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(54) **PLUG DOOR OPENING/CLOSING DEVICE**

(57) A plug door opening/closing device (4; 104) is configured to move a door leaf (3; 103) in a widthwise direction of an entrance (2; 102) to open or close the entrance (2; 102). The plug door opening/closing device (4; 104) includes a movable body (5; 105) and a lock link (70; 107). The movable body (5; 105) is moved together with the door leaf (3; 103) from a fully closed position via a plug-out position to a fully open position. The lock link (70; 107) is moved together with the movable body (5; 105) in a state maintaining relative positions of the movable body (5; 105) and the door leaf (3; 103) as the door leaf (3; 103) moves from the plug-out position to the fully open position.

Fig.1(a)

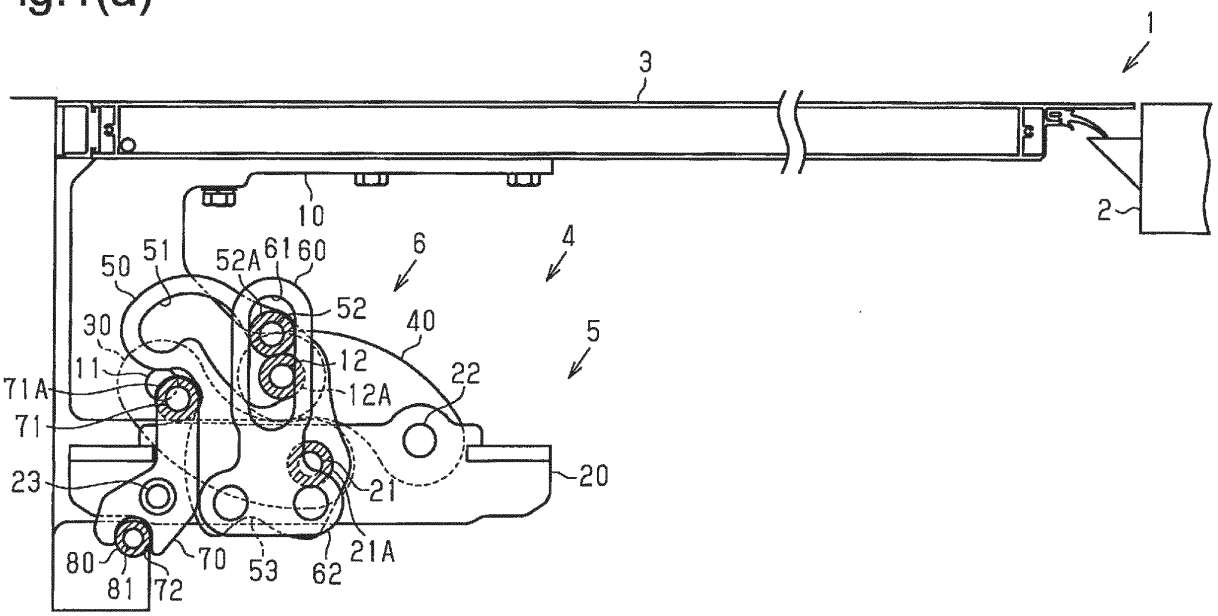

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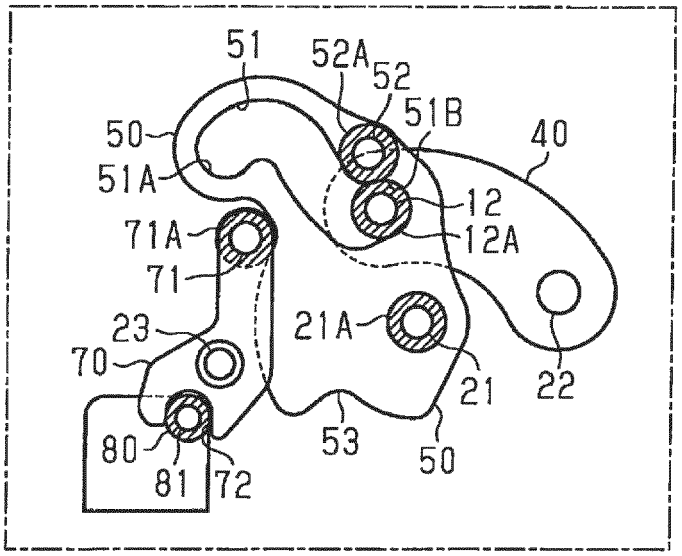
Fig.1(b)



Description

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

[0002] An entrance of a vehicle is provided with a plug door apparatus that generates an opening/closing action that opens or closes a door leaf and a plug action that moves the door leaf in a transverse direction of the vehicle. The plug door apparatus includes a plug door opening/closing device that opens and closes the door leaf.

[0003] Japanese Laid-Open Patent Publication No. 10-169298 describes a plug door apparatus that moves a carriage on a support rail to open or close the door leaf. Guide rollers travel in the guide rail so that a plug action of the door leaf is generated.

[0004] The plug door apparatus described in Japanese Laid-Open Patent Publication No. 10-169298 requires the guide rail that guides the guide rollers to generate the plug action of the door leaf. The guide rail extends over the entire entrance of the vehicle in the widthwise direction of the entrance. This increases the space occupied by the plug door opening/closing device.

[0005] Accordingly, it is an objective of the present invention to provide a plug door opening/closing device that reduces the space occupied by the plug door opening/closing device.

[0006] To achieve the above objective and in accordance with one aspect of the present invention, a plug door opening/closing device is provided that is configured to move a door leaf in a widthwise direction of an opening to open or close the opening. The plug door opening/closing device includes a movable body and a stopper. The movable body is moved together with the door leaf from a fully closed position via a plug-out position to a fully open position. The stopper is moved together with the movable body in a state maintaining relative positions of the movable body and the door leaf as the door leaf moves from the plug-out position to the fully open position.

[0007] With the above configuration, the door leaf can be moved in the widthwise direction of the opening as the movable body moves the door leaf from the plug-out position to the fully open position while the stopper maintains the relative positions of the movable body and the door leaf. This eliminates the need for a guide rail used to generate a plug action. Thus, the space occupied by the plug door opening/closing device can be reduced.

[0008] Preferably, in the plug door opening/closing device described above, the movable body includes a base moved in the widthwise direction of the opening and a plugging unit configured to change a relative distance between the base and the door leaf in a plugging direction that is orthogonal to the widthwise direction of the opening. Preferably, the stopper restricts movement of the plugging unit.

[0009] With the above configuration, the stopper restricts the movement of the plugging unit that changes the relative distance between the door leaf and the base. This limits changes in the relative distance between the base and the door leaf even when the door leaf is operated in a plug-out state.

[0010] Preferably, in the plug door opening/closing device described above, the plugging unit includes a link mechanism.

[0011] With the above configuration, the link mechanism changes the relative distance between the base and the door leaf in the plugging direction. Thus, when the door leaf approaches the base, the link mechanism folds and reduces the space occupied by the plug door opening/closing device.

[0012] Preferably, in the plug door opening/closing device described above, the plugging unit includes a four-joint link.

[0013] With the above configuration, the four-joint link changes the relative distance between the base and the door leaf in the plugging direction. Thus, when the door leaf approaches the base, the four-joint link folds and reduces the space occupied by the plug door opening/closing device. Further, in the four-joint link, the opposing links extending in the plugging direction may have different lengths so that the front end and rear end of the door leaf in the widthwise direction of the opening move along different paths.

[0014] Preferably, the plug door opening/closing device described above includes a lock mechanism configured to lock the base at the fully closed position by movement of the plugging unit when the door leaf is moved from the plug-out position to the fully closed position.

[0015] With the above configuration, the lock mechanism locks the base when the plugging unit generates a plug-in action, that is, when the plugging unit moves the door leaf from the plug-out position to the fully closed position. This restricts movement of the base even when the door leaf is operated in a fully closed state.

[0016] The plug door opening/closing device according to the present invention succeeds in reducing the space occupied by the plug door opening/closing device.

[0017] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

[0018] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1(a) is a plan view showing a plug door opening/closing device in accordance with a first embodiment illustrating a fully closed and locked state;

Fig. 1(b) is a plan view showing part of the plug door opening/closing device in accordance with the first embodiment;

Fig. 2 is a left view of the plug door opening/closing device in accordance with the first embodiment;

Fig. 3 is a cross-sectional view of the plug door open-

ing/closing device in accordance with the first embodiment;

Fig. 4(a) is plan view of the plug door opening/closing device in accordance with the first embodiment illustrating an opening action;

Fig. 4(b) is a plan view showing part of the plug door opening/closing device in accordance with the first embodiment;

Fig. 5(a) is a plan view of the plug door opening/closing device in accordance with the first embodiment illustrating a plug-out action;

Fig. 5(b) is a plan view showing part of the plug door opening/closing device in accordance with the first embodiment;

Fig. 6(a) is a plan view of the plug door opening/closing device in accordance with the first embodiment illustrating an opening action;

Fig. 6(b) is a plan view showing part of the plug door opening/closing device in accordance with the first embodiment;

Fig. 7 is a plan view of the plug door opening/closing device in accordance with the first embodiment illustrating an opening action;

Figs. 8(a) and 8(b) are plan views of a plug door opening/closing device in accordance with a second embodiment illustrating a fully closed and locked state;

Fig. 9 is a cross-sectional view of the plug door opening/closing device in accordance with the second embodiment;

Fig. 10 is a plan view of the plug door opening/closing device in accordance with the second embodiment;

Fig. 11 is a plan view of the plug door opening/closing device in accordance with the second embodiment illustrating a plug-out action;

Fig. 12 is a plan view of the plug door opening/closing device in accordance with the second embodiment illustrating an opening action;

Fig. 13 is a plan view of the plug door opening/closing device in accordance with the second embodiment illustrating an opening action;

Fig. 14 is a plan view of a plug door opening/closing device in accordance with a modified example illustrating a fully closed state; and

Fig. 15 is a plan view of the plug door opening/closing device in accordance with the modified example illustrating a plug-out state.

First Embodiment

[0019] A plug door apparatus including a plug door opening/closing device in accordance with a first embodiment will now be described with reference to Figs. 1(a) to 7.

[0020] As shown in Fig. 1(a), an entrance 2 of a vehicle, such as a railway vehicle, is provided with a plug door apparatus 1 that generates an opening/closing action to open or close a door leaf 3 and a plug action to move the door leaf 3 in a plugging direction (i.e., vehicle transverse direction) that is orthogonal to the widthwise direction of the entrance 2. The plug door apparatus 1 includes the door leaf 3 and a plug door opening/closing device 4 that generates the opening/closing action and the plug action with the door leaf 3. The entrance 2 corresponds to an opening.

[0021] The plug door opening/closing device 4 includes a door bracket 10 and a movable body 5. The door leaf 3 is mounted on the door bracket 10. The movable body 5 moves in the widthwise direction of the entrance 2 while holding the door bracket 10. The movable body 5 includes a main block 20 serving as a base that is movable in the widthwise direction of the entrance 2. The door leaf 3, the door bracket 10, and the main block 20 are arranged in order in the plugging direction from the side closer to the entrance 2. The main block 20 is supported by a support rail (not shown) so as to be movable in the widthwise direction of the entrance 2.

[0022] As shown in Figs. 1(a) and 1(b), the movable body 5 includes a plug mechanism 6 serving as a plugging unit configured to change the relative distance between the main block 20 and the door bracket 10 in the plugging direction. The plug mechanism 6 includes a front arm 30 and a rear arm 40 coupling the door bracket 10 and the main block 20. The door bracket 10 and the main block 20 are located at the same height in the vertical direction. The main block 20 supports the door bracket 10 with the front arm 30 and the rear arm 40 that construct a four-joint, equal-length link. The front arm 30 has one end rotationally coupled to the door bracket 10 by a first rotation shaft 11 and another end rotationally coupled to the main block 20 by a second rotation shaft 21. The second rotation shaft 21 projects upward from the main block 20. The rear arm 40 has one end rotationally coupled to the door bracket 10 by a third rotation shaft 12. The third rotation shaft 12 projects upward from the door bracket 10. The rear arm 40 has another end rotationally coupled to the main block 20 by a fourth rotation shaft 22. When the entrance 2 is in a fully closed state as shown in Fig. 1(a), the door leaf 3 and the movable body 5 are located at a fully closed position.

[0023] As shown in Figs. 2 and 3, the front arm 30 and the rear arm 40 are located in an open space defined by the door bracket 10 and the main block 20. The first rotation shaft 11 is fixed to the door bracket 10 and rotatable relative to the front arm 30. The second rotation shaft 21 is fixed to the main block 20 and rotatable relative to the front arm 30. A guide bearing 21A is arranged on the second rotation shaft 21. The third rotation shaft 12 is fixed to the door bracket 10 and rotatable relative to the rear arm 40. The fourth rotation shaft 22 is fixed to the main block 20 and rotatable relative to the rear arm 40.

[0024] Referring to Fig. 1(a), the plug mechanism 6 rotates the front arm 30 and the rear arm 40 to change the relative distance between the door bracket 10 and the main block 20 in the plugging direction.

[0025] The plug mechanism 6 includes a guide link 50

supported by the second rotation shaft 21 in a rotatable manner. The guide link 50 is located upward in the vertical direction from the main block 20 and the door bracket 10. The guide link 50 includes a first guide groove 51 that guides the third rotation shaft 12. A first guide bearing 12A is arranged on the third rotation shaft 12. The first guide bearing 12A is in contact with the first guide groove 51. The first guide groove 51 is a substantially Z-shaped groove having a depth that is equal to the width of the first guide bearing 12A. The first guide groove 51 is bent at a left end 51A and a right end 51B. Thus, when the first guide bearing 12A is fitted in the left end 51A or right end 51B of the first guide groove 51, the first guide bearing 12A will not be separated from the left end 51A or right end 51B of the first guide groove 51 unless the guide link 50 rotates. The guide link 50 serves as a swing link that transmits movement of a drive bracket 60 to the rear arm 40. Thus, the rear arm 40 is rotated about the fourth rotation shaft 22 as the first guide groove 51 of the guide link 50 guides the third rotation shaft 12. The guide link 50 includes an upwardly projecting fifth rotation shaft 52.

[0026] The plug mechanism 6 includes the drive bracket 60 that is coupled to the fifth rotation shaft 52. The drive bracket 60 is located upward in the vertical direction from the guide link 50. The drive bracket 60 includes a second guide groove 61 that guides the fifth rotation shaft 52 of the guide link 50. A second guide bearing 52A is arranged on the fifth rotation shaft 52. The second guide bearing 52A is in contact with the second guide groove 61. The second guide groove 61 extends from the main block 20 toward the door leaf 3, that is, in the plugging direction. The drive bracket 60 is fixed to a driving device, such as a ball screw, and acts as a drive link moved by the driving device in the widthwise direction of the entrance 2. The drive bracket 60 includes a mount 62 on which the driving device is mounted. The guide link 50 is rotated about the second rotation shaft 21 on the main block 20 as the movement of the drive bracket 60 in the widthwise direction of the entrance 2 guides the fifth rotation shaft 52 in the second guide groove 61.

[0027] The main block 20 includes an upwardly projecting sixth rotation shaft 23. The plug door opening/closing device 4 includes a lock link 70 supported by the sixth rotation shaft 23 in a rotatable manner. The lock link 70 is located upward in the vertical direction from the door bracket 10 and the main block 20. The sixth rotation shaft 23 is coupled to the middle of the lock link 70. A seventh rotation shaft 71 is arranged on one end of the lock link 70. The seventh rotation shaft 71 is in contact with the guide link 50. A third guide bearing 71A is arranged on the seventh rotation shaft 71. The third guide bearing 71A is in contact with the edge of the guide link 50. A portion of the guide link 50 proximate to the main block 20 includes an engagement groove 53 that engages the third guide bearing 71A of the lock link 70. Engagement of the third guide bearing 71A with the engagement groove 53 of the guide link 50 restricts rotation of the guide link 50. The lock link 70 has another end that defines an engagement portion 72. The engagement portion 72 is a semicircular cutout portion. The lock link 70 acts as a stopper.

[0028] The plug door opening/closing device 4 includes a lock roller 80 fixed to the entrance 2. The lock roller 80 is rotated about an eighth rotation shaft 81. The engagement portion 72 of the lock link 70 engages the lock roller 80. A state in which the engagement portion 72 of the lock link 70 is engaged with the lock roller 80 is referred to as a lock state in which the main block 20 cannot be moved. Rotation of the lock link 70 disengages the engagement portion 72 of the lock link 70 from the lock roller 80. The lock roller 80 corresponds to a lock mechanism.

[0029] The operation of the plug door apparatus 1 will now be described with reference to Figs. 1(a) to 7. The operation for shifting the door leaf 3 from a fully closed and locked state to an open state will now be described.

[0030] Figs. 1(a) and 2 show the door leaf 3 at a fully closed position in a fully closed and locked state in which the door leaf 3 cannot be moved even when operated. The door bracket 10 and the main block 20 are opposed to each other in the plugging direction with their opposing surfaces in contact with each other. In the lock state, the engagement portion 72 of the lock link 70 is engaged with the lock roller 80, and the lock link 70 and the lock roller 80 cannot move. More specifically, in the lock state, the main block 20 cannot be moved relative to the entrance 2. Further, the lock link 70 cannot be rotated because the third guide bearing 71A of the lock link 70 is in contact with the side surface of the guide link 50. The fifth rotation shaft 52 of the guide link 50 is located toward the door leaf 3 in the second guide groove 61 of the drive bracket 60. The third rotation shaft 12 of the door bracket 10 is located at the right end in the first guide groove 51 of the guide link 50 in the widthwise direction of the entrance 2. The first guide bearing 12A of the third rotation shaft 12 is located at a position where the first guide groove 51 of the guide link 50 restricts the generation of a plug-out action that would move the door leaf 3 outward from the entrance 2.

[0031] Then, referring to Figs. 4(a) and 4(b), when the driving device moves the drive bracket 60 rightward as viewed in the drawings, the second guide bearing 52A, which is engaged with the second guide groove 61 of the drive bracket 60, is moved rightward as viewed in the drawings. Thus, the guide link 50 is rotated clockwise about the second rotation shaft 21 in a plan view to an unlocking initiation position where unlocking is initiated. Then, the first guide bearing 12A of the third rotation shaft 12 is separated from the right end 51B of the first guide groove 51 in the guide link 50. The third guide bearing 71A of the lock link 70 is in contact with the side surface of the guide link 50. Thus, the lock link 70 cannot be rotated. In this state, the front arm 30 and the rear arm 40 are not rotated. Further, the third guide bearing 71A of the lock link 70 is in contact with the side surface of the guide link 50, and the lock link 70 cannot be rotated.

Thus, the door leaf 3 is still in a closed state, and the lock link 70 is still in the lock state.

[0032] Referring to Figs. 5(a) and Fig. 5(b), when the driving device moves the drive bracket 60 further rightward as viewed in the drawings, the second guide bearing 52A, which is engaged with the second guide groove 61 of the drive bracket 60, is moved further rightward as viewed in the drawings. Thus, the guide link 50 is rotated further clockwise about the second rotation shaft 21 in a plan view. The first guide bearing 12A of the third rotation shaft 12 is moved along the first guide groove 51 of the guide link 50 from the right end 51B toward the left end 51A. This rotates the rear arm 40 clockwise about the fourth rotation shaft 22 in a plan view and separates the door bracket 10 from the main block 20. As the rear arm 40 rotates, the front arm 30 is rotated about the second rotation shaft 21. Consequently, the door leaf 3 generates a plug-out action. In this state, the third guide bearing 71A of the lock link 70 is in contact with the side surface of the guide link 50. This maintains the lock state, and the lock link 70 cannot be rotated.

[0033] Referring to Figs. 6(a) and 6(b), when the driving device moves the drive bracket 60 further rightward as viewed in the drawings, the second guide bearing 52A, which is engaged with the second guide groove 61 of the drive bracket 60, is moved further rightward as viewed in the drawings. Thus, the second guide bearing 52A is moved in the second guide groove 61 toward the main block 20, and the guide link 50 is rotated further clockwise about the second rotation shaft 21 in a plan view. The first guide bearing 12A of the third rotation shaft 12 is moved along the first guide groove 51 of the guide link 50 to the right end 51B and fitted in the right end 51B. Consequently, the rear arm 40 is rotated further clockwise about the fourth rotation shaft 22 in a plan view, and the door bracket 10 is separated from the main block 20 by the maximum extent. Thus, the door leaf 3 is in a plug-out state (plug-out position) and projected out of the entrance 2. In this state, when the guide link 50 rotates to the plug-out position, the lock link 70 becomes rotatable, and the engagement portion 72 of the lock link 70 is disengaged from the lock roller 80. The rotation of the guide link 50 engages the third guide bearing 71A of the lock link 70 with the engagement groove 53 of the guide link 50. This restricts rotation of the guide link 50 and maintains the door leaf 3 in the plug-out state.

[0034] Then, as shown in Fig. 7, the lock link 70, the guide link 50, and the front arm 30 are fixed in this state. The door leaf 3 and the main block 20 are maintained in the plug-out state (plug-out position) and moved in the widthwise direction of the entrance 2 in accordance with the movement of the drive bracket 60 to fully open the entrance 2. When the entrance 2 is fully open, the door leaf 3 and the movable body 5 are located at the fully open position.

[0035] When the door leaf 3 generates a plug-in action, that is, when the door leaf 3 projected from the entrance 2 is moved inward back to its original position, the driving device moves the drive bracket 60 leftward. Since rotation of the guide link 50 is restricted, the door bracket 10 and the main block 20 are moved together leftward and maintained in the plug-out state. The engagement portion 72 of the lock link 70 contacts and engages the lock roller 80. This rotates the lock link 70 counterclockwise about the sixth rotation shaft 23 and disengages the third guide bearing 71A from the engagement groove 53 of the guide link 50. In a state in which the guide link 50 is rotatable, when the drive bracket 60 moves leftward, the guide link 50 is rotated counterclockwise about the second rotation shaft 21. Further, the front arm 30 and the rear arm 40 are rotated counterclockwise, and the door bracket 10 is moved toward the main block 20. This shifts the door leaf 3 to a plug-in state in which the door leaf 3 is not projected outward from the entrance 2.

[0036] With the plug door opening/closing device 4, movement of the drive bracket 60 in the widthwise direction of the entrance 2 allows a plug action to be generated to move the door leaf 3 in the vehicle transverse direction. Further, movement of the drive bracket 60 in the widthwise direction of the entrance 2 allows the door leaf 3 to be maintained in a plug-out state and also allows an opening/closing action to be generated with the door leaf 3. Moreover, the plug door opening/closing device 4 uses the guide link 50 to transmit movement of the drive bracket 60 to the rear arm 40 in order to generate a plug action and opening/closing action with the door leaf 3. Further, engagement of the lock link 70 with the guide link 50 maintains the door leaf 3 in a plug-out state. Thus, maintenance related with each function can be performed with just the rear arm 40.

[0037] As described above, the present embodiment has the advantages described below.

(1) As the movable body 5 moves the door leaf 3 from a plug-out position to the fully open position, the door leaf 3 can be moved in the widthwise direction of the entrance 2 while the lock link 70 continuously maintains the relative positions of the movable body 5 and the door leaf 3. Thus, a plug action can be generated without a guide rail. This allows for reduction in the space occupied by the plug door opening/closing device 4.

(2) The lock link 70 restricts movement that changes the relative distance between the door leaf 3 and the main block 20 of the plug mechanism 6. Thus, even if the door leaf 3 is operated in a plug-out state, changes are restricted in the relative distance between the main block 20 and the door leaf 3.

(3) The link mechanism changes the relative distance between the door leaf 3 and the main block 20 in the plugging direction. Thus, when the door leaf 3 approaches the main block 20, the link mechanism folds and reduces the space occupied by the plug door opening/closing device 4.

(4) The plug-in action of the plug mechanism 6, that is, movement of the door leaf 3 from the plug-out

position to the fully closed position generated by the plug mechanism 6 locks the main block 20 with the lock roller 80. This restricts movement of the main block 20 even if the door leaf 3 is operated in the fully closed state.

Second Embodiment

[0038] A plug door apparatus including a plug door opening/closing device in accordance with a second embodiment will now be described with reference to Figs. 8(a) to 13. The second embodiment differs from the first embodiment in that the drive bracket is coupled to the rear arm and in that the guide link is engaged with the front arm. The description hereafter will focus on the differences from the first embodiment.

[0039] As shown in Fig. 8(a), an entrance 102 is provided with a plug door apparatus 101 that generates an opening/closing action to open or close a door leaf 103 and a plug action to move the door leaf 103 in a plugging direction (i.e., vehicle transverse direction) that is orthogonal to the widthwise direction of the entrance 102. The plug door apparatus 101 includes the door leaf 103 and a plug door opening/closing device 104 that generates the opening/closing action and the plug action with the door leaf 103. The entrance 102 corresponds to an opening.

[0040] The plug door opening/closing device 104 includes a door bracket 110 and a movable body 105. The door leaf 103 is mounted on the door bracket 110. The movable body 105 moves in the widthwise direction of the entrance 102 while holding the door bracket 110. The movable body 105 includes a main block 120 serving as a base that is movable in the widthwise direction of the entrance 102. The door leaf 103, the door bracket 110, and the main block 120 are arranged in order in the plugging direction from the side closer to the entrance 102. The main block 120 is supported by a support rail (not shown) so as to be movable in the widthwise direction of the entrance 102.

[0041] The movable body 105 includes a plug mechanism 106 serving as a plugging unit configured to change the relative distance between the main block 120 and the door bracket 110 in the plugging direction. The plug mechanism 106 includes a front arm 130 and a rear arm 140 coupling the door bracket 110 and the main block 120. The door bracket 110 and the main block 120 are located at the same height in the vertical direction. The main block 120 supports the door bracket 110 with the front arm 130 and the rear arm 140 that construct a four-joint, equal-length link. The front arm 130 has one end rotationally coupled to the door bracket 110 by a first rotation shaft 111 and another end rotationally coupled to the main block 120 by a third rotation shaft 112. A fifth rotation shaft 131 projects upward from the upper surface of the front arm 130. A first guide bearing 131A is arranged on the fifth rotation shaft 131. The rear arm 140 has one end rotationally coupled to the door bracket 110 by a third rotation shaft 112 and another end rotationally coupled to the main block 120 by a fourth rotation shaft 122. A sixth rotation shaft 141 projects upward from the upper surface of the rear arm 140. A second guide bearing 141A is arranged on the sixth rotation shaft 141. When the entrance 102 is in a fully closed state as shown in Fig. 8(a), the door leaf 103 and the movable body 105 are located at a fully closed position.

[0042] The front arm 130 and the rear arm 140 are located in an open space defined by the door bracket 110 and the main block 120 (refer to Fig. 9). The first rotation shaft 111 is fixed to the door bracket 110 and rotatable relative to the front arm 130. The second rotation shaft 121 is fixed to the main block 120 and rotatable relative to the front arm 130. The third rotation shaft 112 is fixed to the door bracket 110 and rotatable relative to the rear arm 140. The fourth rotation shaft 122 is fixed to the main block 120 and rotatable relative to the rear arm 140.

[0043] The plug mechanism 106 rotates the front arm 130 and the rear arm 140 to change the relative distance between the door bracket 110 and the main block 120 in the plugging direction.

[0044] The plug mechanism 106 includes a drive bracket 160 coupled to the sixth rotation shaft 141 of the rear arm 140. The drive bracket 160 is located upward in the vertical direction from the main block 120 and the door bracket 110. The drive bracket 160 includes a first guide groove 161 that guides the second guide bearing 141A of the sixth rotation shaft 141. The first guide groove 161 has a depth that is equal to the width of the second guide bearing 141A. The drive bracket 160 is fixed to a driving device, such as a ball screw, and acts as a drive link moved by the driving device in the widthwise direction of the entrance 102. As the drive bracket 160 moves in the widthwise direction of the entrance 102, the sixth rotation shaft 141 is guided in the first guide groove 161 to rotate the rear arm 140 about the fourth rotation shaft 122 on the main block 120.

[0045] As shown in Fig. 9, the main block 120 includes a mounting plate 125 extending in parallel to and spaced apart from the upper surface of the main block 120. A seventh rotation shaft 151 extends downward in the vertical direction from the mounting plate 125. The seventh rotation shaft 151 extending from the mounting plate 125 is arranged on the main block 120. An eighth rotation shaft 171 extends downward in the vertical direction from the mounting plate 125. The eighth rotation shaft 171 extending from the mounting plate 125 is arranged on the main block 120.

[0046] As shown in Figs. 8(a) and 8(b), the plug mechanism 106 includes a guide link 150 supported by the seventh rotation shaft 151 in a rotatable manner. The guide link 150 is located upward in the vertical direction from the main block 120 and the door bracket 110. Further, the guide link 150 is located upward in the vertical direction from the drive bracket 160. As shown in Fig. 8(b), the guide link 150 has a right surface that contacts

the first guide bearing 131A on the fifth rotation shaft 131 of the front arm 130. This restricts rotation of the guide link 150 about the seventh rotation shaft 151. The guide link 150 has a right end defining a first engagement portion 152 that engages the first guide bearing 131A on the fifth rotation shaft 131 of the front arm 130. The front arm 130 rotates about the second rotation shaft 121 as the first guide bearing 131A of the fifth rotation shaft 131 contacts the right surface of the guide link 150. When the first guide bearing 131A of the fifth rotation shaft 131 reaches the first engagement portion 152 at the right end of the guide link 150, counterclockwise rotation of the front arm 130 is restricted. The guide link 150 acts as a swing link.

[0047] The plug door opening/closing device 104 includes a lock link 170 supported by the eighth rotation shaft 171 in a rotatable manner. The lock link 170 is located upward in the vertical direction from the door bracket 110 and the main block 120. Further, the lock link 170 is located upward in the vertical direction from the guide link 150. The eighth rotation shaft 171 is coupled to the middle of the lock link 170. The lock link 170 engages a ninth rotation shaft 153 arranged on one end of the guide link 150. A third guide bearing 153A is arranged on the ninth rotation shaft 153. A portion of the lock link 170 proximate to the guide link 150 defines a second engagement portion 172 that engages the third guide bearing 153A of the guide link 150. Engagement of the third guide bearing 153A of the guide link 150 with the second engagement portion 172 of the lock link 170 restricts rotation of the guide link 150. The lock link 170 has another end that defines an engagement portion 173. The engagement portion 173 is a semicircular cutout portion. The lock link 170 serves as a stopper.

[0048] The plug door opening/closing device 104 includes a lock roller 180 fixed to the entrance 102. The lock roller 180 is rotated about a tenth rotation shaft 181. The engagement portion 173 of the lock link 170 engages the lock roller 180. A state in which the engagement portion 173 of the lock link 170 is engaged with the lock roller 180 is referred to as a lock state in which the main block 120 cannot be moved. Rotation of the lock link 170 disengages the engagement portion 173 of the lock link 170 from the lock roller 180. The lock roller 180 corresponds to a lock mechanism.

[0049] The operation of the plug door apparatus 101 will now be described with reference to Figs. 8(a) to 13. The operation for shifting the door leaf 103 from a fully closed and locked state to an open state will now be described.

[0050] Fig. 8(a) shows the door leaf 103 at the fully closed position in a fully closed and locked state in which the door leaf 103 cannot be moved even when operated. In the lock state, the engagement portion 173 of the lock link 170 is engaged with the lock roller 180, and the lock link 170 and the lock roller 180 cannot move. More specifically, in the lock state, the main block 120 cannot be moved relative to the entrance 102. Further, the second engagement portion 172 of the lock link 170 is engaged with the third guide bearing 153A of the guide link 150. Thus, the lock link 170 cannot be rotated. The first guide bearing 131A of the front arm 130 is in contact with the right surface of the guide link 150. The guide link 150 is located between the lock link 170 and the first guide bearing 131A of the front arm 130 and cannot be moved. The second guide bearing 141A on the sixth rotation shaft 141 of the rear arm 140 is located in the first guide groove 161 of the drive bracket 160 at the right end in the widthwise direction of the entrance 102. The left surface of the drive bracket 160 is in contact with the first guide bearing 131A on the fifth rotation shaft 131 of the front arm 130. Thus, the drive bracket 160 restricts rotation of the front arm 130 and the rear arm 140.

[0051] As shown in Fig. 10, when the driving device moves the drive bracket 160 to an unlocking initiation position where unlocking is initiated at the right side in Fig. 10, the second guide bearing 141A is located slightly toward the left from the right end in the first guide groove 161 of the drive bracket 160. The first guide bearing 131A of the front arm 130 is separated from the side surface of the drive bracket 160. The first guide bearing 131A of the front arm 130 is in contact with the right surface of the guide link 150. Thus, the lock link 170 remains in the lock state and cannot be rotated. In this state, the front arm 130 and the rear arm 140 are not rotated. Further, the second engagement portion 172 of the lock link 170 is engaged with the third guide bearing 153A of the guide link 150. Thus, the lock link 170 cannot be rotated. Accordingly, the door leaf 103 is still in the closed state, and the lock link 170 is still in the lock state.

[0052] As shown in Fig. 11, the driving device further moves the drive bracket 160 to the plug-out position at the right side in Fig. 11, and the second guide bearing 141A is located at the left end in the first guide groove 161. Thus, the rear arm 140 is rotated clockwise about the fourth rotation shaft 122 in a plan view and separates the door bracket 110 from the main block 120. As the rear arm 140 rotates, the front arm 130 rotates about the second rotation shaft 121. This generates the plug-out action of the door leaf 103. In this state, the second engagement portion 172 of the lock link 170 is engaged with the third guide bearing 153A of the guide link 150. Thus, the lock link 170 cannot be rotated, and the lock state is maintained.

[0053] As shown in Fig. 12, the drive bracket 160, which is moved to the plug-out position of the door leaf 103, pushes the main block 120 in an opening direction. The lock link 170 pushes the guide link 150 and rotates to shift to an unlock state. The door leaf 103, which remains in the plug-out state, moves together with the main block 120. The lock link 170 rotates and is disengaged from the lock roller 180.

[0054] As shown in Fig. 12, as the driving device moves the drive bracket 160 further toward the right as viewed in the drawing, the second guide bearing 141A, which is located in the first guide groove 161 at the left end, moves

further toward the right as viewed in the drawing together with the drive bracket 160. Thus, the rear arm 140 is further rotated clockwise about the fourth rotation shaft 122 in a plan view and separates the door bracket 110 from the main block 120 by the maximum extent. As the rear arm 140 rotates, the front arm 130 rotates clockwise about the second rotation shaft 121 in a plan view. This projects the door leaf 103 out of the entrance 102 in a plug-out state. In this state, the front arm 130 is rotated clockwise about the second rotation shaft 121 to separate the first guide bearing 131A from the right surface of the guide link 150.

[0055] Movement of the drive bracket 160 toward the right as viewed in Fig. 12 moves the main block 120 toward the right as viewed in Fig. 12. This rotates the lock link 170 counterclockwise in a plan view. In this state, the second engagement portion 172 of the lock link 170 pushes the third guide bearing 153A of the guide link 150 and rotates counterclockwise. This disengages the engagement portion 173 of the lock link 170 from the lock roller 180 to shift to an unlock state. The third guide bearing 153A, which is rotated counterclockwise and disengaged from the second engagement portion 172, engages a third engagement portion 174, which is arranged adjacent to the second engagement portion 172 of the lock link 170. Further, when the third guide bearing 153A of the guide link 150 is pushed and the guide link 150 is rotated clockwise, the first engagement portion 152 of the guide link 150 engages the first guide bearing 131A. Thus, the guide link 150 restricts rotation of the front arm 130 and maintains the door leaf 103 in the plug-out state.

[0056] The lock link 170, the guide link 150, and the front arm 130 are fixed as shown in Fig. 13. Thus, the door leaf 103 and the main block 120, which remain in the plug-out state, are moved in the widthwise direction of the entrance 102 in accordance with the movement of the drive bracket 160 to fully open the entrance 102. The door leaf 103 and the movable body 105 are located at the fully open position when the entrance 102 is fully open.

[0057] As shown in Fig. 13, when generating a plug-in action with the door leaf 103, that is, when the door leaf 103 is moved inward from the position projected out of the entrance 102 to its original position, the driving device moves the drive bracket 160 toward the left and restricts rotation of the front arm 130. This integrally moves the door bracket 110 and the main block 120 toward the left in the plug-out state. When the engagement portion 173 of the lock link 170 contacts and engages the lock roller 180, the lock link 170 is rotated clockwise about the eighth rotation shaft 171 and disengages the first engagement portion 152 of the guide link 150 from the first guide bearing 131A. In a state in which the front arm 130 is allowed to rotate, movement of the drive bracket 160 toward the left rotates the rear arm 140 counterclockwise about the fourth rotation shaft 122. This also rotates the front arm 30 counterclockwise and moves the door bracket 110 toward the main block 120. Thus, the door leaf 103 is shifted to a plug-in state in which the door leaf 103 is not projected outward from the entrance 102.

[0058] With the plug door opening/closing device 104, movement of the drive bracket 160 in the widthwise direction of the entrance 102 allows a plug action to be generated to move the door leaf 103 in the vehicle transverse direction. Further, movement of the drive bracket 160 in the widthwise direction of the entrance 102 allows the door leaf 103 to be maintained in a plug-out state and also allows an opening/closing action to be generated with the door leaf 103. Moreover, the plug door opening/closing device 104 transmits movement of the drive bracket 160 to the rear arm 140 in order to generate a plug action and opening/closing action with the door leaf 103. Further, engagement of the guide link 150 with the front arm 130 maintains the door leaf 103 in a plug-out state. Thus, the front arm 130 and the rear arm 140 share functions so that maintenance can be performed separately for each function.

[0059] As described above, the present embodiment has the advantages described below.

(1) As the movable body 105 moves the door leaf 103 from a plug-out position to the fully open position, the door leaf 103 can be moved in the widthwise direction of the entrance 102 while the lock link 170 maintains the relative positions of the movable body 105 and the door leaf 103. Thus, a plug action can be generated without a guide rail. This allows for reduction in the space occupied by the plug door opening/closing device 104.

(2) The lock link 170 restricts movement that changes the relative distance between the door leaf 103 and the main block 120 of the plug mechanism 106. Thus, even if the door leaf 103 is operated in a plug-out state, changes are restricted in the relative distance between the main block 120 and the door leaf 103.

(3) The link mechanism changes the relative distance between the the door leaf 103 and the main block 120 in the plugging direction. Thus, when the door leaf 103 approaches the main block 120, the link mechanism folds and reduces the space occupied by the plug door opening/closing device 104.

(4) The plug-in action of the plug mechanism 106, that is, movement of the door leaf 103 from the plug-out position to the fully closed position generated by the plug mechanism 6 locks the main block 120 with the lock roller 180. This restricts movement of the main block 120 even if the door leaf 103 is operated in a fully closed state.

[0060] The embodiments may be modified as follows.

[0061] In the above embodiments, the front arm 30 (130) and the rear arm 40 (140), which form a four-joint link, do not have to be equal in length. In such a case, the front end and rear end of the door leaf 3 (103) in the widthwise direction of the entrance 2 (102) move along

different paths. In particular, when the rear arm 40 (140) is longer than the front arm 30 (130), the distance can be shortened between the front end of the door leaf 3 (103) and the entrance 2 (102).

[0062] In the above embodiments, the stopper may be a structure that restricts movement of the second guide bearing 52A (141A) in the second guide groove 61 (first guide groove 161) of the drive bracket 60 (160). Further, the outer side of the guide link 50 or the front arm 130 may be directly fixed so that rotation of the guide link 50 in the first embodiment or rotation of the front arm 130 in the second embodiment is restricted in the rotation direction that cancels a plug-out state.

[0063] In the above embodiments, the stopper may be a ratchet that allows for rotation in the plug-out direction and restricts rotation in the opposite direction.

[0064] The plug door opening/closing device 4 (104) in each of the above embodiments includes the link mechanism as the plugging unit that generates a plug action with the door bracket 10 (110). However, a structure other than the link mechanism can be employed. For example, a stopper arranged on the main block may be used to maintain a door leaf of a plugging unit in a plug-out state.

[0065] For example, a slider mechanism may be employed as the plugging unit. As shown in Figs. 14 and 15, a plug door opening/closing device 204 couples a door bracket 210 and a main block 220 with a first slider mechanism 230 and a second slider mechanism 240. The first slider mechanism 230 and the second slider mechanism 240 act as the plugging unit. The first slider mechanism 230 and the second slider mechanism 240 extend to shift a door leaf 203 to a plug-out state. Further, the plug door opening/closing device 204 includes an engagement member 250 that serves as a stopper and engages the extended portion of the first slider mechanism 230. When the first slider mechanism 230 is extended, the engagement member 250 is rotated about a rotation shaft 251 and inserted into the extended portion of the first slider mechanism 230 to maintain the door bracket 210 in the plug-out state.

[0066] In the above embodiments, the stopper mechanically restricts movement of the plugging unit. Instead, the stopper may electrically restrict movement of the plugging unit. That is, the stopper may be powered on and off to actuate a member restricting movement of the plugging unit.

[0067] In the above embodiments, the driving device is exemplified as a ball screw. However, the driving device may be any device that can horizontally move the drive bracket 60 (160) such as a belt.

[0068] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the scope of the invention. For example, one or more of the components may be omitted from the components described in the embodiments (or one or more aspects thereof). Further, components in different embodiments may be appropriately combined.

[0069] The present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

Claims

1. A plug door opening/closing device (4; 104) configured to move a door leaf (3; 103) in a widthwise direction of an opening (2; 102) to open or close the opening (2; 102), the plug door opening/closing device (4; 104) being **characterized by**:

   a movable body (5; 105) moved together with the door leaf (3; 103) from a fully closed position via a plug-out position to a fully open position; and
   a stopper (70; 170) moved together with the movable body (5; 105) in a state maintaining relative positions of the movable body (5; 105) and the door leaf (3; 103) as the door leaf (3; 103) moves from the plug-out position to the fully open position.

2. The plug door opening/closing device (4; 104) according to claim 1, **characterized in that**:

   the movable body (5; 105) includes a base (20; 120) moved in the widthwise direction of the opening (2; 102) and a plugging unit (6; 106) configured to change a relative distance between the base (20; 120) and the door leaf (3; 103) in a plugging direction that is orthogonal to the widthwise direction of the opening (2; 102); wherein the stopper (70; 170) restricts movement of the plugging unit (6; 106).

3. The plug door opening/closing device (4; 104) according to claim 2, **characterized in that** the plugging unit (6; 106) includes a link mechanism (30, 40; 130, 140).

4. The plug door opening/closing device (4; 104) according to claim 2, **characterized in that** the plugging unit (6; 106) includes a four-joint link (30, 40: 130, 140).

5. The plug door opening/closing device (4; 104) according to any one of claims 2 to 4, **characterized by** a lock mechanism (80; 180) configured to lock the base (20; 120) at the fully closed position by movement of the plugging unit (6; 106) when the door leaf (3; 103) is moved from the plug-out position to the fully closed position.

Fig.1(a)

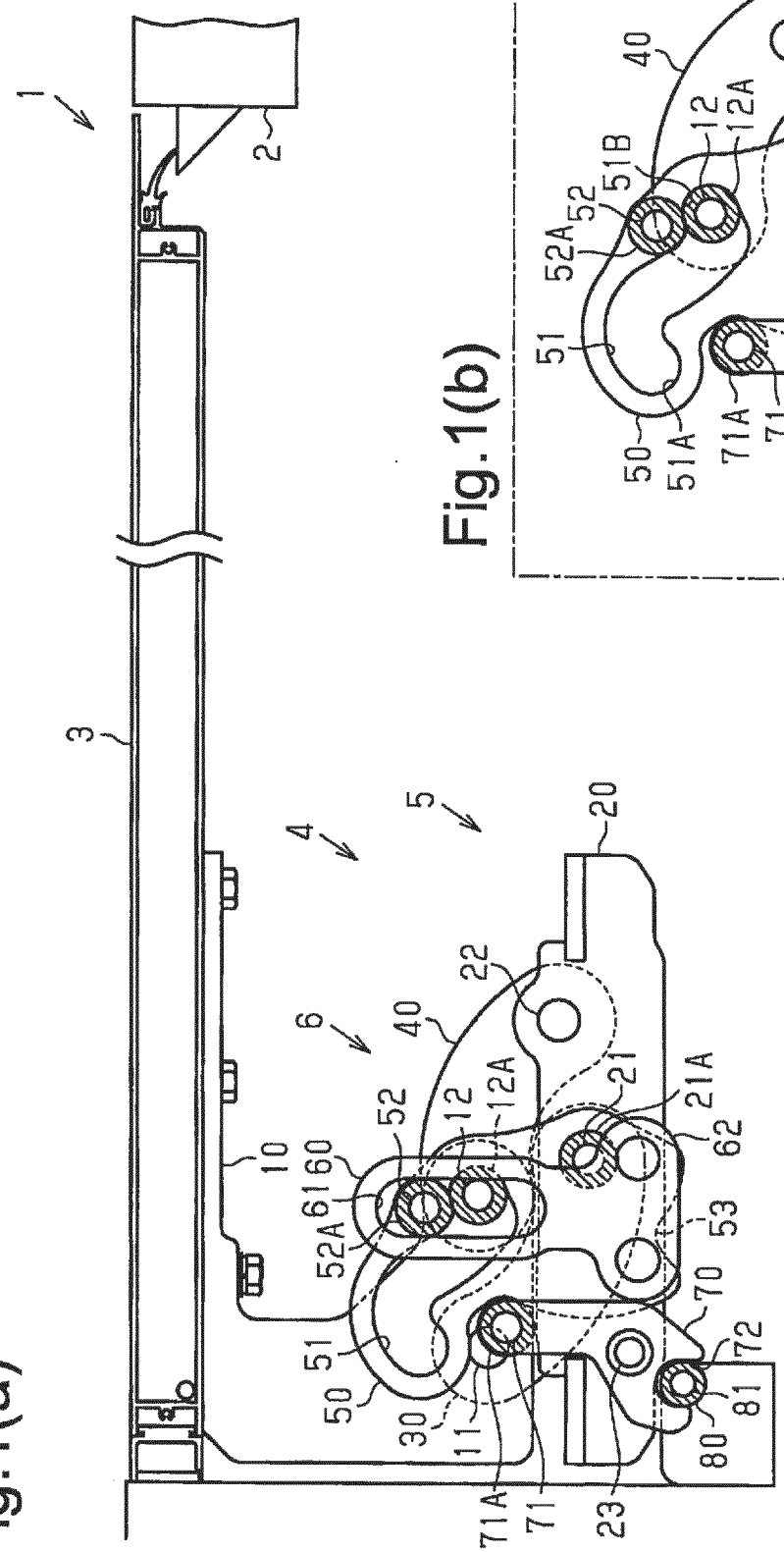

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Fig.1(b)

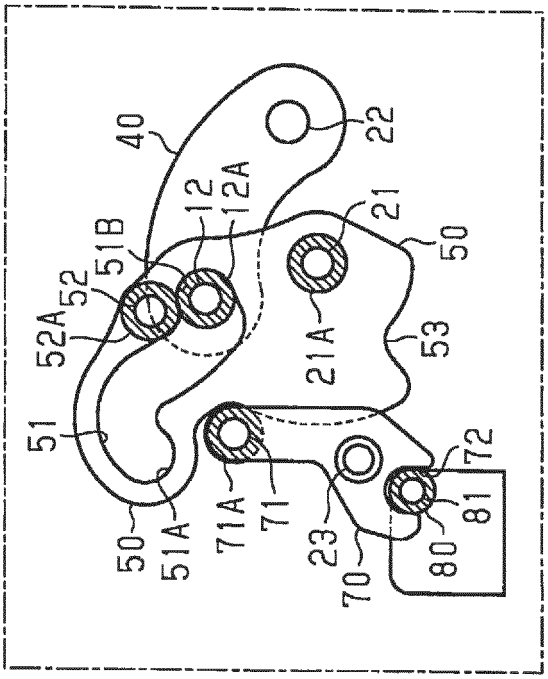
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Fig.2

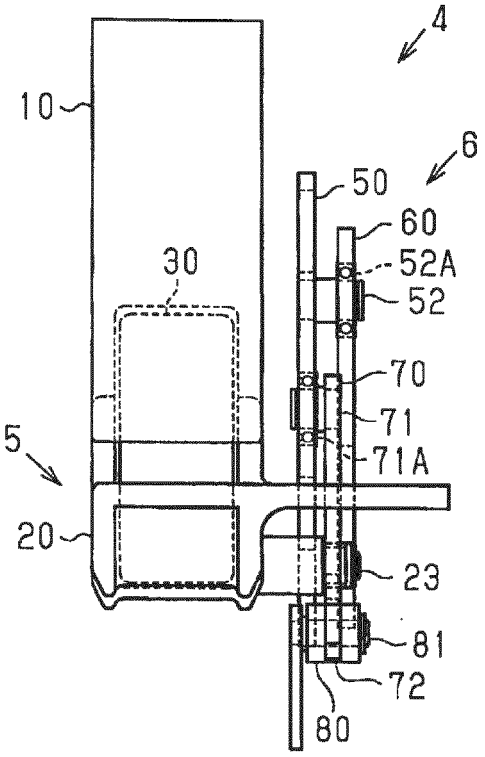
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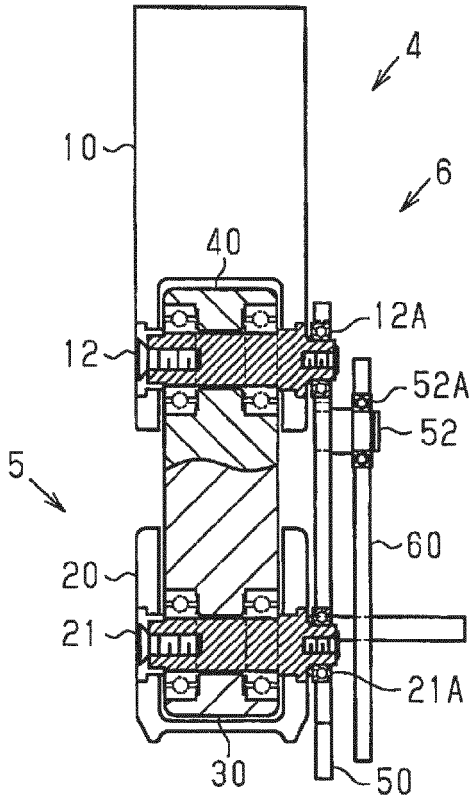
Fig.3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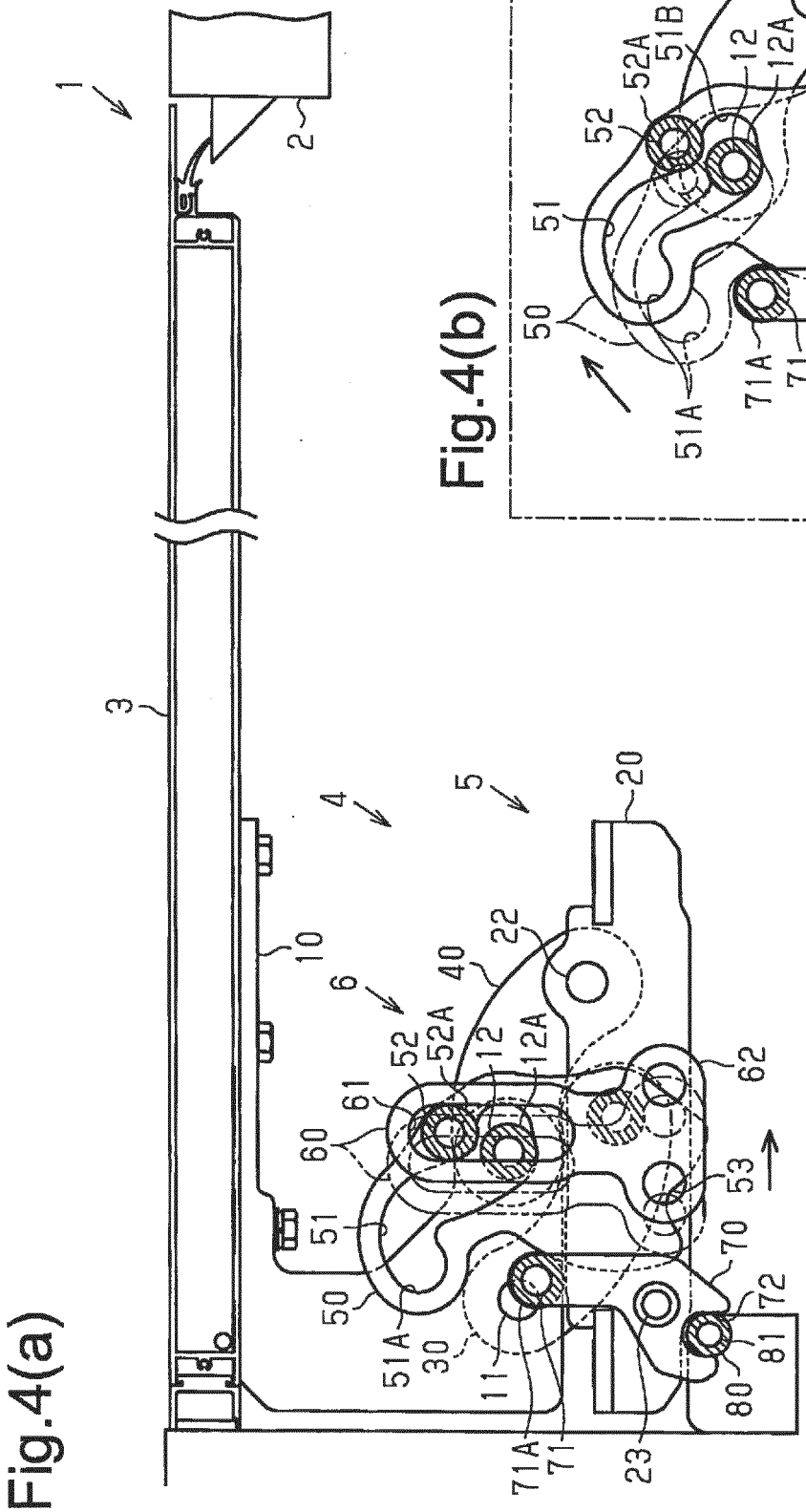
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Fig.4(a)

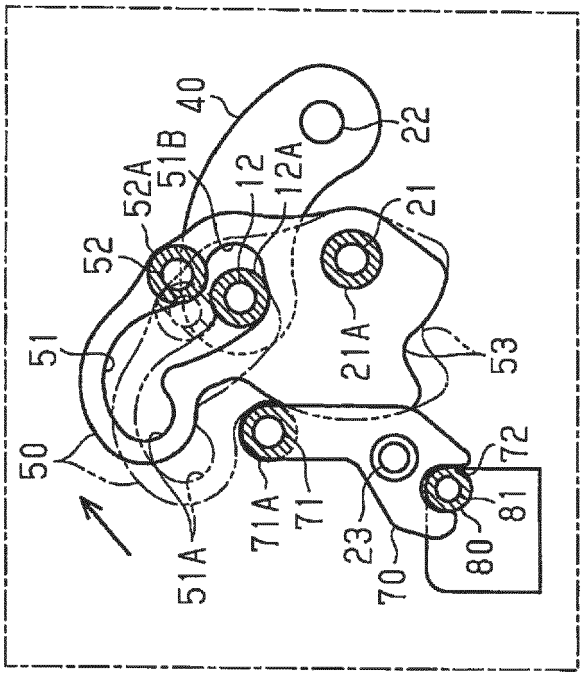
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Fig.4(b)

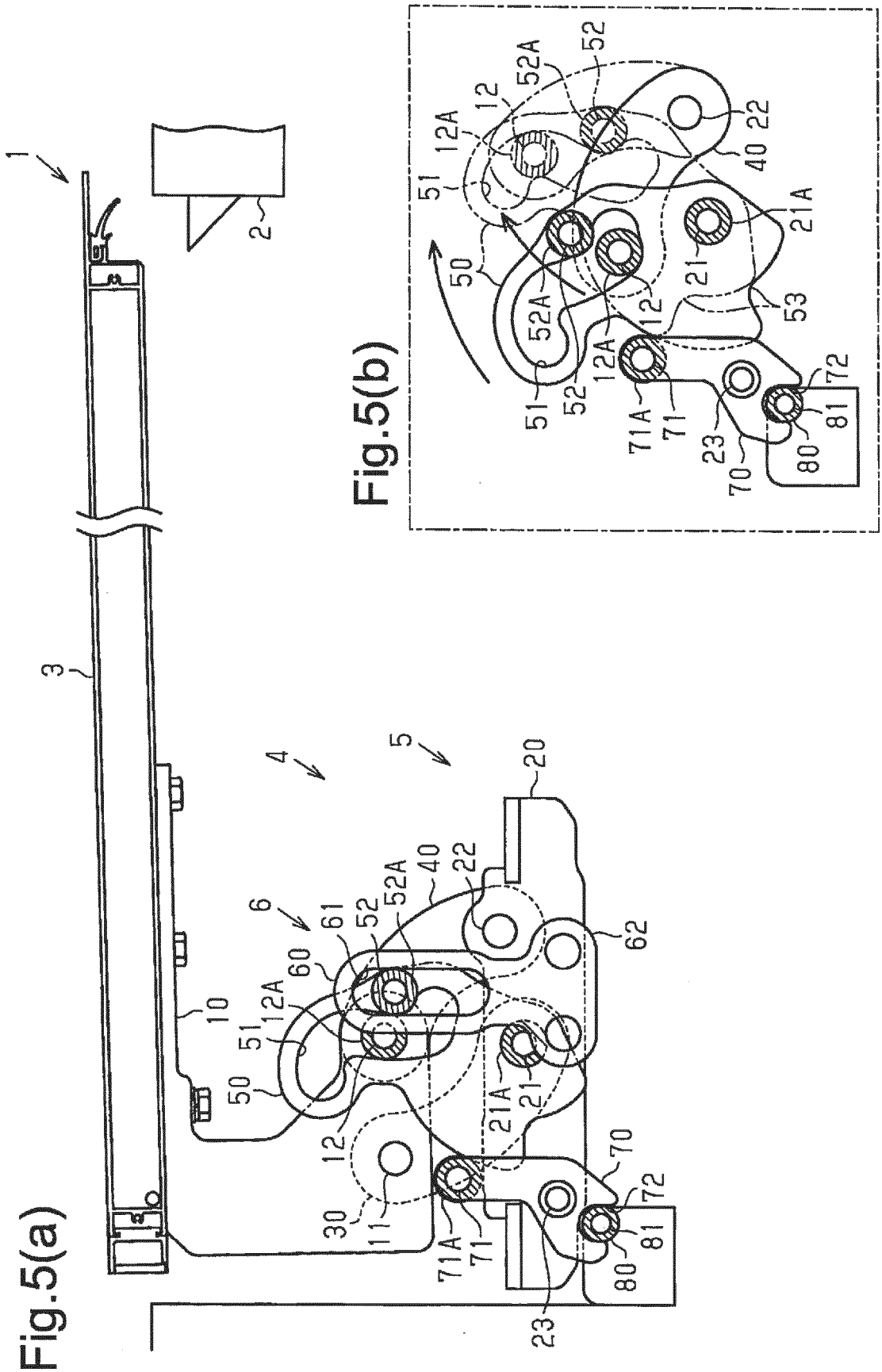
Fig.5(a)
Fig.5(b)
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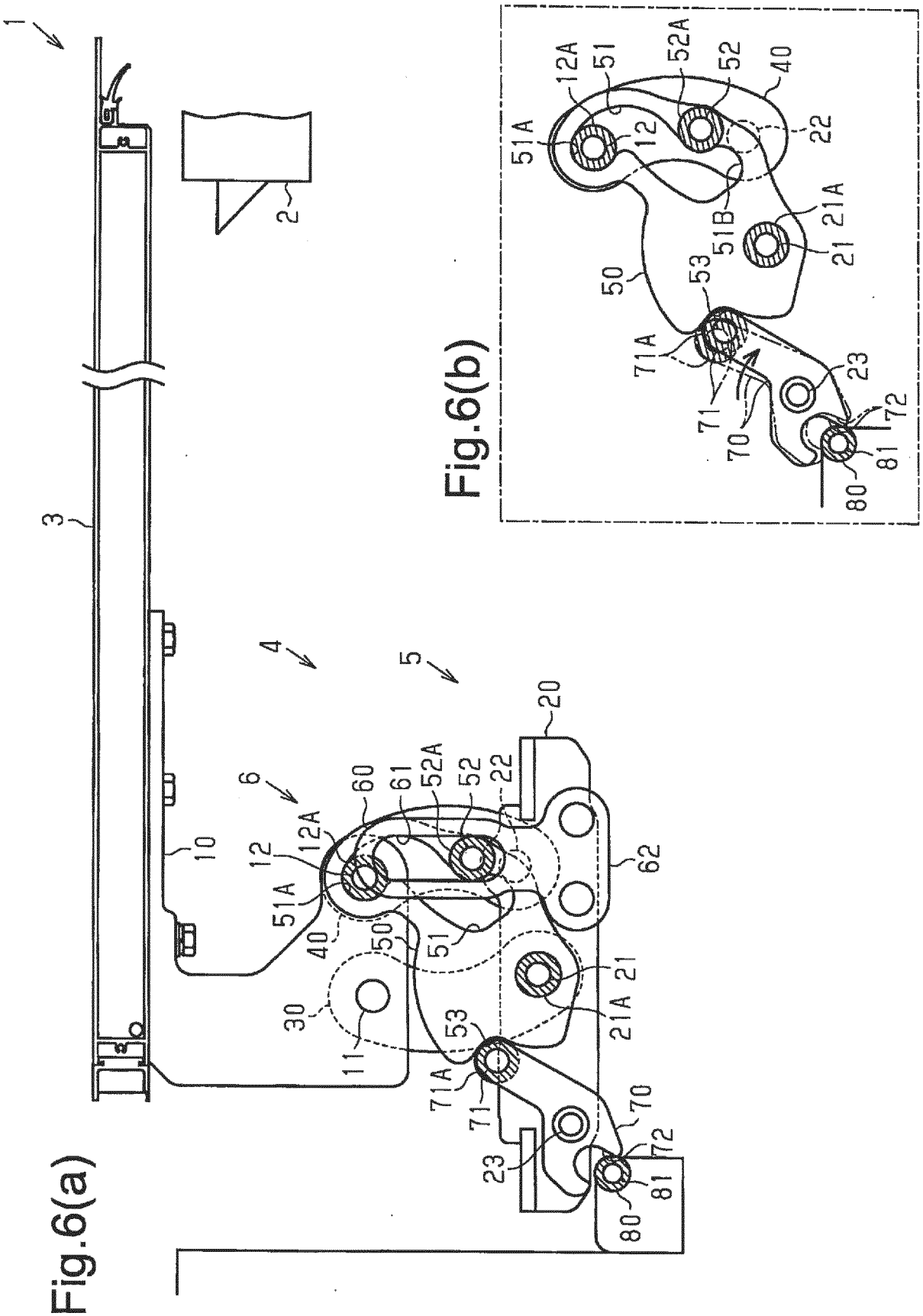
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Fig.6(a)

Fig.6(b)

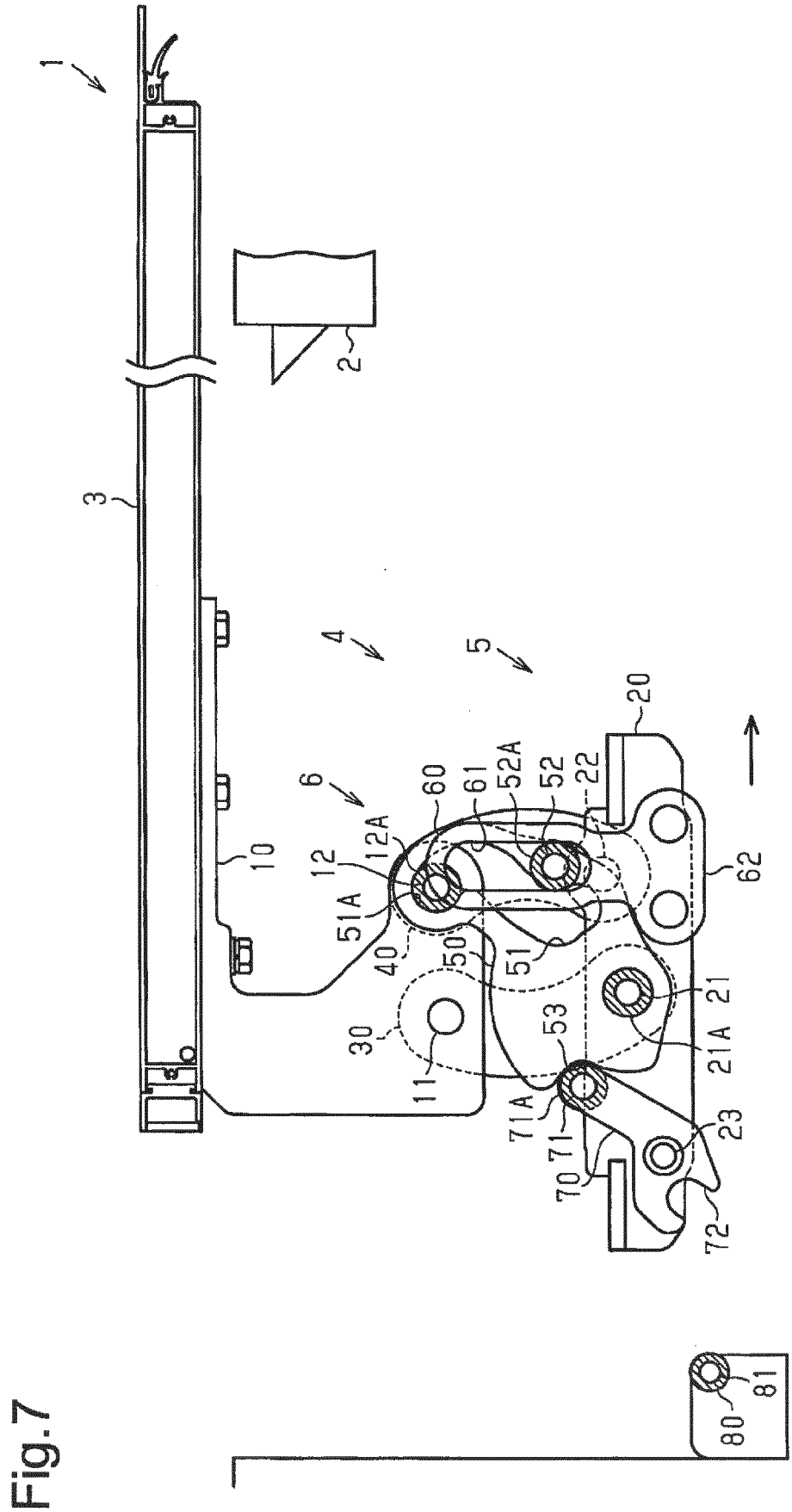
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Fig.7

Fig.8(a)

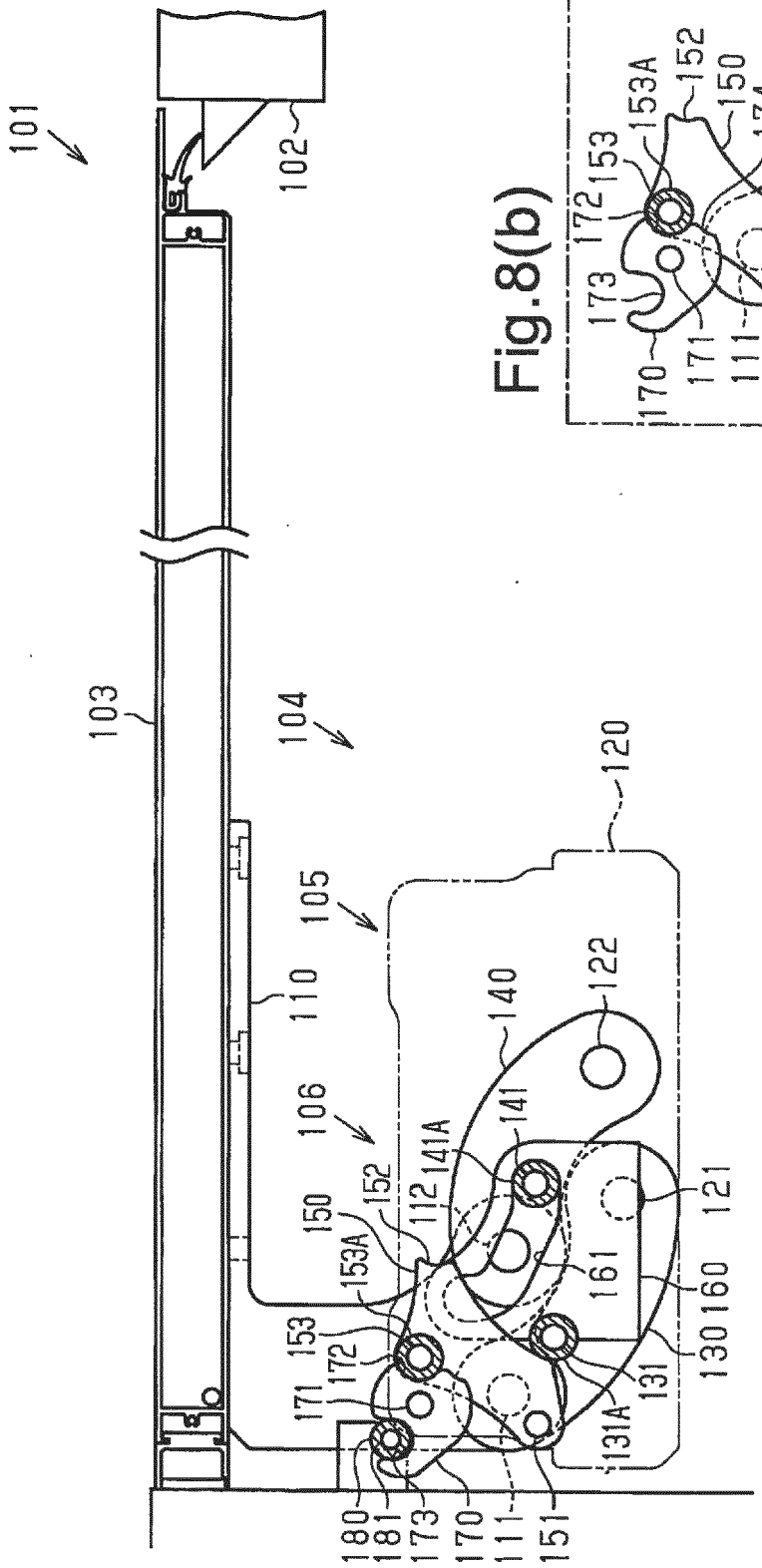
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Fig.8(b)

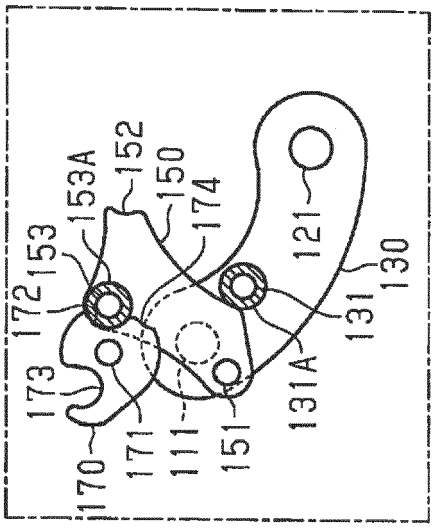
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Fig.9

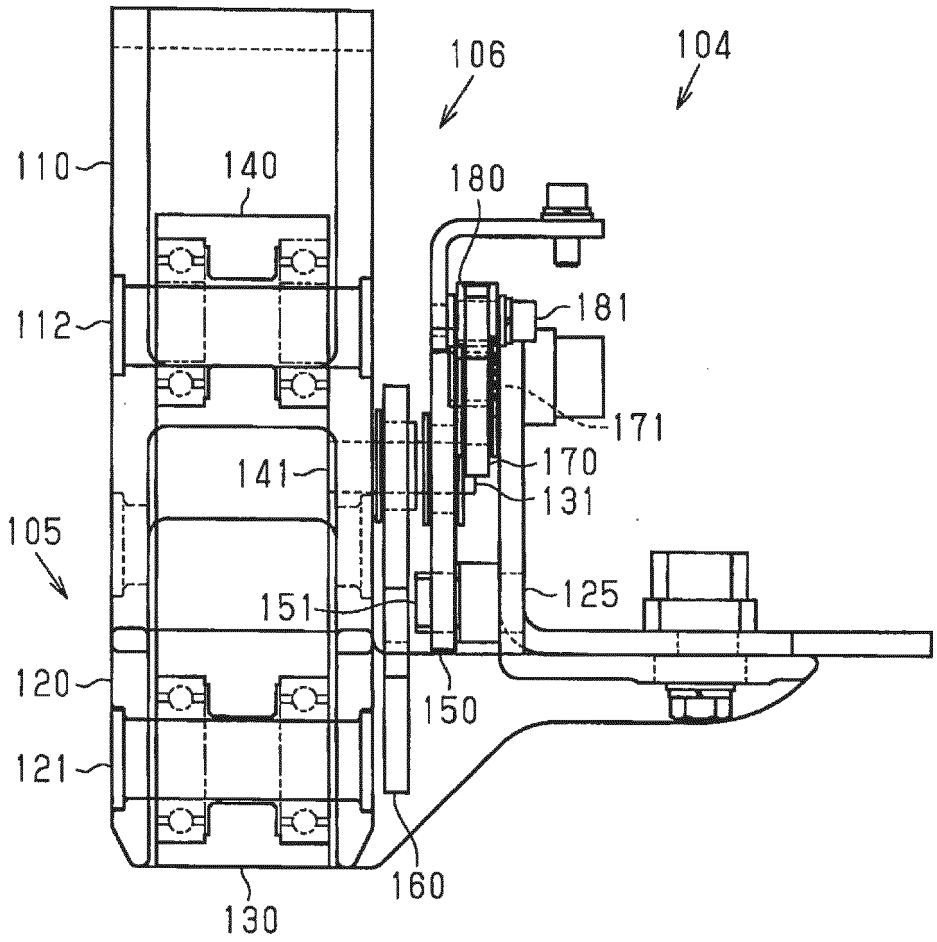
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Fig.10

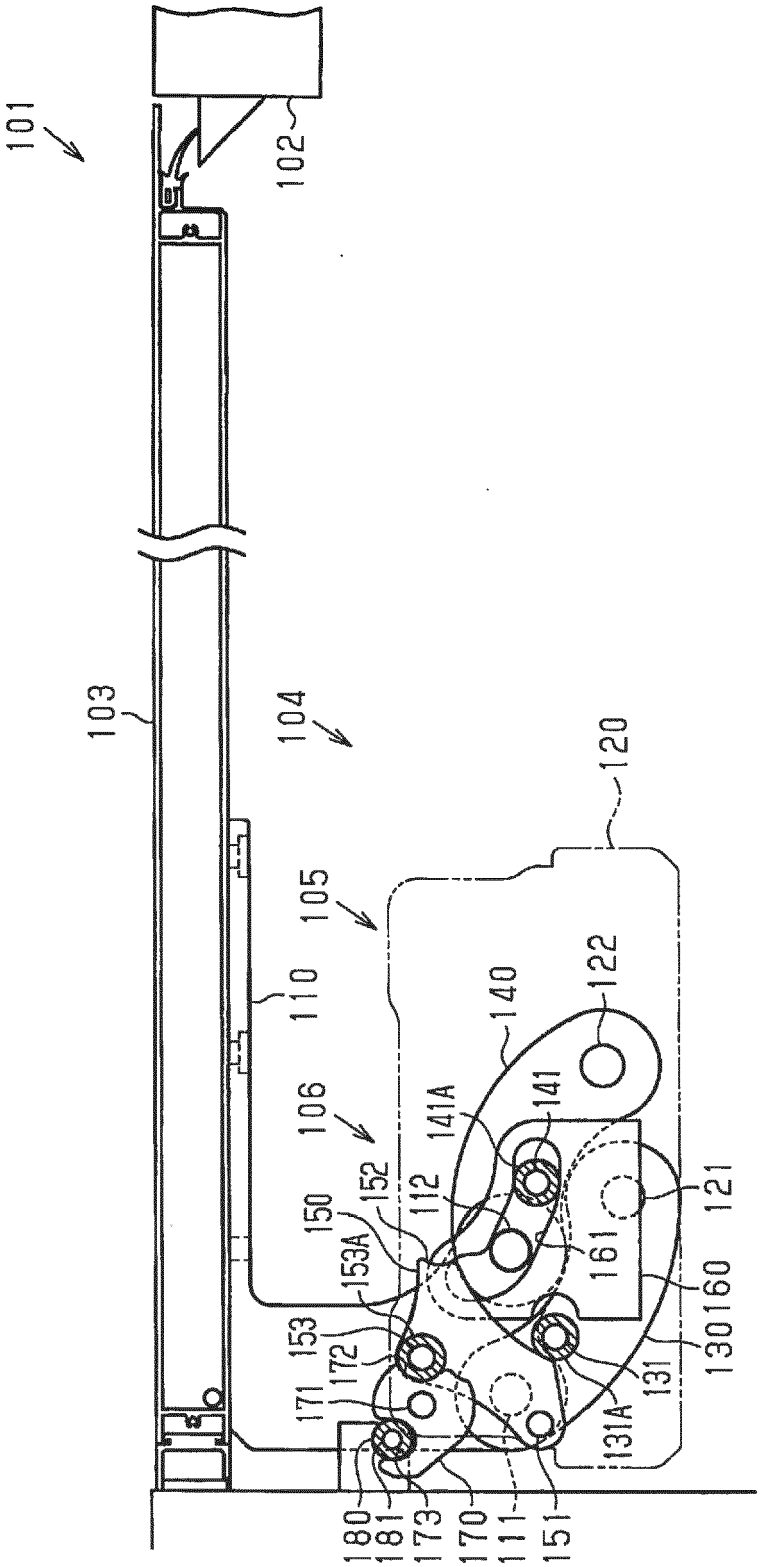
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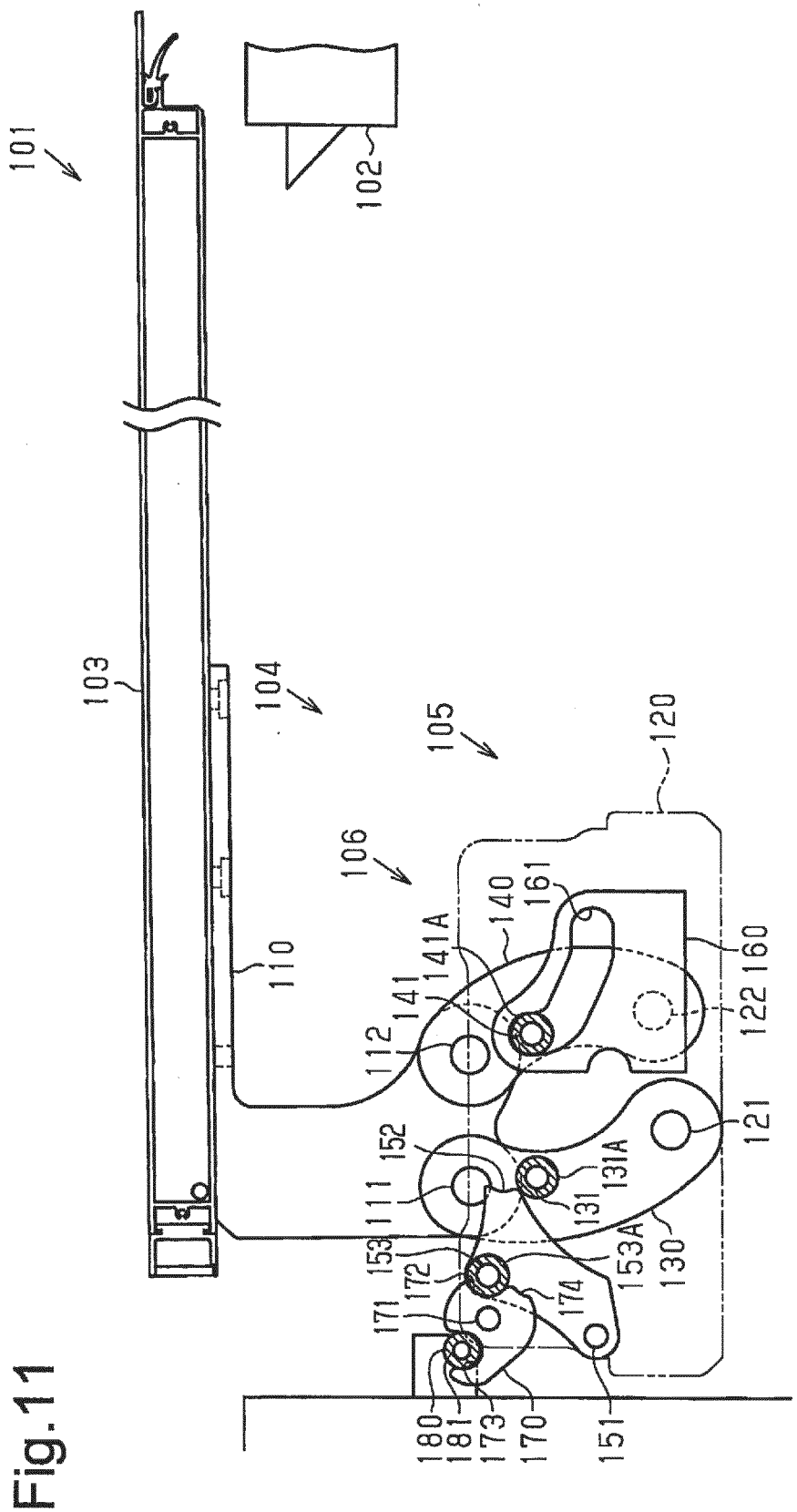
Fig.11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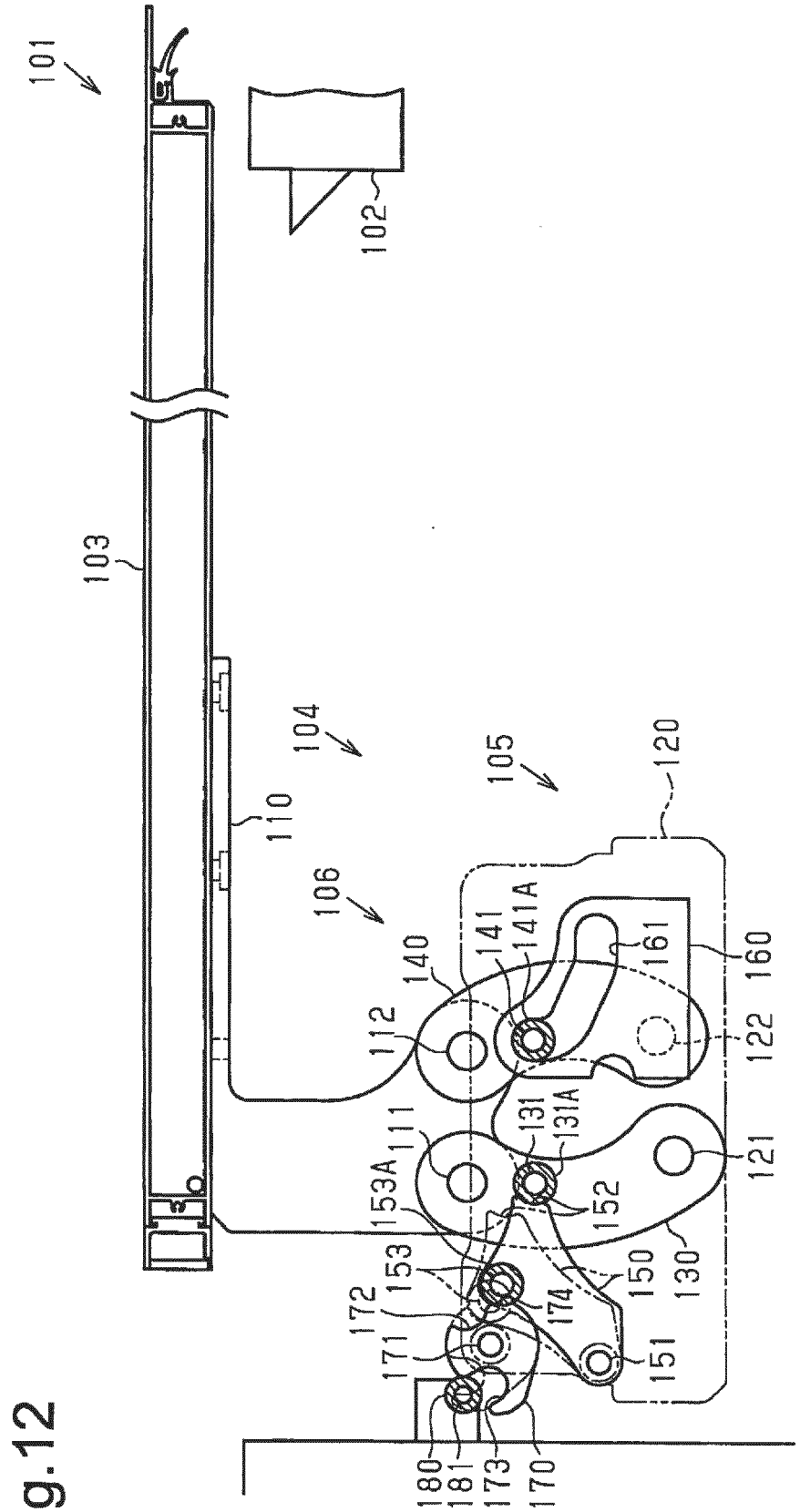
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Fig.12

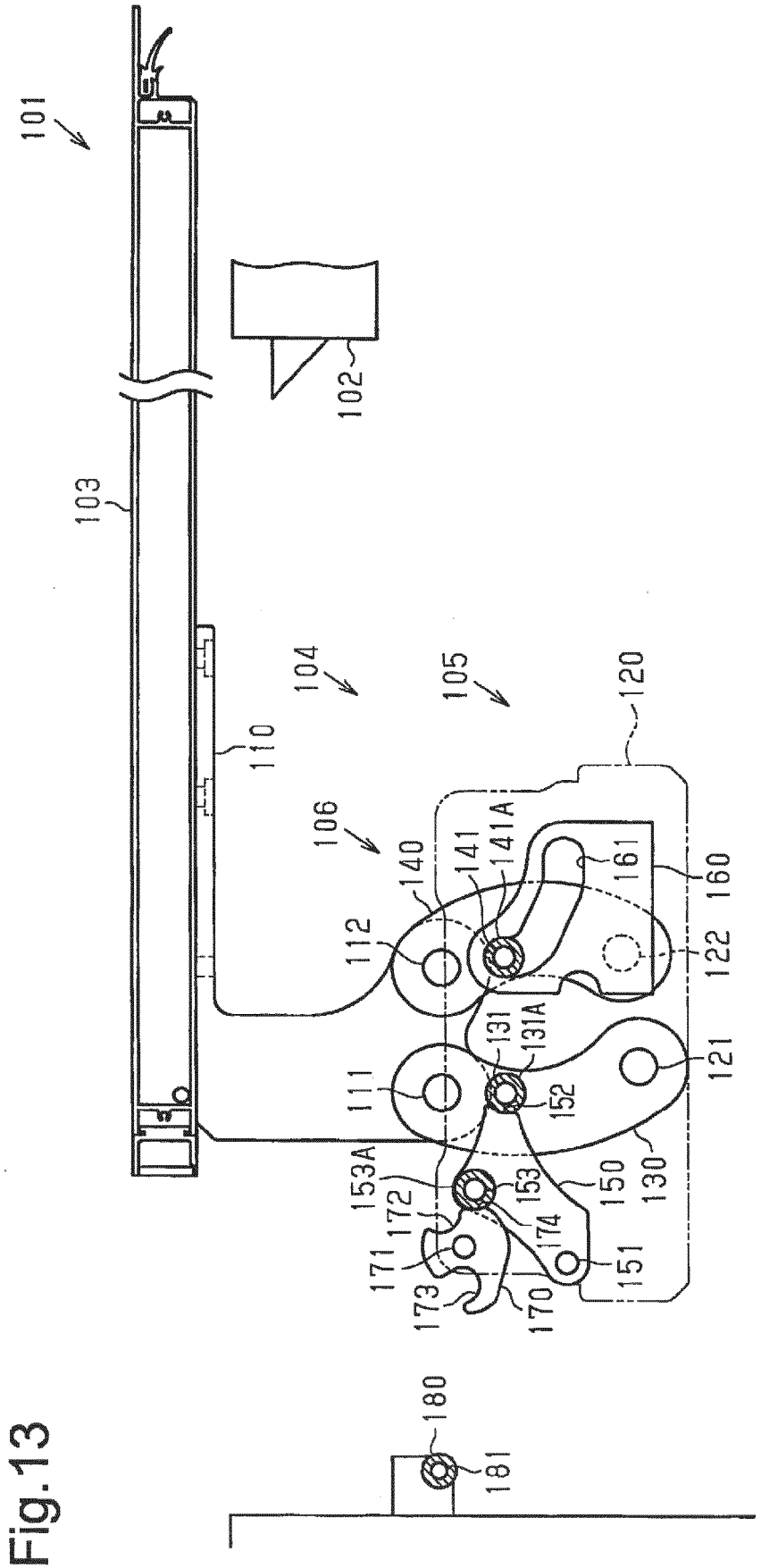
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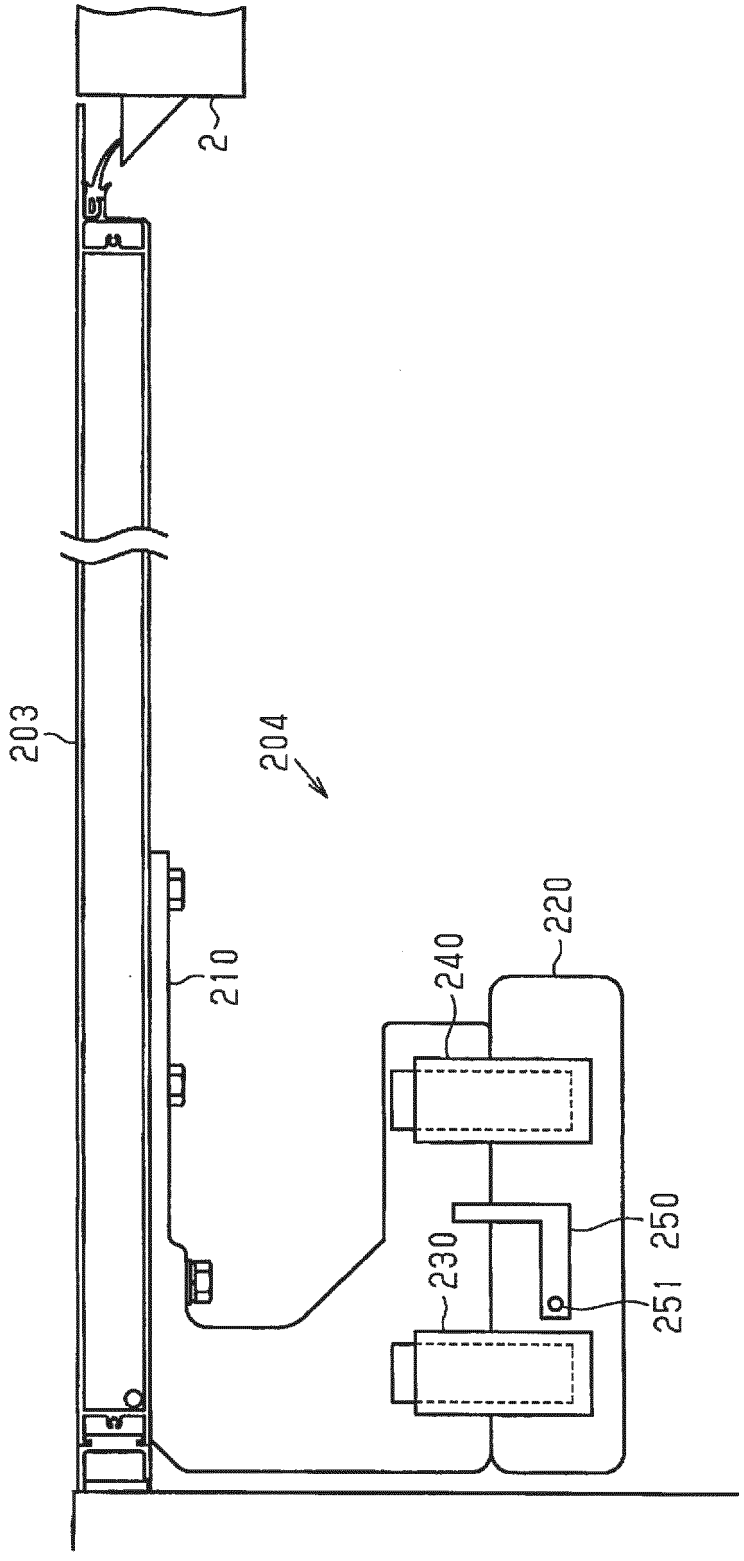
Fig.13

Fig.14



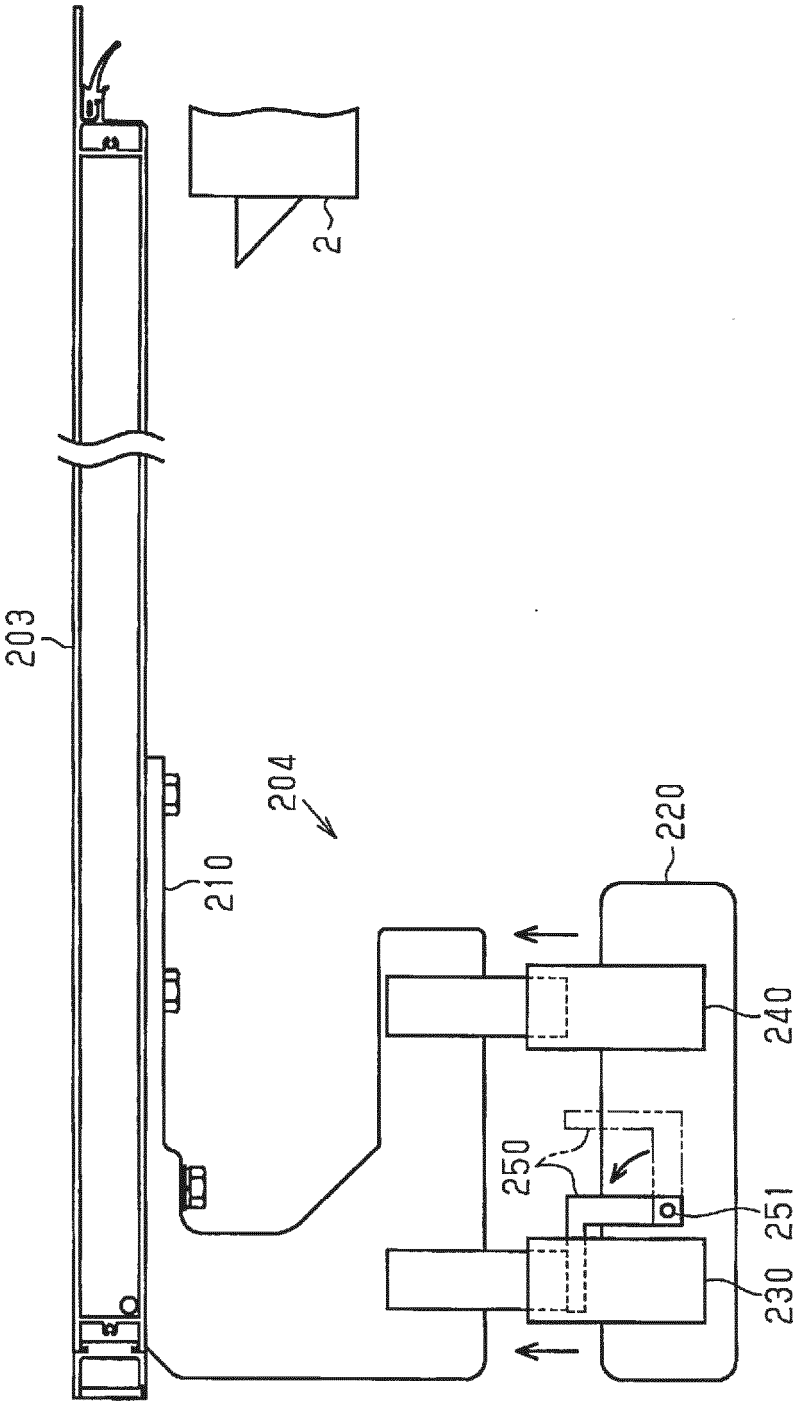


Fig.15

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EUROPEAN SEARCH REPORT

Application Number
EP 19 16 2114

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 197 35 181 A1 (WEBASTO TUERSYSTEME GMBH [DE]) 25 February 1999 (1999-02-25) * column 2, line 57 - column 5, line 63; figures 1-5 *	1-5	INV. E05D15/10
X	EP 2 604 488 A1 (NANJING KANGNI MECHANICAL & ELECTRICAL CO LTD [CN]) 19 June 2013 (2013-06-19) * paragraph [0021] - paragraph [0025]; figures 3,4 *	1,2	

TECHNICAL FIELDS SEARCHED (IPC)

E05D
E05F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30 July 2019	Rémondot, Xavier

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30-07-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19735181 A1	25-02-1999	NONE	
EP 2604488 A1	19-06-2013	CN 102303618 A	04-01-2012
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		WO 2012171279 A1	20-12-2012

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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- JP 10169298 A **[0003] [0004]**