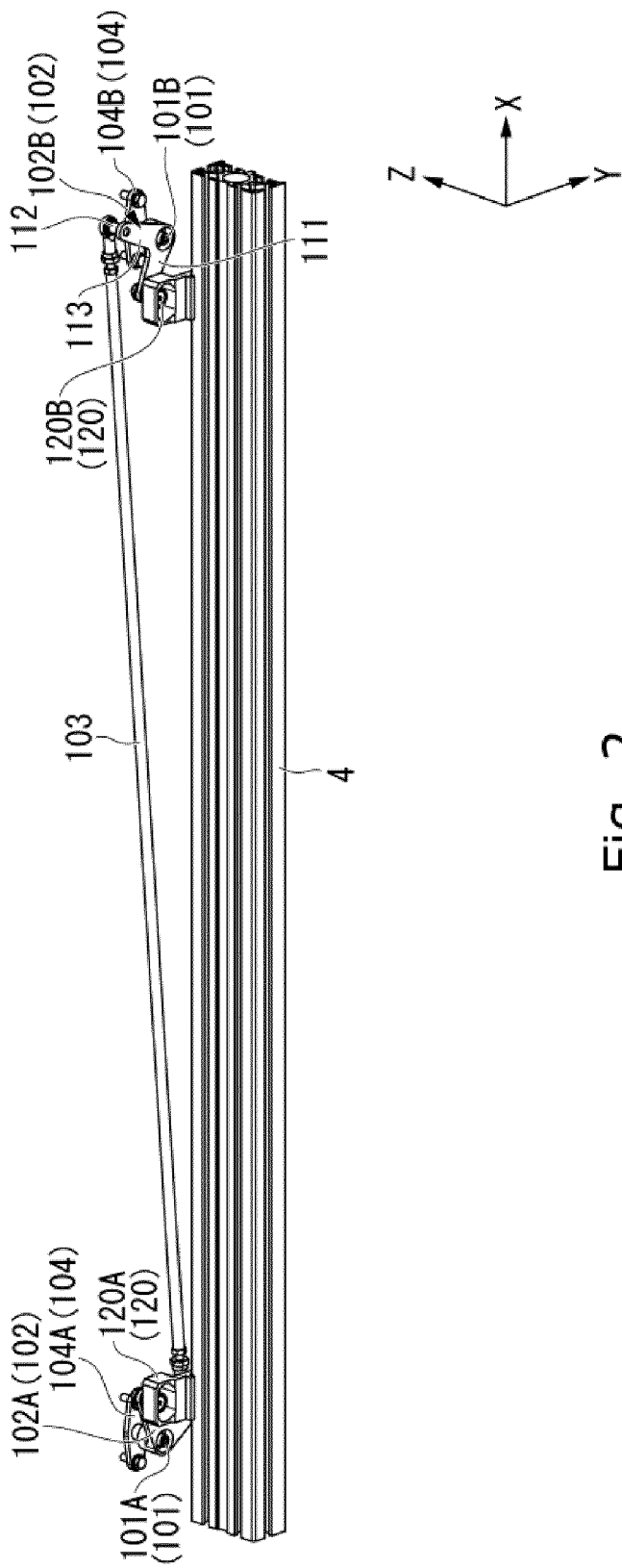


Fig. 2

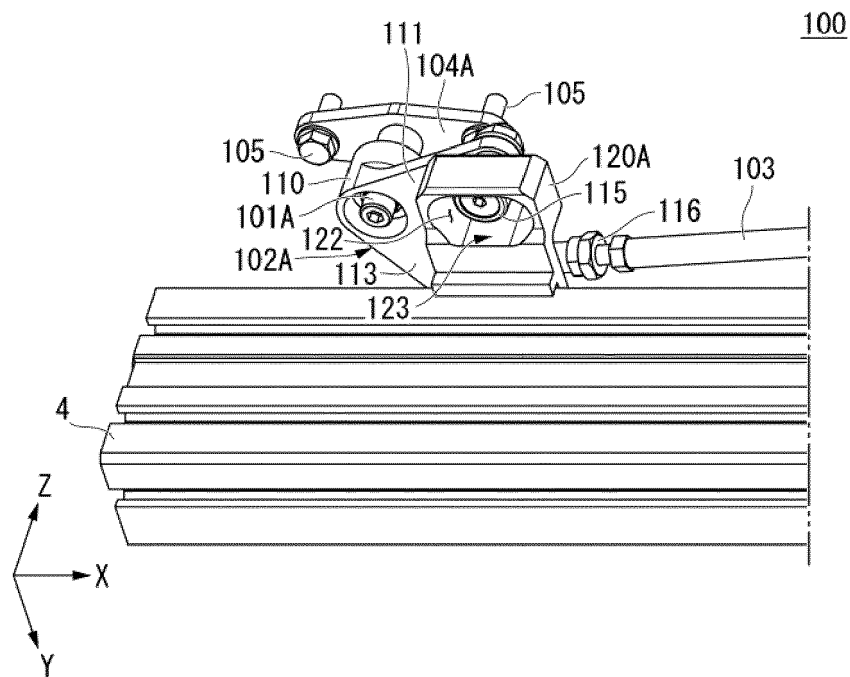


Fig. 3

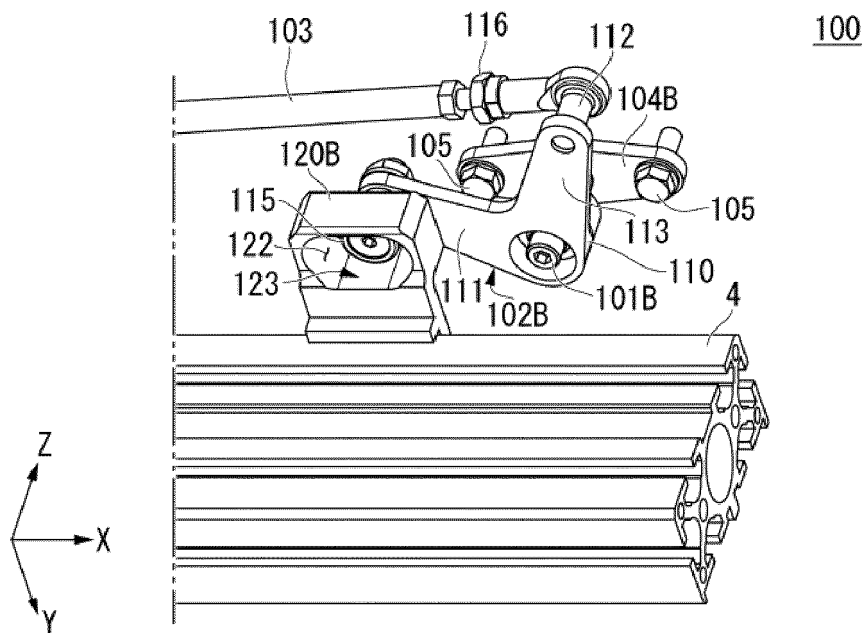


Fig. 4

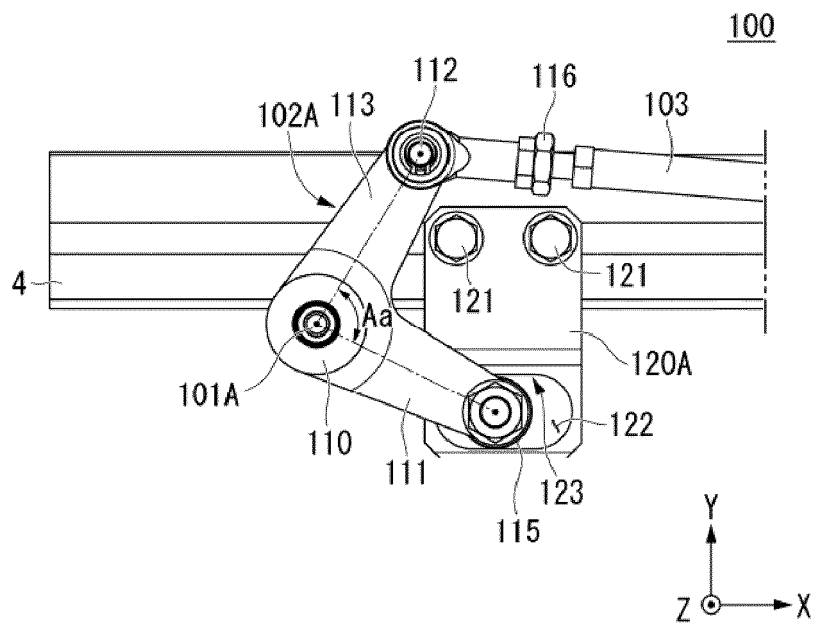


Fig. 5

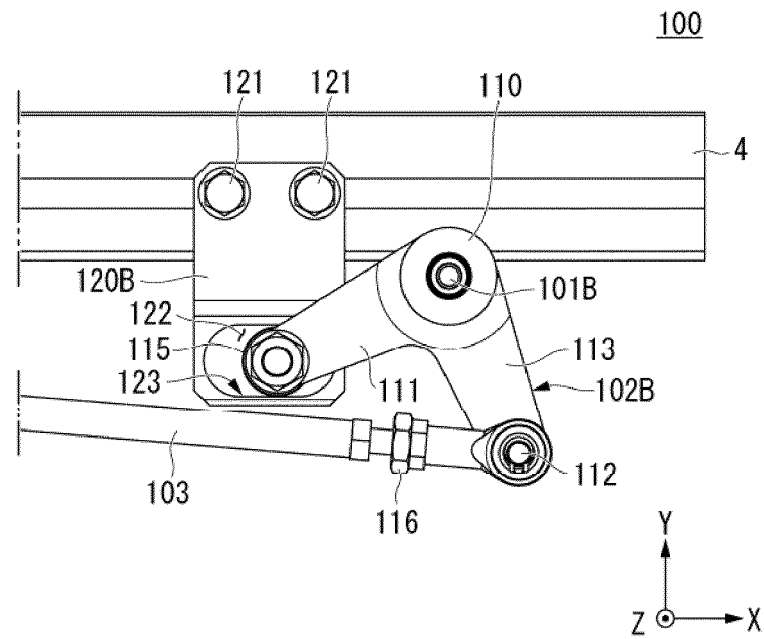


Fig. 6

100

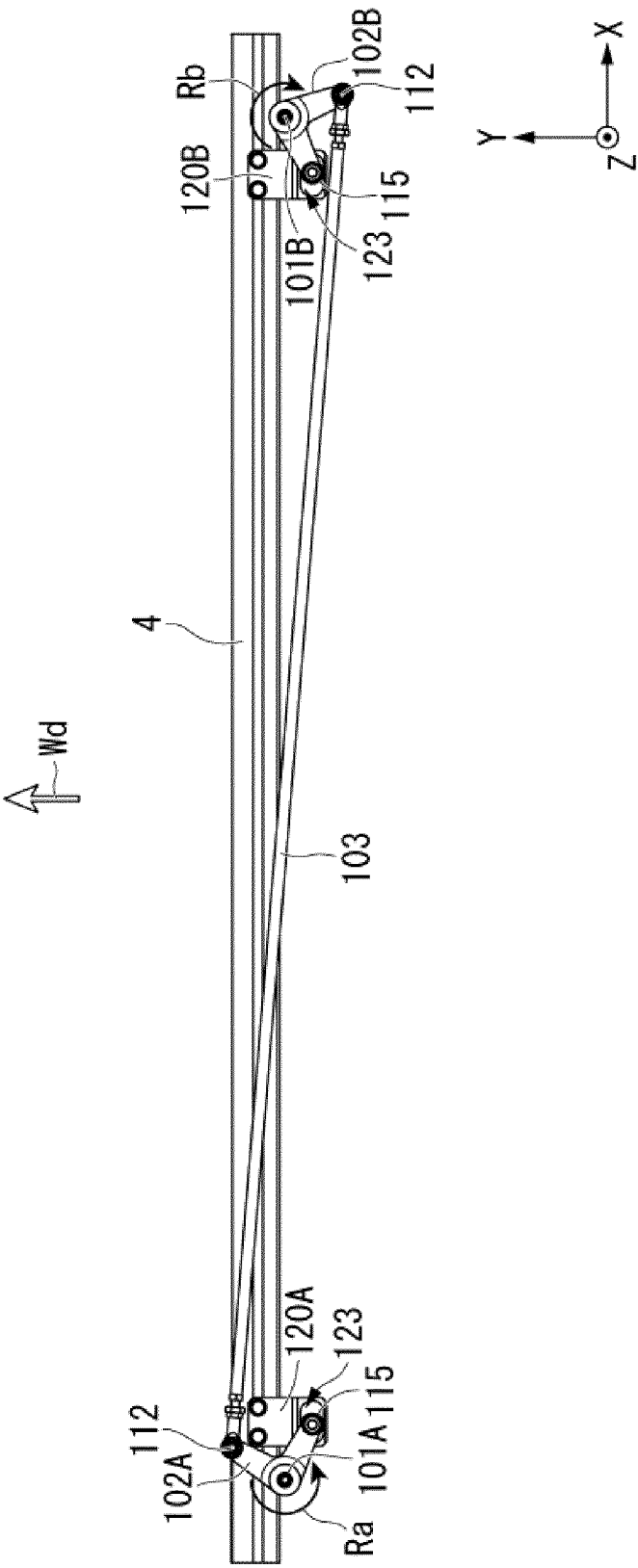


Fig. 7

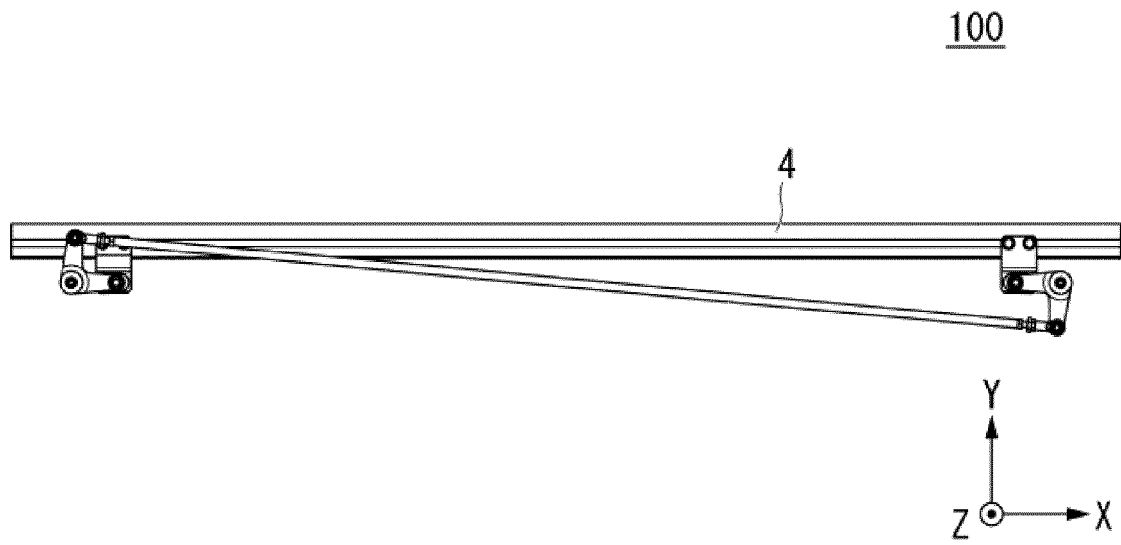


Fig. 8

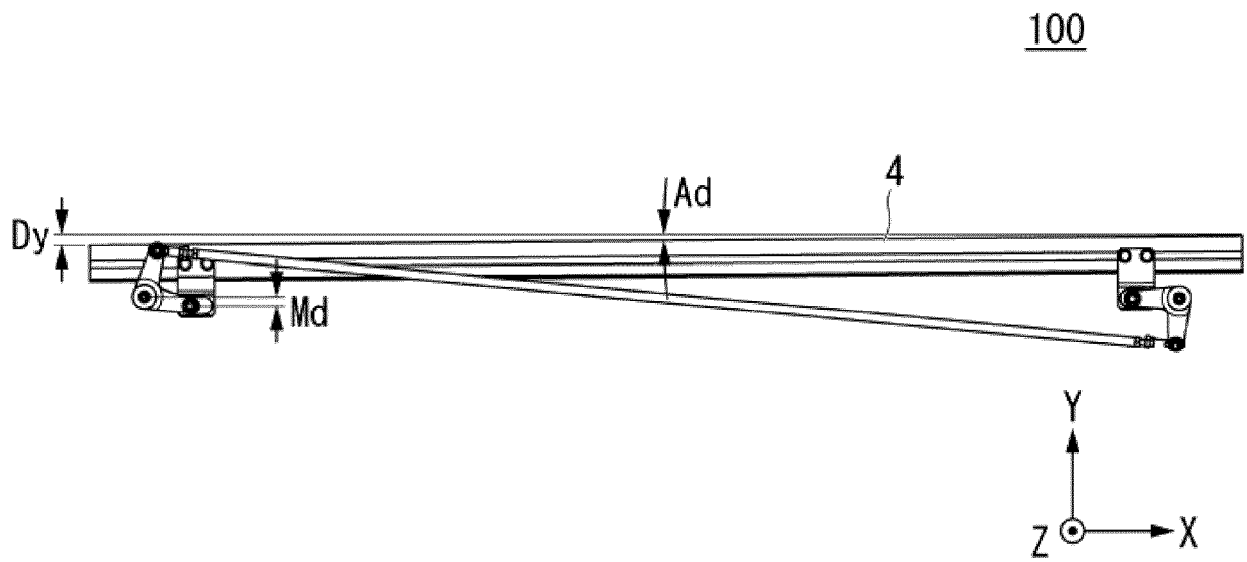


Fig. 9

2001

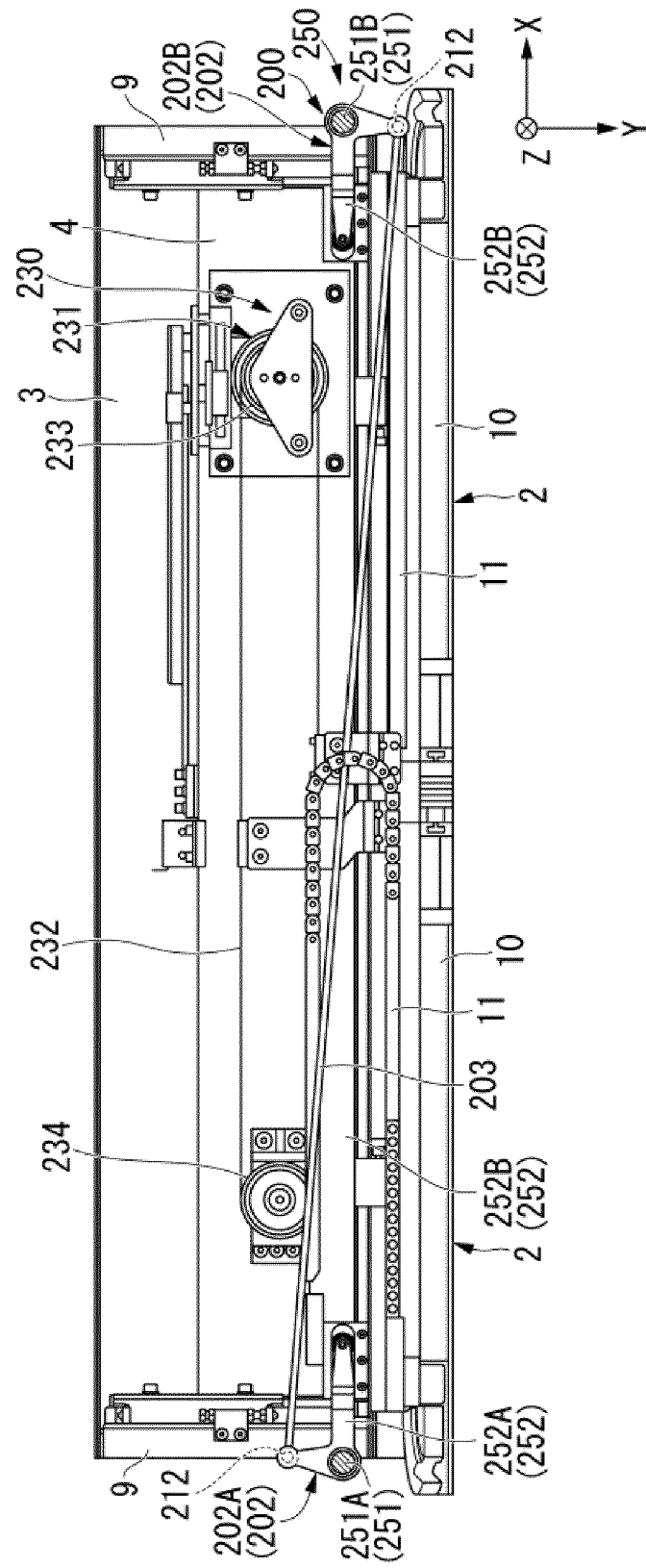


Fig. 10

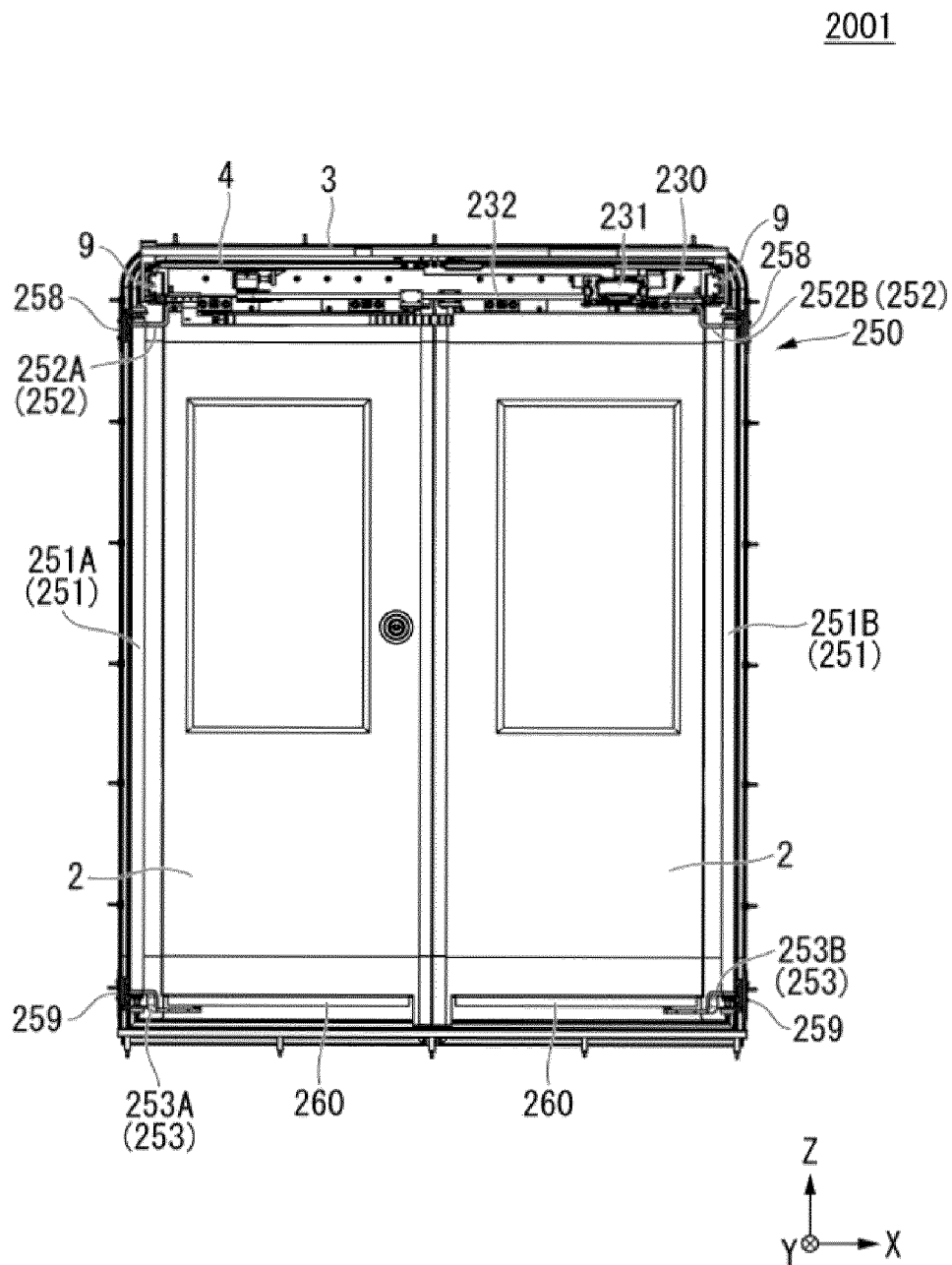


Fig. 11

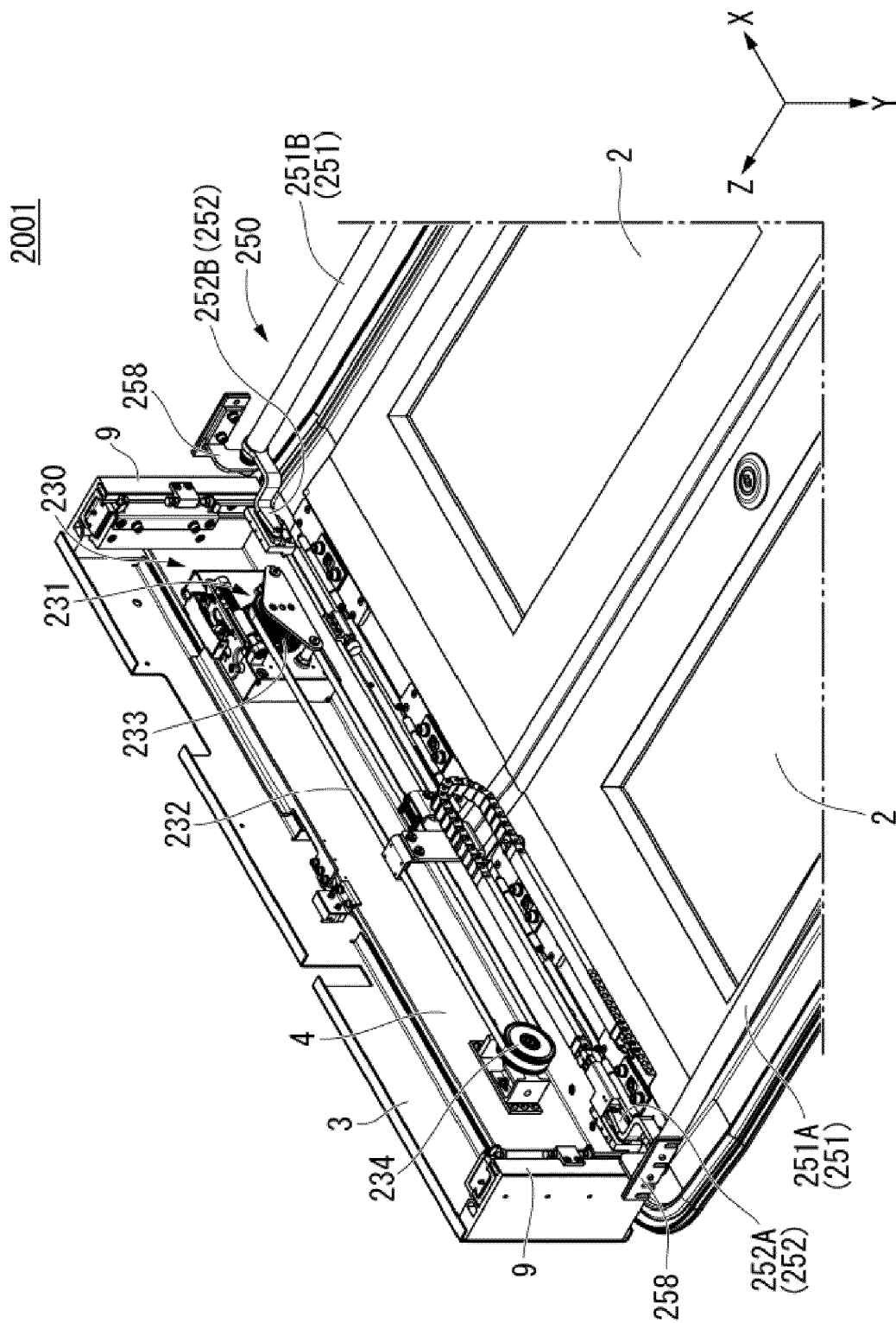


Fig. 12

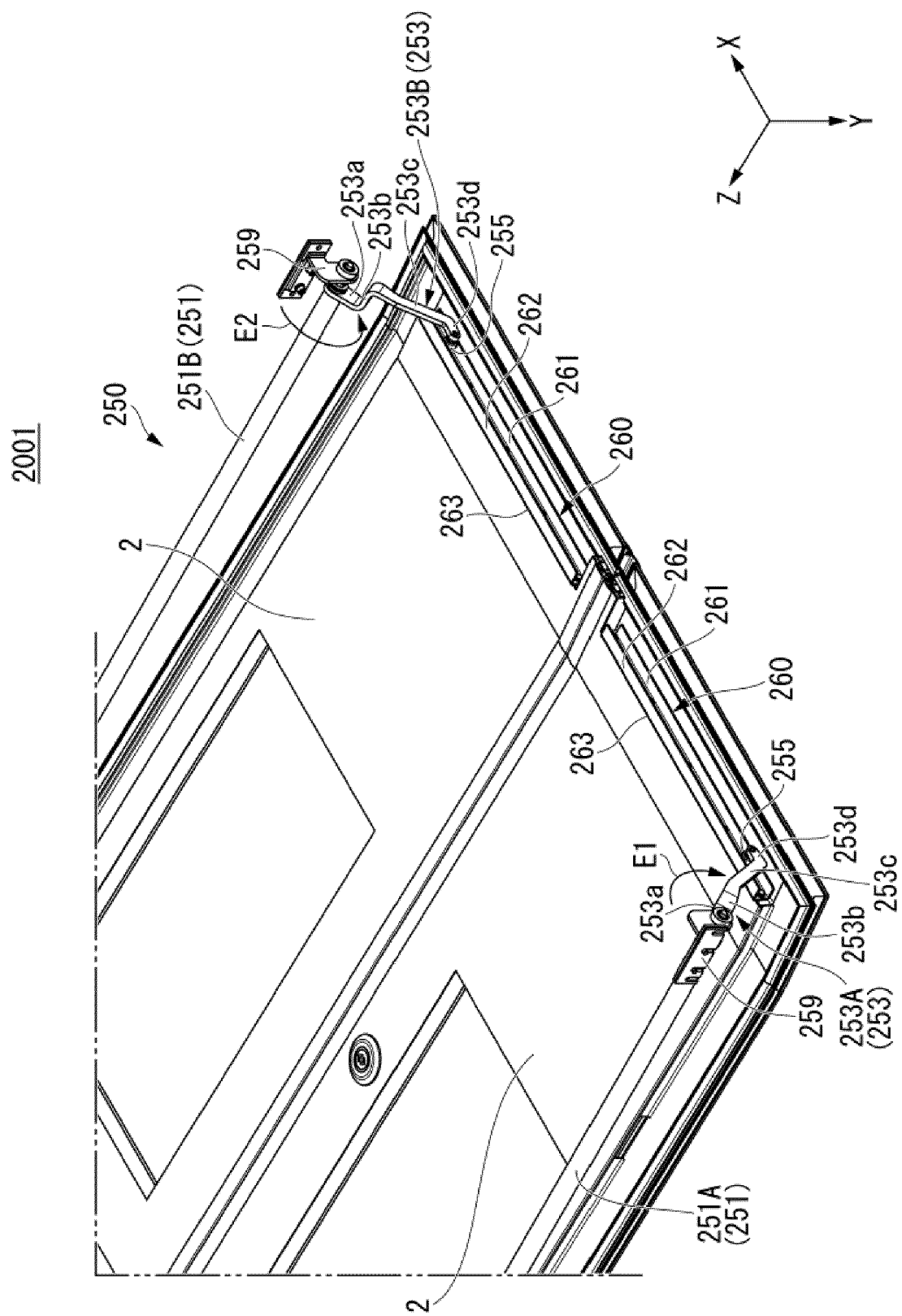


Fig. 13

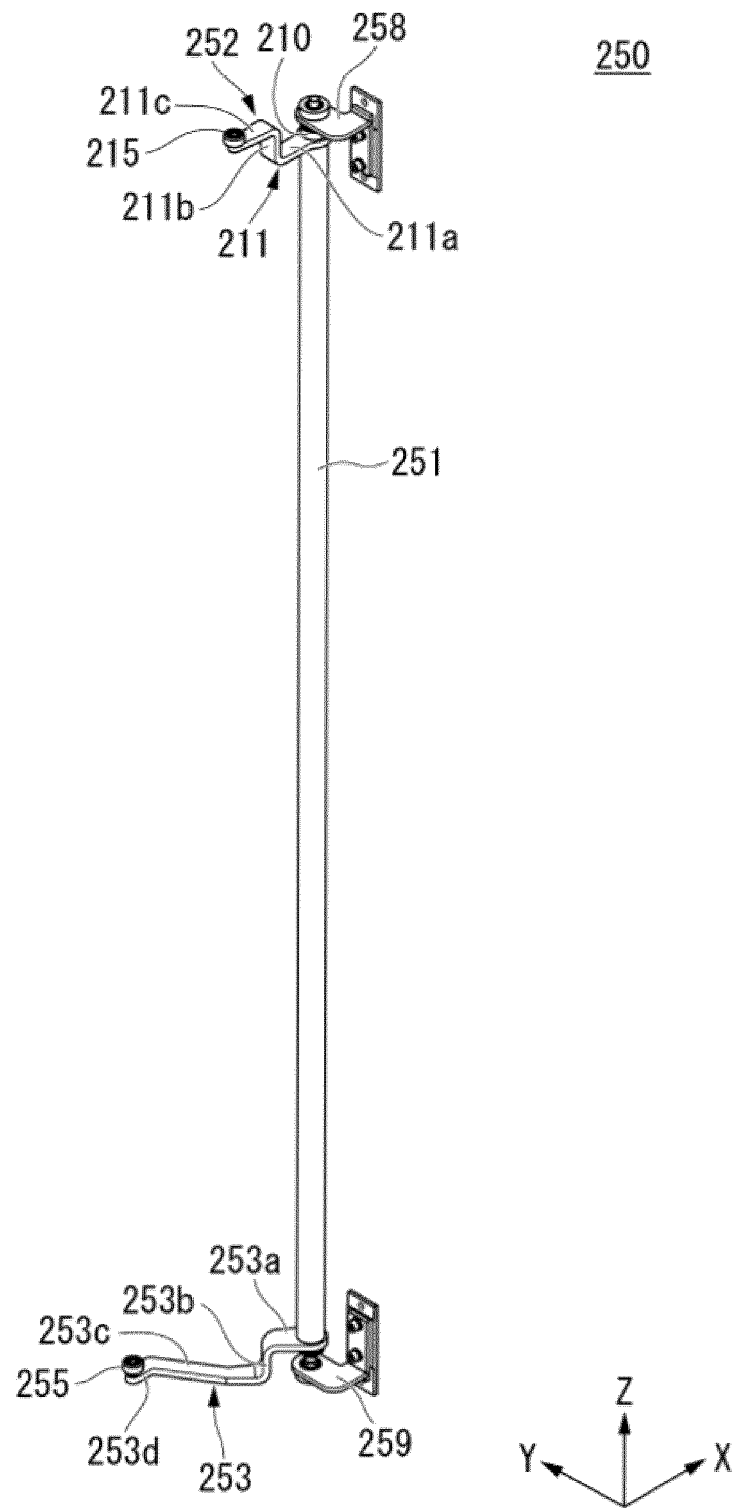


Fig. 14

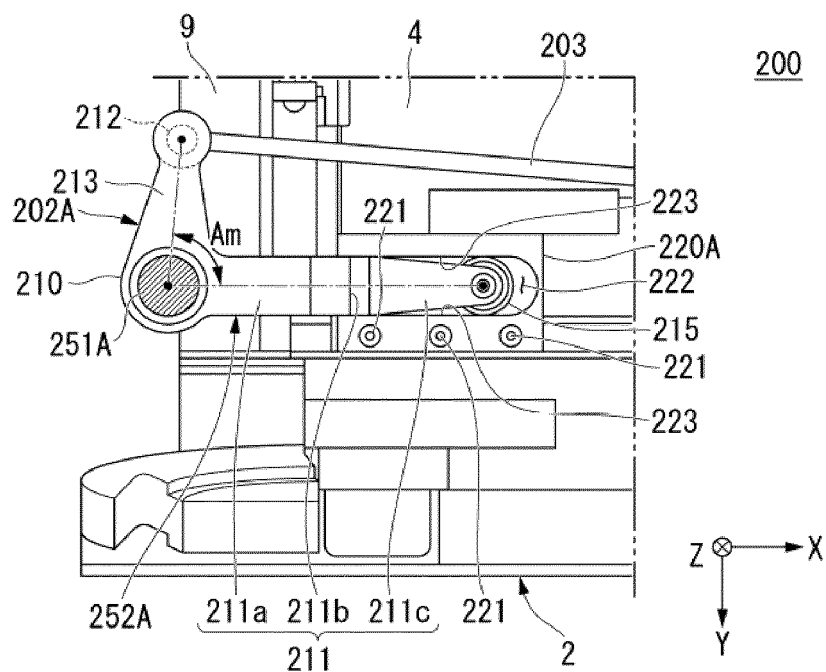


Fig. 15

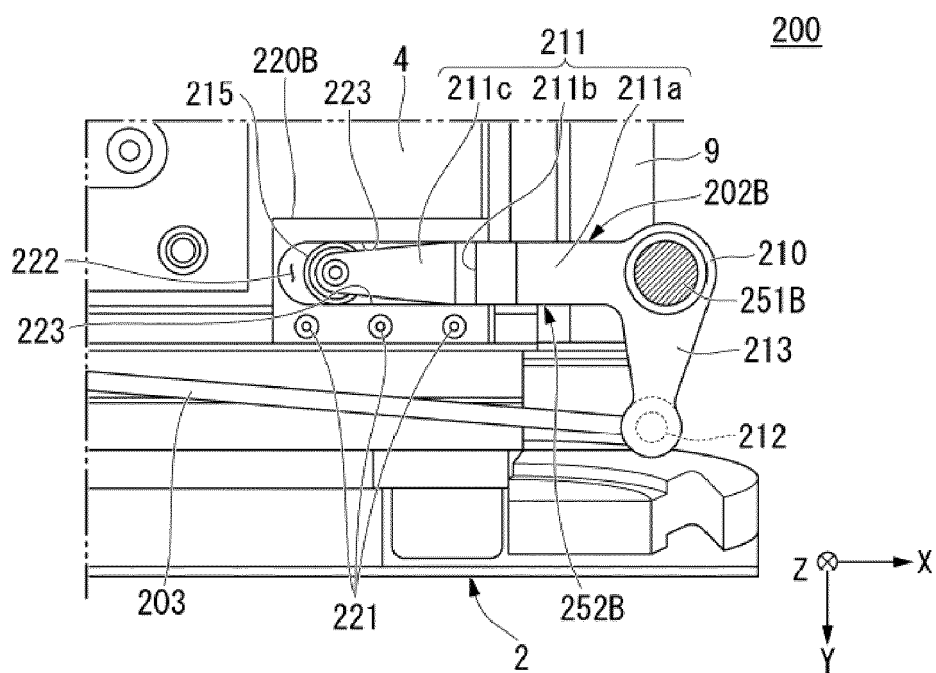


Fig. 16

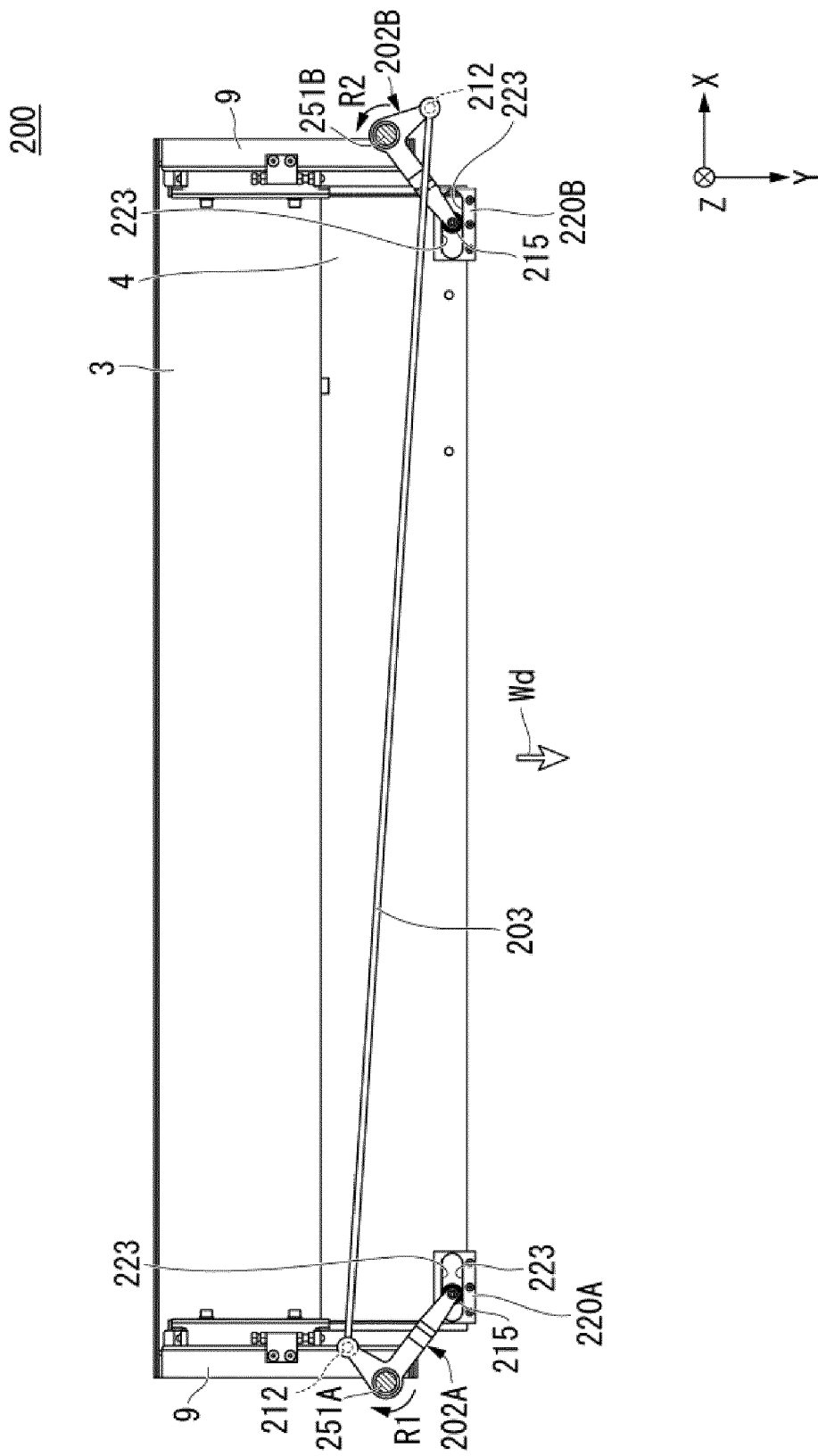


Fig. 17

300

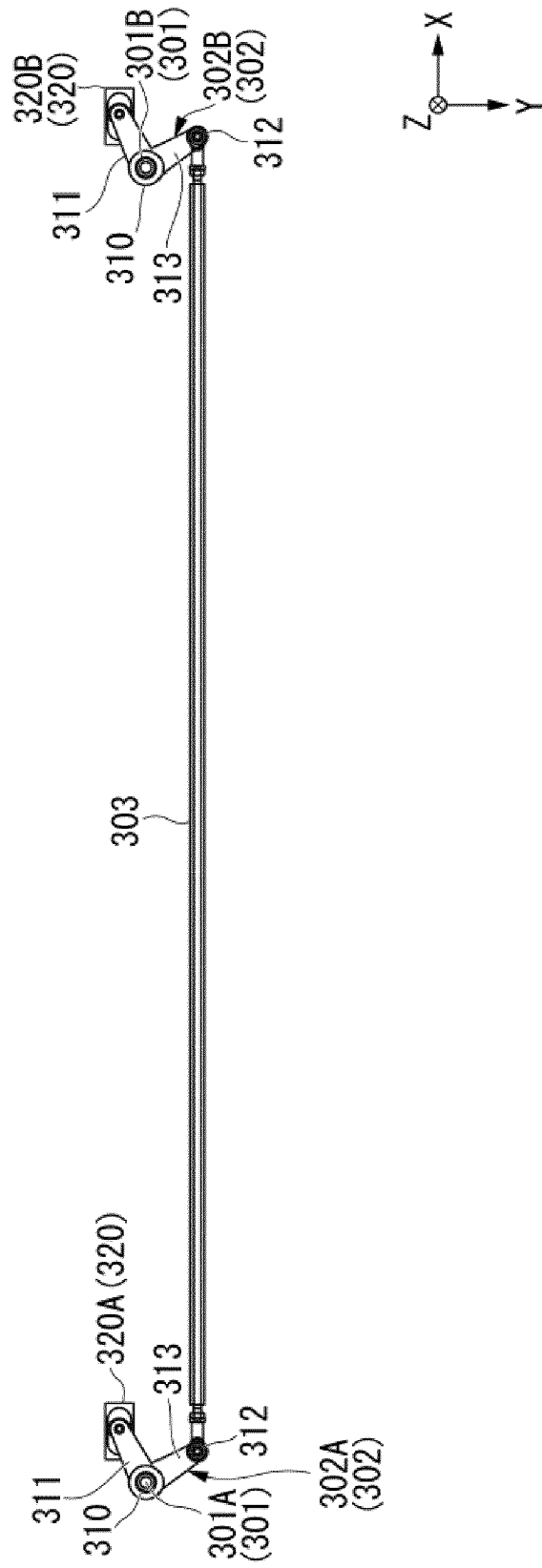


Fig. 18

300

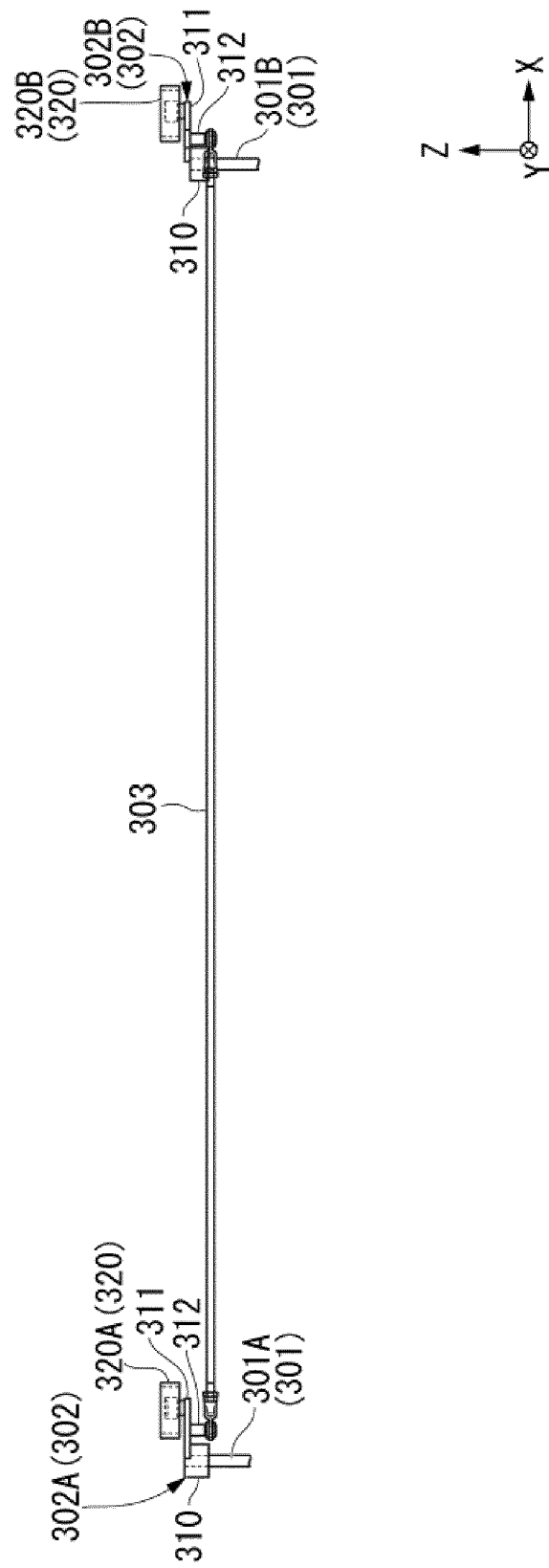


Fig. 19

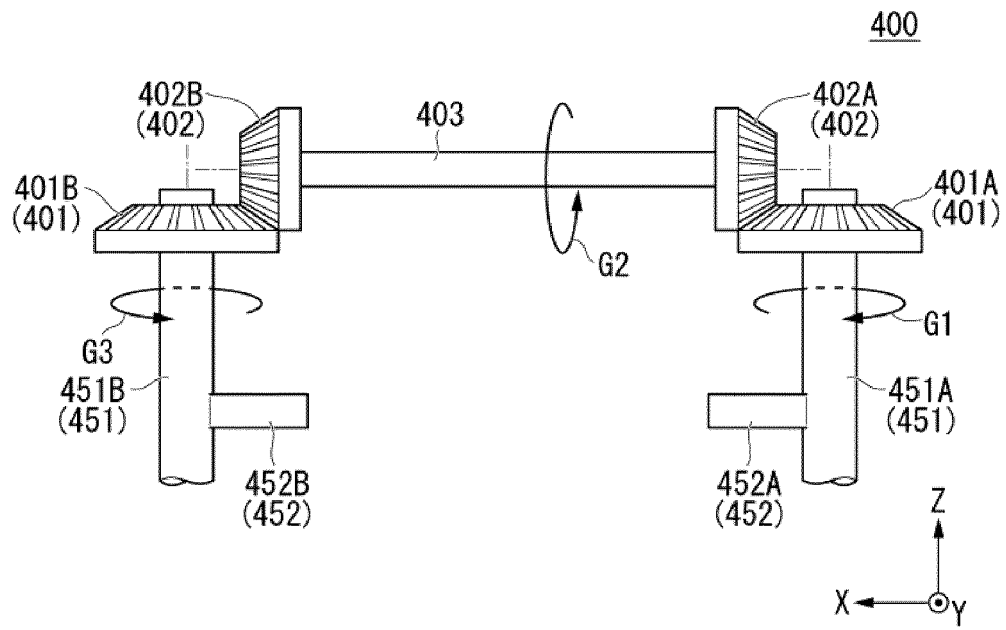


Fig. 20

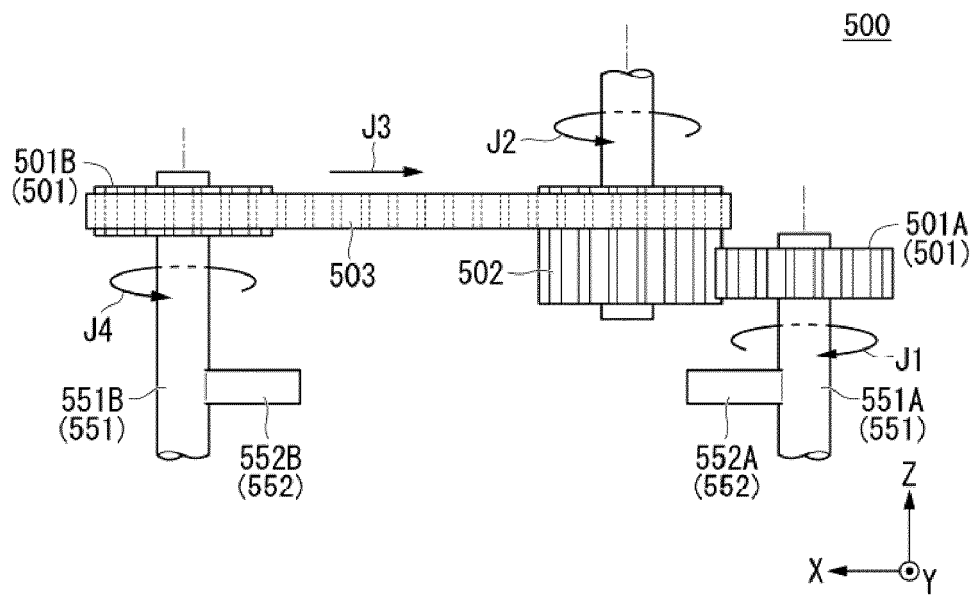


Fig. 21



EUROPEAN SEARCH REPORT

Application Number

EP 21 20 1204

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Y	EP 0 195 880 B1 (CAIMI EXPORT SPA [IT]) 20 December 1989 (1989-12-20) * column 2, line 45 - column 4, line 34; figures 1-7 *	1-7	TECHNICAL FIELDS SEARCHED (IPC) E05D E05F
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Place of search The Hague		Date of completion of the search 14 March 2022	Examiner Viethen, Lorenz
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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ON EUROPEAN PATENT APPLICATION NO.**

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