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(54) **PLUG DOOR DEVICE**

(57) A plug door device (1) related to an embodiment includes: a guide rail (5) defining an opening-closing path (20) of a door (2) for opening or closing an entrance (15) of a vehicle; a drive source (6) for moving the door (2); a rotating member (36) moving along with the door (2) with a driving force from the drive source (6), the rotating member (36) being guided by the guide rail (5) to roll along the opening-closing path (20) when the door (2) is opened or closed; a restraining member (7) moving from an unrestraining position where the door (2) is unrestrained to a restraining position where the rotating member (36) is restrained in a position where the door (2) is fully closed, the restraining member (7) being pushed by the rotating member (36) to move from the unrestraining position to the restraining position when the rotating member (36) moves along the opening-closing path (20) in a closing direction (Vc); and a locking mechanism (8) for retaining the restraining member in the restraining position.

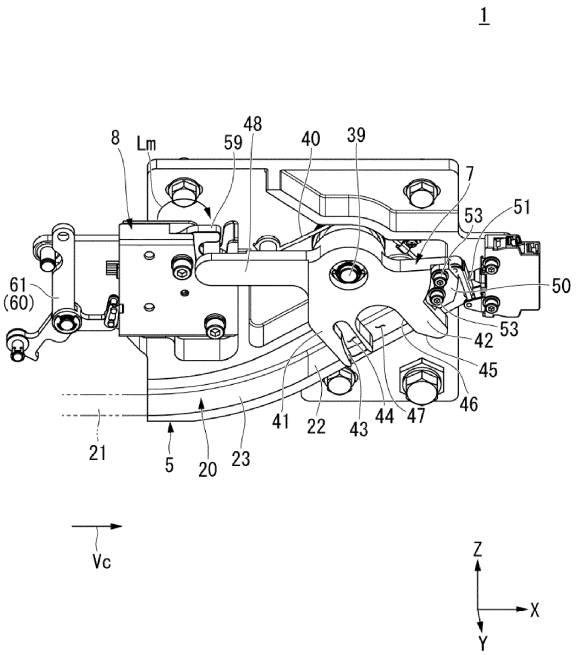

Fig. 2

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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 plugging doors that open and close entrances of vehicles. Here, "to actuate a door in a plugging manner" means moving the door in the width direction of a railway vehicle while moving the door in the front rear direction of the vehicle. The plug door device includes a guide rail that defines an opening-closing path of the door, and a locking mechanism for locking the door in a fully closed position. Driving force from a drive source is used to move the door and operate the locking mechanism. For example, Patent Literature 1 discloses a configuration including a motor for moving the door and a solenoid device for driving the locking mechanism of the door.

RELEVANT REFERENCES

LIST OF RELEVANT PATENT LITERATURE

[0003] Patent Literature 1: Japanese Patent Application Publication No. 2020-100397

SUMMARY

[0004] However, a drive source for the door and a drive source for the door lock are separate provided in the above configuration. There is room for improvement in terms of energy saving.

[0005] The present invention is intended to overcome the above drawback, and one object thereof is to provide a plug door device that can achieve energy saving.

[0006] To solve the above problems, aspects of the present invention are configured as follows. (1) A plug door device according to one aspect of the invention includes: a guide rail defining an opening-closing path of a door for opening or closing an entrance of a vehicle; a drive source for moving the door; a moving member moving along with the door with a driving force from the drive source, the moving member being guided by the guide rail to move along the opening-closing path when the door is opened or closed; a restraining member moving from an unrestraining position where the door is unrestrained to a restraining position where the moving member is restrained in a position where the door is fully closed, the restraining member being pushed by the moving member to move from the unrestraining position to the restraining position when the moving member moves along the opening-closing path in a closing direction; and a locking mechanism for retaining the restraining member in the restraining position.

[0007] With this configuration, the restraining member is moved to the restraining position (where the door is locked in the fully closed position) utilizing the driving force of the drive source (door drive source) that is provided for driving the door. Therefore, no additional actuator other than the door drive source is required to move the restraining member, which results in energy saving.

[0008] (2) In the plug door device described in (1), the restraining member is displaced relative to the guide rail in a height direction of the vehicle.

[0009] In the plug door device described in (2), the restraining member may have a first arm and a second arm arranged in this order in the closing direction, when the restraining member is in the unrestraining position, the first arm does not cross the opening-closing path but the second arm crosses the opening-closing path. Whereas when the restraining member is in the restraining position, the first arm and the second arm cross the opening-closing path.

(4) In the plug door device described in (3), the opening-closing path may be divided into a linear portion extending along a front-rear direction of the vehicle and an inclined portion inclined relative to the linear portion. The second arm may include a first surface that is disposed orthogonal to the inclined portion when the restraining member is in the unrestraining position and a second surface that is disposed orthogonal to the inclined portion when the restraining member is in the restraining position.

(5) In the plug door device described in (1), at least a part of the restraining member may be disposed in a range of the guide rail in the height direction of the vehicle.

(6) In the plug door device described in (5), the restraining member may have a guide wall that contacts the moving member in the unrestraining position and guides movement of the moving member along the opening-closing path.

(7) In the plug door device described in any one of (1) to (6), the restraining member may be rotatable about a shaft that extends in the height direction of the vehicle.

(8) In the plug door device described in (7), the restraining member may have a retained portion retained by the locking mechanism, and the retained portion is disposed opposite to a portion that restrains the moving member with respect to the shaft.

(9) In the plug door device described in (8), the retained portion may be formed as a part of the restraining member such that the retained portion and the restraining member together form a single body.

(10) In the plug door device described in anyone of (1) to (9), the restraining member may have a pushing member that pushes a switch when the restraining member is in the restraining position.

(11) In the plug door device described in any one of (1) to (10), the moving member may be a rotating member that is rotatable about an axis extending in a height direction of the vehicle and that rolls along the opening-closing path, and the rotating member may have a circular shape when viewed from the height direction.

(12) In the plug door device described in any one of (1) to (11), the restraining member may have an elastic member that applies an elastic force to the restraining member such that the restraining member is held in the unrestraining position.

(13) In the plug door device described in (12), the restraining member is rotatable about a shaft that extends in a height direction of the vehicle, and the elastic member may be a torsion spring wound around the shaft.

(14) In the plug door device described in (12), the restraining member may be rotatable about a shaft that extends in a height direction of the vehicle, and the elastic member may be a compression spring compressible in a direction intersecting the shaft. One end of the compression spring may be connected to the guide rail, and the other end of the compression spring may be connected to the restraining member. A center axis line of the compression spring may be situated on an opposite side to the closing direction with respect to a boundary position where the center axis line passes the shaft as viewed from the height direction when the moving member moves in the unrestraining position, and the center axis line may be situated on the closed direction side with respect to the boundary position as viewed from the height direction when the moving member is in the restraining position.

(15) In the plug door device described in any one of (1) to (14), further provided is a second moving member that moves along with the door with a driving force from the drive source, the second supporting member being spaced apart from the moving member such that the second moving member does not contact the guide rail when the door is opened or closed. The restraining member may have a restraining wall that restrains the second moving member in the position where the door is fully closed, and the restraining wall may face the closing direction and slop toward the closing direction as viewed from a height direction of the vehicle.

(16) A plug door device according to another aspect of the invention includes: a guide rail defining an opening-closing path of a door for opening or closing an entrance of a vehicle; a drive source for moving the door; a rotating member moving along with the door with a driving force from the drive source, the rotating member being guided by the guide rail to roll along the opening-closing path when the door is opened or closed; a restraining member moving from an unrestraining position where the door is unrestrained to a restraining position where the rotating member is restrained in a position where the door is fully closed, the restraining member being pushed by the rotating member to move from the unrestraining position to the restraining position when the rotating member moves along the opening-closing path in a closing direction; and a locking mechanism for retaining the restraining member in the restraining position. The rotating member is rotatable about an axis extending in a height direction of the vehicle, and he rotating member has a circular shape when viewed from the height direction. The restraining member is displaced relative to the guide rail in the height direction, and the restraining member has a first arm and a second arm arranged in this order in the closing direction. When the restraining member is in the unrestraining position, the first arm does not cross the opening-closing path but the second arm crosses the opening-closing path, and when the restraining member is in the restraining position, the first arm and the second arm cross the opening-closing path. The opening-closing path is divided into a linear portion extending along a front-rear direction of the vehicle and an inclined portion inclined relative to the linear portion. The second arm includes a first surface that is disposed orthogonal to the inclined portion when the restraining member is in the unrestraining position and a second surface that is disposed orthogonal to the inclined portion when the restraining member is in the restraining position. The restraining member is rotatable about a shaft that extends in the height direction. The restraining member has a retained portion retained by the locking mechanism, and the retained portion is disposed opposite to a portion that restrains the rotating member with respect to the shaft. The retained portion is formed as a part of the restraining member such that the retained portion and the restraining member together form a single body. The restraining member has a pushing member that pushes a switch when the restraining member is in the restraining position. A torsion spring wound around the shaft is provided and the torsion spring applies an elastic force to the restraining member to keep the restraining member in the unrestraining position. A second moving member that moves along with the door with a driving force from the drive source is provided, and the second moving member is spaced apart from the rotat-

ing member such that the second moving member does not contact the guide rail when the door is opened or closed. The restraining member has a restraining wall that restrains the second moving member in the position where the door is fully closed, and the restraining wall faces the closing direction and slops toward the closing direction as viewed from a height direction of the vehicle.

With this configuration, the restraining member is moved to the restraining position (where the door is locked in the fully closed position) utilizing the driving force of the drive source (door drive source) that is provided for driving the door. Therefore, no additional actuator other than the door drive source is required to move the restraining member, which results in energy saving. In addition, the rotating member that rolls along the opening-closing path while guided by the guide rail when the door is opened or closed is provided. The rotating member is rotatable about the axis extending in the height direction of the vehicle, and has a circular shape when viewed from the height direction. Thus, the rotating member reduces friction against the guide rail, so that the rotating member can be moved smoothly from the unrestraining position to the restraining position. Since the restraining member is rotatable about the shaft that extends in the height direction of the vehicle, no space in the height direction is required to allow the rotation of the restraining member and it is possible to reduce the size of the restraining member in the height direction. In addition, the restraining member is disposed opposite to the portion that restrains the rotating member with respect to the shaft and has the retained portion that is retained by the locking mechanism. Thus, the retained portion and the portion that restrains the rotating member are separated from each other with the shaft interposed therebetween. This arrangement creates a space for the placement of the locking mechanism and increase the degree of freedom in the placement of the locking mechanism. The retained portion is formed as a part of the restraining member such that they together form a single body. Therefore, the number of components can be reduced and the cost can be lowered compared with the case where the retained portion where is retained by the locking mechanism is provided separately from the restraining member. The restraining member is provided with the pushing member that presses the switch when the restraining member is in the restraining position, thereby allowing adjustment of the position at which the restraining member presses the switch by adjusting the position of the pushing member. The second moving member that moves along with the door with a driving force from the drive source is provided, and the second moving member is spaced apart from the rotating member such that the second moving member does not contact the guide rail when the door is opened or closed. The restraining member has the restraining wall that slopes toward the closing direction as viewed from the height direction of the vehicle and restrains the supporting member in the position where the door is fully closed. Thus, even if the rotating member is dislodged by any chance, the second moving member is restrained by the restraining wall. Since the restraining member is displaced in the height direction of the vehicle with respect to the guide rail it is possible to flexibly design the shape of the guide rail, thus increasing the design freedom of the guide rail. The restraining member has the first arm and second arm arranged in this order in the closing direction. When the restraining member is in the unrestraining position, the first arm does not cross the opening-closing path but the second arm crosses the opening-closing path. Thus, when the restraining member is in the unrestraining position, the second arm is pushed by the roller to move the rotating member from the unrestraining position to the restraining position. Whereas when the restraining member is in the restrained position, the first arm and the second arm cross the opening-closing path. Thus, when the restraining member is situated in the restraining position, the rotating member can be restrained by the first arm and the second arm. The opening-closing path may be divided into a linear portion extending along a front-rear direction of the vehicle and an inclined portion inclined relative to the linear portion. The second arm has the first surface 45 that is arranged orthogonal to the inclined portion 22 when the restraining member is in the unrestraining position. Thus, when the restraining member is in the unrestraining position, the first surface of the second arm is pushed by the rotating member to move the rotating member from the unrestraining position to the restraining position. Whereas when the restraining member is in the restrained position, the second arm has the second surface that is arranged orthogonal to the inclined portion so that the roller 36 is restrained by the second surface of the second arm when the restraining member is in the restraining position. Further, the torsion spring that applies the elastic force to the restraining member to keep it in the unrestraining position is provided. Thus, the restraining member can be kept in the unrestraining position by utilizing the elastic force of the torsion spring. Consequently, the rotating member is able to smoothly push the restraining member in the unrestraining position. The torsion spring is wrapped around the shaft. Thus, it is possible to save the space for placing the torsion spring.

(17) A plug door device according to yet another aspect of the invention includes: a guide rail defining an opening-closing path of a door for opening or closing an entrance of a vehicle; a drive source for mov-

ing the door; a rotating member moving along with the door with a driving force from the drive source, the rotating member being guided by the guide rail to roll along the opening-closing path when the door is opened or closed; a restraining member moving from an unrestraining position where the door is unrestrained to a restraining position where the rotating member is restrained in a position where the door is fully closed, the restraining member being pushed by the rotating member to move from the unrestraining position to the restraining position when the rotating member moves along the opening-closing path in a closing direction; and a locking mechanism for retaining the restraining member in the restraining position. The rotating member is rotatable about an axis extending in a height direction of the vehicle, and the rotating member has a circular shape when viewed from the height direction. The restraining member is displaced relative to the guide rail in the height direction, and the restraining member have a first arm and a second arm arranged in this order in the closing direction. When the restraining member is in the unrestraining position, the first arm does not cross the opening-closing path but the second arm crosses the opening-closing path, and when the restraining member is in the restraining position, the first arm and the second arm cross the opening-closing path. The opening-closing path may be divided into a linear portion extending along a front-rear direction of the vehicle and an inclined portion inclined relative to the linear portion. The second arm includes a first surface that is disposed orthogonal to the inclined portion when the restraining member is in the unrestraining position and a second surface that is disposed orthogonal to the inclined portion when the restraining member is in the restraining position. The restraining member is rotatable about a shaft that extends in the height direction. The restraining member has a retained portion retained by the locking mechanism, and the retained portion is disposed opposite to a portion that restrains the rotating member with respect to the shaft. The retained portion is formed as a part of the restraining member such that the retained portion and the restraining member together form a single body. The restraining member has a pushing member that pushes a switch when the restraining member is in the restraining position. A compression spring compressible in a direction intersecting the shaft is provided. One end of the compression spring is connected to the guide rail, and the other end of the compression spring may be connected to the restraining member. A center axis line of the compression spring is situated on an opposite side to the closing direction with respect to a boundary position where the center axis line passes the shaft as viewed from the height direction when the rotating member moves in the unrestraining position, and the center axis line is situated on the closed direction side with respect to the boundary position as viewed from the height direction when the rotating member is in the restraining position. A second moving member that moves along with the door with a driving force from the drive source is provided, and the second moving member is spaced apart from the rotating member such that the second moving member does not contact the guide rail when the door is opened or closed. The restraining member has a restraining wall that restrains the second moving member in the position where the door is fully closed, and the restraining wall faces the closing direction and slops toward the closing direction as viewed from a height direction of the vehicle.

With this configuration, the restraining member is moved to the restraining position (where the door is locked in the fully closed position) utilizing the driving force of the drive source (door drive source) that is provided for driving the door. Therefore, no additional actuator other than the door drive source is required to move the restraining member, which results in energy saving. In addition, the rotating member that rolls along the opening-closing path while guided by the guide rail when the door is opened or closed is provided. The rotating member is rotatable about the axis extending in the height direction of the vehicle, and has a circular shape when viewed from the height direction. Thus, the rotating member reduces friction against the guide rail, so that the rotating member can be moved smoothly from the unrestraining position to the restraining position. Since the restraining member is rotatable about the shaft that extends in the height direction of the vehicle, no space in the height direction is required to allow the rotation of the restraining member and it is possible to reduce the size of the restraining member in the height direction. In addition, the restraining member is disposed opposite to the portion that restrains the rotating member with respect to the shaft and has the retained portion that is retained by the locking mechanism. Thus, the retained portion and the portion that restrains the rotating member are separated from each other with the shaft interposed therebetween. This arrangement creates a space for the placement of the locking mechanism and increase the degree of freedom in the placement of the locking mechanism. The retained portion is formed as a part of the restraining member such that they together form a single body. Therefore, the number of components can be reduced and the cost can be lowered compared with the case where the retained portion where is retained by the locking mechanism is provided separately from the restraining member. The restraining member is provided with the pushing member that presses the switch when the restraining member is in the restraining position, thereby allowing adjustment of the position at which the restraining member presses the switch by adjusting the position

of the pushing member. The plug door device further includes the supporting member that moves along with the door with the driving force from the drive source and is spaced apart from the rotating member such that it does not contact the guide rail when the door is opened and closed. The restraining member has the restraining wall that slopes toward the closing direction as viewed from the height direction of the vehicle and restrains the supporting member in the position where the door is fully closed. Thus, even if the rotating member is dislodged by any chance, the second moving member is restrained by the restraining wall. Since the restraining member is displaced in the height direction of the vehicle with respect to the guide rail it is possible to flexibly design the shape of the guide rail, thus increasing the design freedom of the guide rail. The restraining member has the first arm and second arm arranged in this order in the closing direction. When the restraining member is in the unrestraining position, the first arm does not cross the opening-closing path but the second arm crosses the opening-closing path. Thus, when the restraining member is in the unrestraining position, the second arm is pushed by the roller to move the rotating member from the unrestraining position to the restraining position. Whereas when the restraining member is in the restrained position, the first arm and the second arm cross the opening-closing path. Thus, when the restraining member is situated in the restraining position, the rotating member can be restrained by the first arm and the second arm. The opening-closing path may be divided into a linear portion extending along a front-rear direction of the vehicle and an inclined portion inclined relative to the linear portion. The second arm has the first surface that is arranged orthogonal to the inclined portion when the restraining member is in the unrestraining position. Thus, when the restraining member is in the unrestraining position, the first surface of the second arm is pushed by the rotating member to move the rotating member from the unrestraining position to the restraining position. Whereas when the restraining member is in the restrained position, the second arm has the second surface that is arranged orthogonal to the inclined portion so that the roller 36 is restrained by the second surface of the second arm when the restraining member is in the restraining position. As described, provided is the compression spring that can be compressed in the direction intersecting the shaft. One end of the compression spring is connected to the guide rail, and the other end of the compression spring is connected to the restraining member. The center axis line of the compression spring is situated on the opposite side to the closing direction with respect to the boundary position where the center axis line passes the shaft as seen from the height direction when the rotating member moves in the unrestraining position. When the rotating member is in the restraining position, the center axis line is situated on the closed direction side with respect to the boundary position as seen from the height direction. With this configuration, it is possible to change the direction in which the force of the compression spring is applied to the restraining member depending on the position of the rotating member.

(18) A plug door device according to still yet another aspect of the invention includes: a guide rail defining an opening-closing path of a door for opening or closing an entrance of a vehicle; a drive source for moving the door; a rotating member moving along with the door with a driving force from the drive source, the rotating member being guided by the guide rail to roll along the opening-closing path when the door is opened or closed; a restraining member moving from an unrestraining position where the door is unrestrained to a restraining position where the rotating member is restrained in a position where the door is fully closed, the restraining member being pushed by the rotating member to move from the unrestraining position to the restraining position when the rotating member moves along the opening-closing path in a closing direction; and a locking mechanism for retaining the restraining member in the restraining position. The rotating member is rotatable about an axis extending in a height direction of the vehicle, and the rotating member has a circular shape when viewed from the height direction. At least a part of the restraining member is disposed in a range of the guide rail in the height direction, The restraining member has a guide wall that contacts the rotating member in the unrestraining position and guides movement of the rotating member along the opening-closing path. The restraining member is rotatable about a shaft that extends in the height direction. The restraining member is rotatable about a shaft that extends in the height direction. The retained portion is formed as a part of the restraining member such that the retained portion and the restraining member together form a single body. The restraining member has a pushing member that pushes a switch when the restraining member is in the restraining position. A torsion spring wound around the shaft is provided and the torsion spring applies an elastic force to the restraining member to keep the restraining member in the unrestraining position. A second moving member that moves along with the door with a driving force from the drive source is provided, and the second moving member is spaced apart from the rotating member such that the second moving member does not contact the guide rail when the door is opened or closed. The restraining member has a restraining wall that restrains the second moving member in the position where the door is fully closed, and the restraining wall faces the closing direction and

slops toward the closing direction as viewed from a height direction of the vehicle.

[0010] With this configuration, the restraining member is moved to the restraining position (where the door is locked in the fully closed position) utilizing the driving force of the drive source (door drive source) that is provided for driving the door. Therefore, no additional actuator other than the door drive source is required to move the restraining member, which results in energy saving. In addition, the rotating member that rolls along the opening-closing path while guided by the guide rail when the door is opened or closed is provided. The rotating member is rotatable about the axis extending in the height direction of the vehicle, and has a circular shape when viewed from the height direction. Thus, the rotating member reduces friction against the guide rail, so that the rotating member can be moved smoothly from the unrestraining position to the restraining position. Since the restraining member is rotatable about the shaft that extends in the height direction of the vehicle, no space in the height direction is required to allow the rotation of the restraining member and it is possible to reduce the size of the restraining member in the height direction. In addition, the restraining member is disposed opposite to the portion that restrains the rotating member with respect to the shaft and has the retained portion that is retained by the locking mechanism. Thus, the retained portion and the portion that restrains the rotating member are separated from each other with the shaft interposed therebetween. This arrangement creates a space for the placement of the locking mechanism and increase the degree of freedom in the placement of the locking mechanism. The retained portion is formed as a part of the restraining member such that they together form a single body. Therefore, the number of components can be reduced and the cost can be lowered compared with the case where the retained portion where is retained by the locking mechanism is provided separately from the restraining member. The restraining member is provided with the pushing member that presses the switch when the restraining member is in the restraining position, thereby allowing adjustment of the position at which the restraining member presses the switch by adjusting the position of the pushing member. The plug door device further includes the supporting member that moves along with the door with the driving force from the drive source and is spaced apart from the rotating member such that it does not contact the guide rail when the door is opened and closed. The restraining member has the restraining wall that slopes toward the closing direction as viewed from the height direction of the vehicle and restrains the supporting member in the position where the door is fully closed. Thus, even if the rotating member is dislodged by any chance, the second moving member is restrained by the restraining wall. Further, the torsion spring that applies the elastic force to the restraining member to keep it in the unrestraining position is provided. Thus, the restraining member can be kept in the unrestraining position by utilizing the elastic force of the torsion spring. Consequently, the rotating member is able to smoothly push the restraining member in the unrestraining position. The torsion spring is wrapped around the shaft. Thus, it is possible to save the space for placing the torsion spring. In this configuration, at least a part of the restraining member is disposed within the height range of the guide rail in the height direction of the vehicle. Thus, it is not necessary to provide a space for the restraining member in the height direction and thereby it is possible to downsize in the height direction. The restraining member has the guide wall that contacts the rotating member in the unrestraining position and guides the movement of the rotating member along the opening-closing path. Thus, the guide rail or the guide wall allows the rotating member to move along the opening-closing path by thus enabling the rotating member to be moved smoothly from the unrestraining position to the restraining position.

ADVANTAGEOUS EFFECTS

[0011] The present invention can provide a plug door device capable of achieving energy saving.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a perspective view of a plug door device relating to a first embodiment.
Fig. 2 is an enlarged view of the portion II of Fig. 1.
Fig. 3 is a perspective view showing an area including a rotating member and a supporting member of the first embodiment.
Fig. 4 illustrates an operation of an restraining member of the first embodiment.
Fig. 5 is a bottom view of a plug door device relating to a second embodiment.
Fig. 6 is a perspective view of a plug door device relating to a third embodiment.
Fig. 7 is a bottom view of the plug door device relating to the third embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0013] 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 pair of doors separately slidable to open or close the entrance/exit 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

[0014] Fig. 1 is a perspective view showing a plug door device relating to a first embodiment. Fig. 2 is an enlarged view of the portion II of Fig. 1. Fig. 3 is a perspective view showing an area including a rotating member and a supporting member of the first embodiment. 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 guide rail 5 (see Fig. 2), a drive source 6, and a restraining member 7, and a locking mechanism 8. In Fig. 1, the pair of doors 2 is shown in the chain double-dashed line. Fig. 1 shows a state where the doors 2 are fully closed.

[0015] 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 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 inside in the width direction are respectively denoted as the +Y side and the - Y side. The upper side and lower side in the gravitational direction are respectively denoted as the +Z side and the -Z side.

[0016] The plug door device 1 has a swingable arm mechanism for guiding the doors 2 moving in the width (Y direction) and front-rear directions. 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 vehicle side wall when the doors 2 are fully closed. The doors 2 each include a door leave 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.

[0017] 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 an entrance/exit 15 of the vehicle. The stationary base 3 extends in the front-rear direction crossing over the upper edge of the entrance/exit 15. A rail base 9 extending in the width direction is coupled to the respective ends of the stationary base 3 in the front-rear direction.

[0018] 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 entrance/exit 15. The respective ends of the slidable base 4 in the front-rear direction are movable in the width direction along the rail bases 9.

[0019] As shown in Fig. 2, the guide rail 5 defines an opening-closing path 20 of the doors 2 for opening and closing the vehicle's entrance/exit 15 (see Fig. 1). The guide rail 5 is provided above the entrance/exit 15. The guide rail 5 is supported by the fixed base 3 (see Fig. 1). The guide rail 5 is attached to the fixed base 3 with a plurality of bolts or other fastening members.

[0020] The opening-closing path 20 is divided into a linear portion 21 extending along the front-rear direction and an inclined portion 22 inclined relative to the linear portion 21. A connecting portion 23 between the linear portion 21 and the inclined portion 22 is curved into an arc shape. In Fig. 2, a part of the linear portion 21 is shown in the chain double-dashed line.

[0021] 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.

[0022] 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 converting mechanism 31 converts the rotation of the output shaft of the motor around the axis extending along the front-rear direction into rotation around the axis extending along the width direction. The power transmission mechanism 31 includes a gear 33 rotatable around an axis extending along the width direction. A pulley 34 is provided at a position away in the front-rear direction from the gear 33 and rotatable around an axis parallel to the rotational axis of the gear 33 (extending along the width direction).

[0023] The belt 32 bridges the gear 33 and the pulley 34. The belt 32 is movable cooperatively as the gear 33 rotates and movable around the gear 33 and the pulley 34. The belt 32 is connected to the door hunger 11. The door hunger 11 is movable in the front-rear direction as the belt 32 moves. A coupling member 35 is attached to the belt 32 and movable as the belt 32 moves. As shown in Fig. 3, the rotating member 36 (moving member) and the supporting member 37 (second moving member) are supported by the coupling member 35.

[0024] For example, the rotating member 36 is a rotating member 36 that rolls along the opening-closing path 20. The rotating member 36 moves along with the door 2 (see Fig. 1) with the driving force from the drive source 6 (see Fig. 1). The rotating member 36 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. The rotating member 36 is rotatably connected to the coupling member 35 about an axis extending in the height direction. The shape of the rotating member 36 is circular when viewed from the height direction.

[0025] The door 2 on the -X side of the pair of the doors 2 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.

[0026] 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 hunger 11 and the coupling member 35, and the door hunger 11 and the coupling member 35 then move. At the fully open position, the doors 2 open (fully open) the entrance/exit 15 and are positioned on the outer side of the vehicle. In the example shown in Fig. 1, the -X-side door 2 first moves from the fully closed position outwardly in the width direction (specifically, obliquely including 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 outwardly in the width direction (specifically, obliquely including the width direction) and then moves linearly toward the +X side, to reach the fully opened position.

[0027] 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 a door attached to a ball nut corresponding to a nut is 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 a door attached to a rack rail is opened or closed. For example, the door driving system may be changed in accordance with required specifications.

[0028] For example, the supporting member 37 is a pin that extends in the height direction. The supporting member 37 extends in the upper direction from the connecting member 35. The supporting member 37 moves along with the door 2 (see Fig. 1) with the driving force from the drive source 6 (see Fig. 1). The supporting member 37 is disposed separately from the rotating member 36 such that it does not contact the guide rail 5 when the doors 2 are opened and closed.

[0029] The restraining member 7 restrains the rotating member 36 in the fully closed position of the doors 2 (see Fig. 1). The restraining member 7 is displaced in the height direction relative to the guide rail 5. The restraining member 7 is provided below the guide rail 5. The restraining member 7 is rotatable about a shaft 39 extending in the height direction.

[0030] An upper portion of the shaft 39 is fixed to the guide rail 5. As shown in Fig. 2, a torsion spring 40 (elastic member) is wound around the shaft 39. The position where the door is not restrained is hereinafter referred to as a "unrestraining position" and the position where the rotating member 36 is restrained in the fully closed position of the door is referred to as the "restraining position". The restraining position coincides with the fully closed position of the doors. The position of the restraining member 7 shown in Figs. 1 to 3 and the position of the restraining member 7 shown in the solid line in Fig. 4 are in the restraining position. The restraining member 7 shown in the chain double-dashed line in Fig. 4 is in the unrestraining position. The torsion spring 40 applies an elastic force to the restraining member 7 such that the restraining member 7 is held in the unrestraining position (the position shown in the chain double-dashed line in Fig. 4).

[0031] The restraining member 7 is held in the unrestraining position (the position shown in the chain double-dashed line in Fig. 4) with the elastic force from the torsion spring 40 when no external force is applied. The direction in which the doors 2 close is hereinafter referred to as the "closing direction".

[0032] Here, the closing direction refers to a direction in which the door 2 moves from the fully opened position to the fully closed position. When the door 2 moves from the fully opened position to the closed position, it initially moves straight along the front-rear direction. Thereafter, the door 2 moves inward in the width direction (specifically, diagonally including the width direction). The direction in which the door 2 moves changes between the beginning and the end of the closing movement. In the accompanying drawings, the direction in which the -X side-door among the pair of doors 2 is closed is shown in the arrow Vc direction (specifically, the component along the front-rear direction of the closing direction) as the closing direction.

[0033] The restraining member 7 is pushed by the rotating member 36 that moves in the closing direction Vc along the opening-closing path 20, and is moved from the unrestraining position (the position shown in the chain double-dashed line in Fig. 4) to the restraining position (the position shown in the solid line in Fig. 4).

[0034] As shown in Fig. 2, the restraining member 7 has a first arm 41 and a second arm 42 arranged in this order in the closing direction Vc. The first arm 41 and the second arm 42 are connected such that they together form a U-shape when viewed from the height direction. When the restraining member 7 is in the unrestraining

position (the position shown in the chain double-dashed line in Fig. 4), the first arm 41 does not cross the opening-closing path 20 but the second arm 42 crosses the opening-closing path 20. When the restraining member 7 is in the restraining position (the position shown in the solid line in Fig. 4), the first arm 41 and second arm 42 cross the opening-closing path 20. "Cross" herein means, for example, that any of the arms extends in a direction intersecting the extending direction of the opening-closing path 20 while overlapping the opening-closing path 20 as viewed from the height direction. The term "does not cross" or "uncrossed" herein means, for example, that any of the arms does not overlap with the opening-closing path 20 when viewed from the height direction.

[0035] As shown in Fig. 4, when the restraining member 7 is situated in the unrestraining position, the first arm 41 is disposed in a position avoiding the opening-closing path 20 (the position shown in the chain double-dashed line in Fig. 4). When the restraining member 7 is in the unrestraining position, the +Y end of the first arm 41 is disposed on the -Y side such that it does not overlap the opening-closing path 20. A groove 44 is formed in the first arm 41 and the groove 44 opens on a tip surface of the first arm 41. A tip portion of the inner surface of the groove 44 that faces the closing direction Vc serves as a restraining wall 43. The restraining wall 43 restrains the supporting member 37 (see Fig. 3) in the position where the door is fully closed. The restraining wall 43 is inclined with respect to the closing direction Vc. When the restraining member 7 is in the unrestraining position, the restraining wall 43 extends toward the closing direction Vc as viewed from the height direction as it approaches the shaft 39.

[0036] The second arm 42 is disposed away from the first arm 41 in the closing direction Vc. The second arm 42 has a first surface 45 and a second surface 46. The first surface 45 intersects the inclined portion 22 perpendicularly viewed from the height direction when the restraining member 7 is in the unrestraining position (the position shown in the chain double-dashed line in Fig. 4). The second surface 46 intersects the inclined portion 22 perpendicularly viewed from the height direction when the restraining member 7 is in the restraining position (the position shown in the solid line in Fig. 4).

[0037] The first surface 45 is connected to the second surface 46 such that it inclines toward the +X side as it approaches the +Y side when viewed from the height direction. The first surface 45 crosses the +Y side of the inclined portion 22 (the portion where the second surface 46 does not cross) when the restraining member 7 is in the unrestrained position (the position shown in the chain double-dashed line in Fig. 4). The first surface 45 does not intersect the inclined portion 22 when the restraining member 7 is in the restraining position (the position shown in the solid line in Fig. 4). When the restraining member 7 is situated in the restraining position, the first surface 45 is disposed such that it does not overlap the inclined portion 22 on the +X side.

[0038] The second surface 46 defines an inner surface of an U-shaped opening 47 formed in the restraining member 7. The second surface 46 crosses the -Y side of the inclined portion 22 (the portion that the first surface 45 does not cross) when the restraining member 7 is in the unrestraining position (the position shown in the chain double-dashed line in Fig. 4). The second surface 46 crosses the entire inclined portion 22 when the restraining member 7 is in the restraining position (the position shown in the solid line in Fig. 4).

[0039] The restraining member 7 includes a retained portion 48 that is retained by the locking mechanism 8. The retained portion 48 is provided on the opposite side of the shaft 39 to the restraining portion that restrains the rotating member 36 (e.g., the portion where the second arm 42 is provided) as viewed from the height direction. The restrained portion 48 extends along a direction orthogonal to the shaft 39 as viewed from the height direction. The retained portion 48 extends from a portion closer to the shaft 39 toward the -X side when the restraining member 7 is in the restraining position (the position shown in the solid line in Fig. 4). The retained portion 48 is formed integrally with the restraining member 7 using the same member.

[0040] The restraining member 7 has a pushing member 50 that pushes a switch 51 when the restraining member 7 is in the restraining position. For example, the switch 51 is provided for detecting that the door is locked in the fully closed position. The pushing member 50 is provided on the closing direction Vc side (+X side) of the shaft 39. The pushing member 50 is provided on the opposite side to the retained portion 48 with respect to the shaft 39 viewed from the height direction.

[0041] The pushing member 50 is detachably attached to the restraining member 7. The pushing member 50 has an elongate hole 52 along the rotational direction of the restraining member 7 (the circumferential direction of the shaft 39). The pushing member 50 is attached to the restraining member 7 by two or more bolts 53 (for example, two bolts in this embodiment) arranged along the elongate hole 52.

[0042] The locking mechanism 8 retains the restraining member 7 in the restraining position (the position shown in the solid line in Fig. 4). As shown in Fig. 2, the locking mechanism 8 has a lever 59 that pivots with the driving force from the drive source 6 (see Fig. 1). The lever 59 is connected to the drive source 6 via a link mechanism 60. The link mechanism 60 includes an arm 61 and a rod 62 (see Fig. 1).

[0043] When the restraining member 7 moves to the restraining position, the lever 59 is pushed by the retained portion 48 of the restraining member 7 (specifically, the portion extending upward from the tip of the retained portion 48), and the lever 59 is moved in the direction of the arrow Lm in Fig. 2 (clockwise direction with respect to the Z-axis when viewed from the -Z side). Then, a latch (not shown) in the locking mechanism 8 is locked, and the retained portion 48 of the restraining member 7 is

supported by the lever 59. As a result, the rotating member 36 and the supporting member 37 are restrained by the restraining member 7 at the position where the door is fully closed, and the door is locked (locked state).

[0044] When the arm 61 is pulled with the driving force from the drive source 6, the latch in the locking mechanism 8 is unlocked, and the lever 59 moves in the direction opposite to the direction of the arrow Lm in Fig. 2. Then, the retained portion 48 of the restraining member 7 is released from the support by the lever 59. As a result, the restraining member 7 returns to the unrestraining position (the position shown in the chain double-dashed line in Fig. 4) by the elastic force (restoring force) of the torsion spring 40. Thus, the rotating member 36 and the supporting member 37 are released from the restraint by the restraining member 7, and the door is unlocked (unlocked state).

[0045] Fig. 4 illustrates an operation of the restraining member 7 of the first embodiment. In Fig. 4, the restraining member 7 in the restraining position is shown with the solid line, and the restraining member 7 in the unrestraining position is shown with the chain double-dashed line. The elastic force by the torsion spring 40 is constantly applied to the restraining member 7. Therefore, when no external force is applied to the restraining member 7, the restraining member is held in the unrestraining position (the position shown in the chain double-dashed line in Fig. 4). When the restraining member 7 is in the unrestraining position, the rotating member 36 and the supporting member 37 are configured to be movable together with the door with the driving force from the drive source 6 (see Fig. 1).

[0046] The rotating member 36 (see Fig. 3) 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. Specifically, when the door 2 is closed from the fully open position, the rotating member 36 moves straight along the linear portion 21 (see Fig. 2) at the start. Thereafter, the rotating member 36 moves inward in the width direction (specifically, diagonally including the width direction) along the inclined portion 22. The direction in which the rotating member 36 moves changes between the beginning and the end of its movement in the closing direction Vc. Whereas the supporting member 37 (see Fig. 3) moves along a path that is situated apart from and below the opening-closing path 20 such that the supporting member 37 does not contact the guide rail 5 when the door opens and closes.

[0047] When the rotating member 36 moves in the closing direction Vc along the opening-closing path 20, the rotating member 36 first contacts the second arm 42 (the second arm 42 shown in the chain double-dashed line in Fig. 4) that crosses the opening-closing path 20. When the rotating member 36 moves further in the closing direction Vc along the opening-closing direction, the rotating member 36 pushes the second arm 42 in the closing direction Vc against the elastic force of the torsion spring 40. As the second arm 42 is pushed to the closing direction Vc by the rotating member 36, the restraining member 7 moves (rotates) from the unrestraining position (the position shown in the chain double-dashed line in Fig. 4) to the restraining position (the position shown in the solid line in Fig. 4).

[0048] The restraining member 7 moves to the restraining position (the position shown in the solid line in Fig. 4), and then the retained portion 48 of the restraining member 7 pushes the lever 59. The lever 59 is moved in the direction indicated by the arrow Lm in Fig. 2. This causes the latch to be locked in the locking mechanism 8. When the latch is locked, the locking mechanism 8 keeps the retained portion 48 of the restraining member 7 to be retained by the lever 59 (see Fig. 2) while the door is in the fully closed position (restraining position).

[0049] When the restraining member 7 is in the restraining position, the first arm 41 and the second arm 42 each cross the opening-closing path 20. As shown in Fig. 3, the first arm 41 restricts the rotating member 36 and the supporting member 37 from moving in the direction opposite to the closing direction Vc along the opening-closing path 20 when the restraining member 7 is in the restraining position. The second arm 42 restricts the rotating member 36 from moving further in the closing direction Vc along the opening-closing direction when the restraining member 7 is in the restraining position. The restraining wall 43 of the first arm 41 restricts the supporting member 37 from moving in the direction opposite to the closing direction Vc when the restraining member 7 is in the restraining position.

[0050] In this way, the rotating member 36 and the supporting member 37 are restrained by the restraining member 7 at the position where the door is fully closed. Since the rotating member 36 and the supporting member 37 are restrained by the restraining member 7, the door is locked (in the locked state). When the restraining member 7 is in the restraining position, the switch 51 is pressed by the pushing member 50 (see Fig. 4). In this way, it is possible to detect that the door is locked in the fully closed position.

[0051] Whereas when unlocking the door from the locked state, the arm 61 (see Fig. 2) is pulled with the driving force from the drive source 6. Then, the latch inside the locking mechanism 8 is unlocked, and the lever 59 moves in the direction opposite to the arrow Lm in Figure 2. The retained portion 48 of the restraining member 7 is released from the support by the lever 59. Then, the elastic force (restoring force) of the torsion spring 40 causes the restraining member 7 to return to the unrestraining position (the position shown in the chain double-dashed line in Fig. 4). The rotating member 36 and the supporting member 37 (see Fig. 3) is able to move in the direction opposite to the closing direction Vc along the opening-closing path 20 as they are released from the restraint by the restraining member 7. As described above, the door is unlocked (unlocked state).

[0052] As described above, the plug door device 1 of this embodiment includes the guide rail 5 defining the

opening-closing path 20 of the door 2 for opening-closing the entrance/exit 15 of the vehicle, the drive source 6 for moving the door 2, and the rotating member 36 that moves along with the door 2 with the driving force from the drive source 6 and rolls along the opening-closing path 20 while being guided by the guide rail 5 when the door 2 opens/closes. The plug door device 1 further includes the restraining member 7 that is pushed by the rotating member 36 when the rotating member 36 moves in the closing direction Vc along the opening-closing path 20 to move from the unrestraining position for unrestraining the door 2 to the restraining position for restraining the rotating member 36 for the fully closed door 2, and the locking mechanism 8 that holds the restraining member 7 in the restraining position. The restraining member 7 is displaced relative to the guide rail 5 in the height direction of the vehicle. The restraining member 7 has the first arm 41 and second arm 42 arranged in this order in the closing direction Vc. When the restraining member 7 is in the unrestraining position (the position shown in the chain double-dashed line in Fig. 4), the first arm 41 does not cross the opening-closing path 20 but the second arm 42 crosses the opening-closing path 20. When the restraining member 7 is in the restraining position, the first arm 41 and the second arm 42 each cross the opening-closing path 20. The opening-closing path 20 is divided into the linear portion 21 extending along the front-rear direction of the vehicle and the inclined portion 22 inclined relative to the linear portion 21. The second arm 42 includes the first surface 45 that is disposed orthogonal to the inclined portion 22 when the restraining member 7 is in the unrestraining position and the second surface 46 that is disposed orthogonal to the inclined portion 22 when the restraining member 7 is in the restraining position. The restraining member 7 is rotatable about the shaft 39 that extends in the height direction of the vehicle. The restraining member 7 has the retained portion 48 that is disposed opposite to the portion that restrains the rotating member 36 with respect to the shaft 39 and is retained by the locking mechanism 8. The retained portion 48 is formed integrally with the restraining member 7 using the same member. The restraining member 7 has a pushing member 50 that pushes a switch 51 when the restraining member 7 is in the restraining position. The plug door device 1 has the torsion spring 40 that is wound around the shaft 39 and applies an elastic force to the restraining member 7 to keep it in the unrestraining position. The plug door device further includes the supporting member 37 that moves along with the door 2 with the driving force from the drive source 6 and is spaced apart from the rotating member 36 such that it does not contact the guide rail 5 when the door 2 is opened and closed. The restraining member 7 has the restraining wall 43 that slopes toward the closing direction Vc as seen from the height direction of the vehicle and restrains the supporting member 37 when the door is fully closed.

[0053] With this configuration, the restraining member 7 is moved to the restraining position (where the door 2 is locked in the fully closed position) utilizing the driving force of the drive source 6 (door drive source) that is for driving the door 2. Therefore, no additional actuator other than the door drive source is required to move the restraining member 7, which results in energy saving. In is not necessary to provide a separate actuator (not shown) for locking the restraining member 7. By providing the rotating member 36 that rolls along the opening-closing path 20 while being guided by the guide rail 5 when the door 2 opens and closes, it is possible to reduce friction against the guide rail 5. Consequently, the rotating member 36 can be moved smoothly from the unrestraining position to the restraining position. Since the restraining member 7 is rotatable about the shaft 39 that extends in the height direction of the vehicle, no space in the height direction is required to allow the rotation of the restraining member 7 and it is possible to reduce the size of the restraining member 7 in the height direction. In addition, the restraining member 7 is disposed opposite to the portion that restrains the rotating member 36 with respect to the shaft 39 and has the retained portion 48 that is retained by the locking mechanism 8. Thus, the retained portion 48 and the portion that restrains the rotating member 36 are separated from each other with the shaft 39 interposed therebetween. This arrangement creates a space for the placement of the locking mechanism 8 and increase the degree of freedom in the placement of the locking mechanism 8. The retained portion 48 is formed as a part of the restraining member 7 such that they together form a single body. Therefore, the number of components can be reduced and the cost can be lowered compared with the case where the retained portion where is retained by the locking mechanism 8 is provided separately from the restraining member 7. The restraining member 7 is provided with the pushing member 50 that presses the switch 51 when the restraining member 7 is in the restraining position, thereby allowing adjustment of the position at which the restraining member 7 presses the switch 51 by adjusting the position of the pushing member 50. The plug door device further includes the supporting member 37 that moves along with the door with the driving force from the drive source 6 and is spaced apart from the rotating member 36 such that it does not contact the guide rail 5 when the door is opened and closed. The restraining member 7 has the restraining wall 43 that slopes toward the closing direction Vc as seen from the height direction of the vehicle and restrains the supporting member 37 when the door 2 is fully closed. Thus, even if the rotating member 36 is dislodged by any chance, the supporting member 37 is restrained by the restraining wall 43. Consequently, the door 2 can be held in the locked state. Since the restraining member 7 is displaced in the height direction of the vehicle with respect to the guide rail 5, it is possible to flexibly design the shape of the guide rail 5, thus increasing the design freedom of the guide rail 5. The restraining member 7 has the first arm 41 and second arm 42 arranged in this

order in the closing direction Vc. When the restraining member 7 is in the unrestraining position, the first arm 41 does not cross the opening-closing path 20 but the second arm 42 crosses the opening-closing path 20. Thus, when the restraining member 7 is in the unrestraining position, the second arm 42 is pushed by the rotating member 36 to move the rotating member 36 from the unrestraining position to the restraining position. Whereas when the restraining member 7 is in the restrained position, the first arm 41 and the second arm 42 cross the opening-closing path 20. Thus, when the restraining member 7 is situated in the restraining position, the rotating member 36 can be restrained by the first arm 41 and the second arm 42. The opening-closing path 20 is divided into the linear portion 21 extending along the front-rear direction of the vehicle and the inclined portion 22 inclined relative to the linear portion 21. The second arm 42 has the first surface 45 that is arranged orthogonal to the inclined portion 22 when the restraining member 7 is in the unrestraining position. Thus, when the restraining member 7 is in the unrestraining position, the first surface 45 of the second arm 42 is pushed by the rotating member 36 to move the rotating member 36 from the unrestraining position to the restraining position. Whereas when the restraining member 7 is in the restrained position, the second arm 42 has the second surface 46 that is arranged orthogonal to the inclined portion 22 so that the rotating member 36 is restrained by the second surface 46 of the second arm 42 when the restraining member 7 is in the restraining position. Further, the torsion spring 40 that applies the elastic force to the restraining member 7 to keep it in the unrestraining position is provided. Thus, the restraining member 7 can be kept in the unrestraining position by utilizing the elastic force of the torsion spring 40. Consequently, the rotating member 36 is able to smoothly push the restraining member 7 in the unrestraining position. The torsion spring 40 is wrapped around the shaft 39. Thus, it is possible to save the space for placing the torsion spring 40.

Second Embodiment

[0054] Fig. 5 is a bottom view of a plug door device 201 relating to the second embodiment. Fig. 5 is the bottom view corresponding to Fig. 4. In Fig. 5, the restraining member 7 in the restraining position is shown with the solid line, and the restraining member 7 in the unrestraining position is shown with the chain double-dashed line. In the first embodiment, the elastic member is the torsion spring 40 (see Fig. 2) wound around the shaft 39, but the elastic member is not limited to this. For example, as shown in Fig. 5, the elastic member may be a compression spring 240 that is compressible in the direction intersecting the shaft 39. In Fig 5, the same elements as in the first embodiment are denoted by the same reference numerals and detailed descriptions thereof will be omitted.

[0055] As shown in Fig. 5, the guide rail 5 is provided with a first pin 241 extending in the height direction. A second pin 242 extending parallel to the first pin 241 is provided on the restraining member 7. One end of the compression spring 240 is connected to the guide rail 5 via the first pin 241. The other end of the compression spring 240 is connected to the restraining member 7 via the second pin 242. The position of a center axis line Ac of the compression spring 240 when it overlaps with the center of the shaft 39 (axial center) as viewed from the height direction may be hereinafter referred to as a "boundary position Bp". The boundary position Bp corresponds to a virtual straight line passing through the center of the first pin 241 and the axial center of the shaft 39 when viewed from the height direction.

[0056] The center axis line Ac of the compression spring 240 is situated on the opposite side to the closing direction Vc with respect to the boundary position Bp (the position shown in the chain double-dashed line in Fig. 5) viewed from the height direction when the rotating member 36 moves in the unrestraining position (when the rotating member 36 is allowed to move along the opening-closing path 20). Whereas when the rotating member 36 is in the restraining position, the center axis line Ac of the compression spring 240 is situated on the closing direction Vc side with respect to the boundary position Bp viewed from the height direction (the position shown in the solid line in Fig. 5).

[0057] As described, provided is the compression spring 240 that can be compressed in the direction intersecting the shaft 39. One end of the compression spring 240 is connected to the guide rail 5, and the other end of the compression spring 240 is connected to the restraining member 7. The center axis line Ac of the compression spring 240 is situated on the opposite side to the closing direction Vc with respect to the boundary position Bp where the center axis line Ac passes the shaft 39 as seen from the height direction when the rotating member 36 moves in the unrestraining position. When the rotating member 36 is in the restraining position, the center axis line Ac is situated on the closed direction Vc side with respect to the boundary position Bp as seen from the height direction. With this configuration, it is possible to change the direction in which the force of the compression spring 240 is applied to the restraining member 7 depending on the position of the rotating member 36.

Third Embodiment

[0058] Fig. 6 is a perspective view of a plug door device relating to a third embodiment. Fig. 7 is a bottom view showing the plug door device relating to the third embodiment. In Fig. 7, a restraining member 307 in the restraining position is shown with the solid line, and the restraining member 307 in the unrestraining position is shown in the chain double-dashed line. In the first embodiment, the restraining member 7 is displaced in the height direction relative to the guide rail 5 (see Fig. 2), however, the

arrangement is not limited to this. For example, as shown in Fig. 6, at least a part of the restraining member 307 may be disposed within a height range of the guide rail 5. Here, "within the height range of the guide rail 5" means within the range between the topmost and the bottommost ends of the guide rail 5. In Figs. 6 and 7, the same elements as in the first embodiment are denoted by the same reference numerals and detailed descriptions thereof will be omitted.

[0059] As shown in Fig. 7, the restraining member 307 has a guide wall 371. The guide wall 371 contacts the rotating member 36 in the unrestraining position (position shown in the chain double-dashed line in Fig. 7) to guide the movement of the rotating member 36 along the opening-closing path 20. When the restraining member 307 is in the unrestraining position, the guide wall 371 curves in an arc shape along the inclined portion 22 of the opening-closing path 20 when viewed from the height direction. Whereas when the restraining member 307 is in the restraining position (the position shown in the solid line in Fig. 7), the guide wall 371 serves as a stopper wall that prevents the rotating member 36 from moving along the opening-closing path 20 in the direction opposite to the closing direction Vc.

[0060] As shown in Fig. 6, the restraining member 307 has a pushing portion 372. The pushing portion 372 presses the switch 51 when the restraining member 307 is in the restraining position. The pushing portion 372 is formed as a part of the restraining member 307 such that they together form a single body.

[0061] The plug door device 301 of this embodiment is not equipped with the supporting member 37 (see Fig. 3). Therefore, the restraining member 307 does not have the restraining wall 43 (see Fig. 3) that restrains the supporting member 37.

[0062] In this configuration, at least a part of the restraining member 307 is disposed within the height range of the guide rail 5 in the height direction of the vehicle. Thus, it is not necessary to provide a space for the restraining member 307 in the height direction and thereby it is possible to downsize in the height direction. The restraining member 307 has the guide wall 371 that contacts the rotating member 36 in the unrestraining position and guides the movement of the rotating member 36 along the opening-closing path 20. Thus, the guide rail 5 or the guide wall 371 allows the rotating member 36 to move along the opening-closing path 20 by thus enabling the rotating member 36 to be moved smoothly from the unrestraining position to the restraining position. The restraining member 307 has the pushing portion 372 that presses the switch 51 when the restraining member 307 is in the restraining position. The pushing portion 372 is formed as a part of the restraining member 307 to form together a single body. Therefore, the number of components can be reduced and the cost can be lowered compared to the case where the pushing portion that presses the switch 51 is provided separately from the restraining member 307. The plug door device 301 according to the above embodiment does not have the supporting member 37, which results in reduction in the number of components and costs. Since the restraining member 307 does not have the restraining wall 43 that restrains the supporting member 37, the restraining member 307 can be formed in any shape and the design freedom of the restraining member 307 is increased. In this embodiment, instead of the supporting member 37, any other member capable of keeping the door 2 in the locked state may be provided for the event that the rotating member 36 is dislodged by any chance.

[0063] The proportion of the restraining member 307 to the height range of the guide rail 5 in the third embodiment is not particularly limited, but from the viewpoint of downsizing in the height direction, it is preferable that the entire restraining member 307 is disposed within the height range of the guide rail 5.

[0064] 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.

[0065] In the above-described embodiments, the example is given in which the restraining member 7 (307) is rotatably provided about the shaft 39 extending in the height direction of the vehicle, but this is not limited thereto. For example, the restraining member may be provided movable in the front/rear and width directions of the vehicle. For example, the directions in which the restraining member can move may be changed in accordance with required specifications.

[0066] In the above embodiment, the restraining member 7 has the retained portion 48 that is disposed opposite to the portion that restrains the rotating member 36 with respect to the shaft 39 and is retained by the locking mechanism 8. For example, the retained portion 48 may be disposed on the same side as the portion that restrains the rotating member 36 in the restraining member 7. For example, the installation position of the retained portion 48 can be changed in accordance with required specifications.

[0067] In the above-mentioned embodiment, the retained portion 48 is integrally formed with the restraining member 7 (see Fig. 2), but this is not limited thereto. For example, the retained portion 48 may be formed as a separate member from the restraining member 7. The configuration of the retained portion 48 can be changed in accordance with required specifications.

[0068] In the above embodiment, the restraining member 7 has the pushing member 50 that presses the switch 51 when the restraining member 7 is in the restraining position (see Fig. 2), but the configuration is not limited to this. For example, the restraining member 7 may not have the pushing member 50. For example, the pushing member 50 may be provided on a member other than the restraining member 7. For example, the installation position of the pushing member 50 can be changed in accordance with required specifications.

[0069] In the above embodiment, the moving member

is the rotating member 36 that rolls along the opening-closing path 20 (see Fig. 3). However, the moving member is not limited to this. For example, the moving member need not be the rotating member 36 (rotating body). For example, the moving member may be a pin fixed non-rotatably to the coupling member 35. For example, the configuration of the moving member can be changed in accordance with required specifications.

[0070] In the embodiments described above, the plug door device is described has the elastic member that applies the elastic force to the restraining member so that the restraining member is held in the unrestraining position. For example, the plug door device may not be provided with the elastic member. For example, the restraining member may be kept in the unrestraining position by the self-weight of the restraining member. For example, the restraining member may be kept in the unrestraining position by a weight connected to the restraining member. For example, how the restraining member is kept in the unrestraining position may be changed in accordance with required specifications.

[0071] The above embodiments are described with reference to an example plug door device including the pair of doors separately slidable to open or close the entrance/exit of the railway vehicle. However, the configuration is not limited to this. For example, the plug door device may be installed in a vehicle other than a railway vehicle. For example, the plug door device may include a single sliding door.

[0072] 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.

LIST OF REFERENCE NUMBERS

[0073] 1, 201, 301 ... plug door device, 2 ... door, 5 ... guide rail, 6 ... drive source (6), 7, 307 ... restraining member, 8 ... locking mechanism, 15 ... entrance/exit, 20 ... opening-closing path, 21 ... linear portion, 22 ... inclined portion, 36 ... rotating member (moving member), 39 ... shaft, 40 ... torsion spring (elastic member), 41 ... first arm, 42 ... second arm, 45 ... first surface, 46 ... second surface, 48 ... retained portion, 50 ... pushing member, 51 ... switch, 240 ... compression spring (elastic member), 371 ... guide wall, Ac ... center axis line, Bp ... boundary position, Vc ... closing direction

Claims

1. A plug door device (1), comprising:

a guide rail defining an opening-closing path (20) of a door (2) for opening or closing an entrance (15) of a vehicle;
a drive source (6) for moving the door (2);
a moving member (36) moving along with the door (2) with a driving force from the drive source (6), the moving member (36) being guided by the guide rail (5) to move along the opening-closing path (20) when the door (2) is opened or closed;
a restraining member (7) moving from an unrestraining position where the door (2) is unrestrained to a restraining position where the moving member (36) is restrained in a position where the door is fully closed, the restraining member (7) being pushed by the moving member (36) to move from the unrestraining position to the restraining position when the moving member (36) moves along the opening-closing path (20) in a closing direction (Vc); and
a locking mechanism (8) for retaining the restraining member (7) in the restraining position.

2. The plug door device (1) of claim 1, wherein the restraining member (7) is displaced relative to the guide rail (5) in a height direction of the vehicle.

3. The plug door device (1) of claim 2, wherein the restraining member (7) has a first arm (41) and a second arm (42) arranged in this order in the closing direction (Vc),

wherein, when the restraining member (7) is in the unrestraining position, the first arm (41) does not cross the opening-closing path (20) but the second arm (42) crosses the opening-closing path (20), and
wherein, when the restraining member (7) is in the restraining position, the first arm (41) and the second arm (42) cross the opening-closing path (20).

4. The plug door device (1) of claim 3, wherein the opening-closing path (20) is divided into a linear portion (21) extending along a front-rear direction of the vehicle and an inclined portion (22) inclined relative to the linear portion (21),
wherein the second arm (42) includes a first surface (45) that is disposed orthogonal to the inclined portion (22) when the restraining member (7) is in the unrestraining position and a second surface (46) that is disposed orthogonal to the inclined portion (22) when the restraining member (7) is in the restraining position.

5. The plug door device (1) of claim 1, wherein at least a part of the restraining member (7) is disposed in a range of the guide rail (5) in the height direction of the vehicle.

6. The plug door device (1) of claim 5, wherein the restraining member (7) has a guide wall (371) that contacts the moving member (36) in the unrestraining

position and guides movement of the moving member (36) along the opening-closing path (20).

7. The plug door device (1) of any one of claims 1 to 6, wherein the restraining member (7) is rotatable about a shaft (39) that extends in a height direction of the vehicle.

8. The plug door device (1) of claim 7, wherein the restraining member (7) has a retained portion (48) retained by the locking mechanism (8), and the retained portion (48) is disposed opposite to a portion that restrains the moving member (36) with respect to the shaft (39).

9. The plug door device (1) of claim 8, wherein the retained portion (48) is formed as a part of the restraining member (7) such that the retained portion (48) and the restraining member (7) together form a single body.

10. The plug door device (1) of any one of claims 1 to 9, wherein the restraining member (7) has a pushing member (50) that pushes a switch (51) when the restraining member (7) is in the restraining position.

11. The plug door device (1) of any one of claims 1 to 10, wherein the moving member (36) is a rotating member (36) that is rotatable about an axis extending in a height direction of the vehicle and that rolls along the opening-closing path (20), and
wherein the rotating member (36) has a circular shape when viewed from the height direction.

12. The plug door device (1) of any one of claims 1 to 11, wherein the restraining member (7) has an elastic member (40) that applies an elastic force to the restraining member (7) such that the restraining member (7) is held in the unrestraining position.

13. The plug door device (1) of claim 12, wherein the restraining member (7) is rotatable about a shaft (39) that extends in a height direction of the vehicle, and wherein the elastic member (40) is a torsion spring (40) wound around the shaft (39).

14. The plug door device (1) of claim 12, wherein the restraining member (7) is rotatable about a shaft (39) that extends in a height direction of the vehicle,

wherein the elastic member (40) is a compression spring (240) compressible in a direction intersecting the shaft (39),
wherein one end of the compression spring (240) is connected to the guide rail (5),
wherein the other end of the compression spring (240) is connected to the restraining member (7), and
wherein a center axis line (Ac) of the compression spring is situated on an opposite side to the closing direction (Vc) with respect to a boundary position (Bp) where the center axis line (Ac) passes the shaft (39) as viewed from the height direction when the moving member (36) moves in the unrestraining position, and the center axis line (Ac) is situated on the closed direction side with respect to the boundary position (Bp) as viewed from the height direction when the moving member (36) is in the restraining position.

15. The plug door device (1) of any one of claims 1 to 14, further comprising a second moving member (37) moving along with the door (2) with a driving force from the drive source (6), the second moving member (36) being spaced apart from the moving member (36) such that the second moving member (37) does not contact the guide rail (5) when the door (2) is opened or closed,

wherein the restraining member (7) has a restraining wall that restrains the second moving member (37) in the position where the door (2) is fully closed, and
wherein the restraining wall faces the closing direction (Vc) and slops toward the closing direction (Vc) as viewed from a height direction of the vehicle.

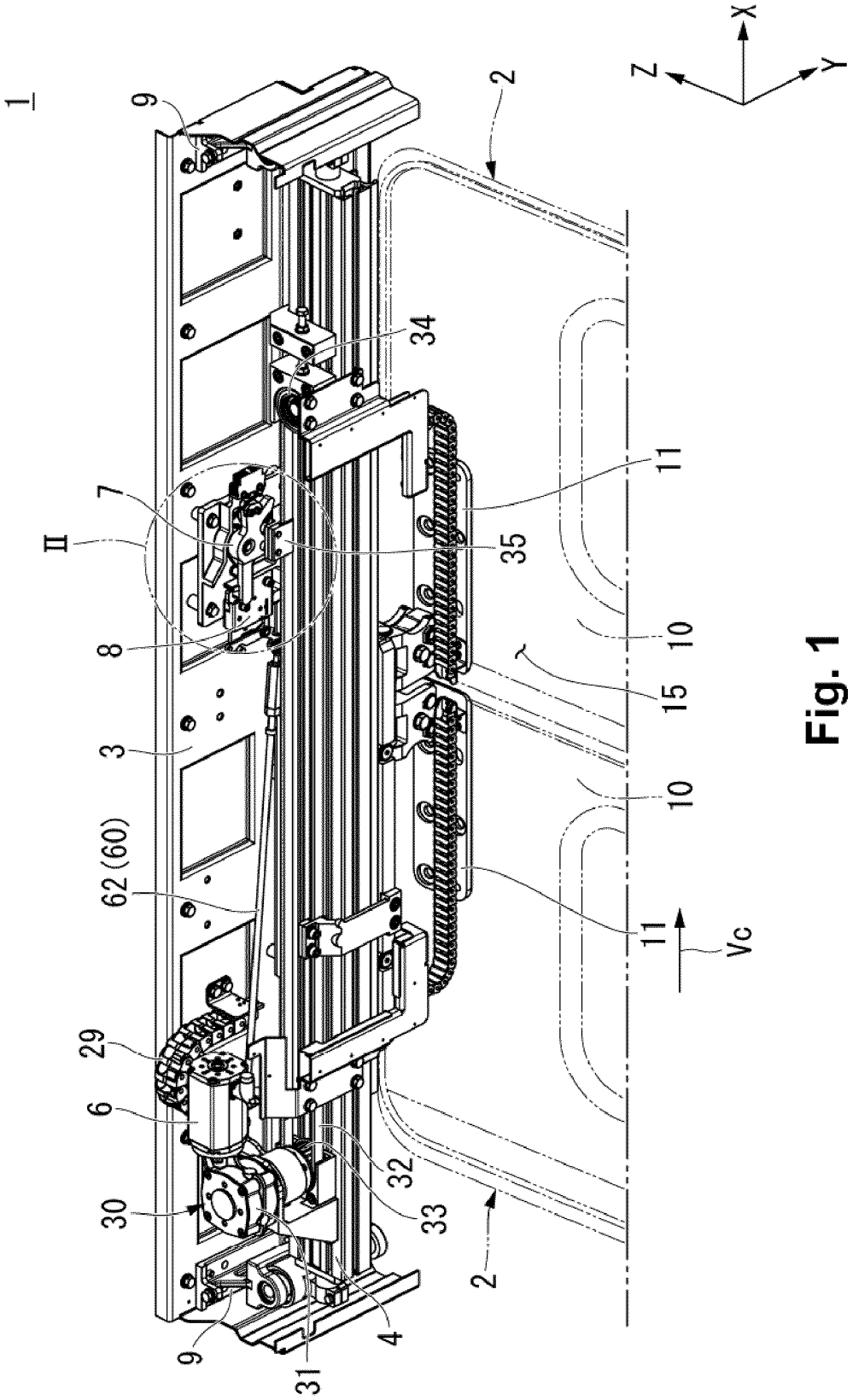

Fig. 1

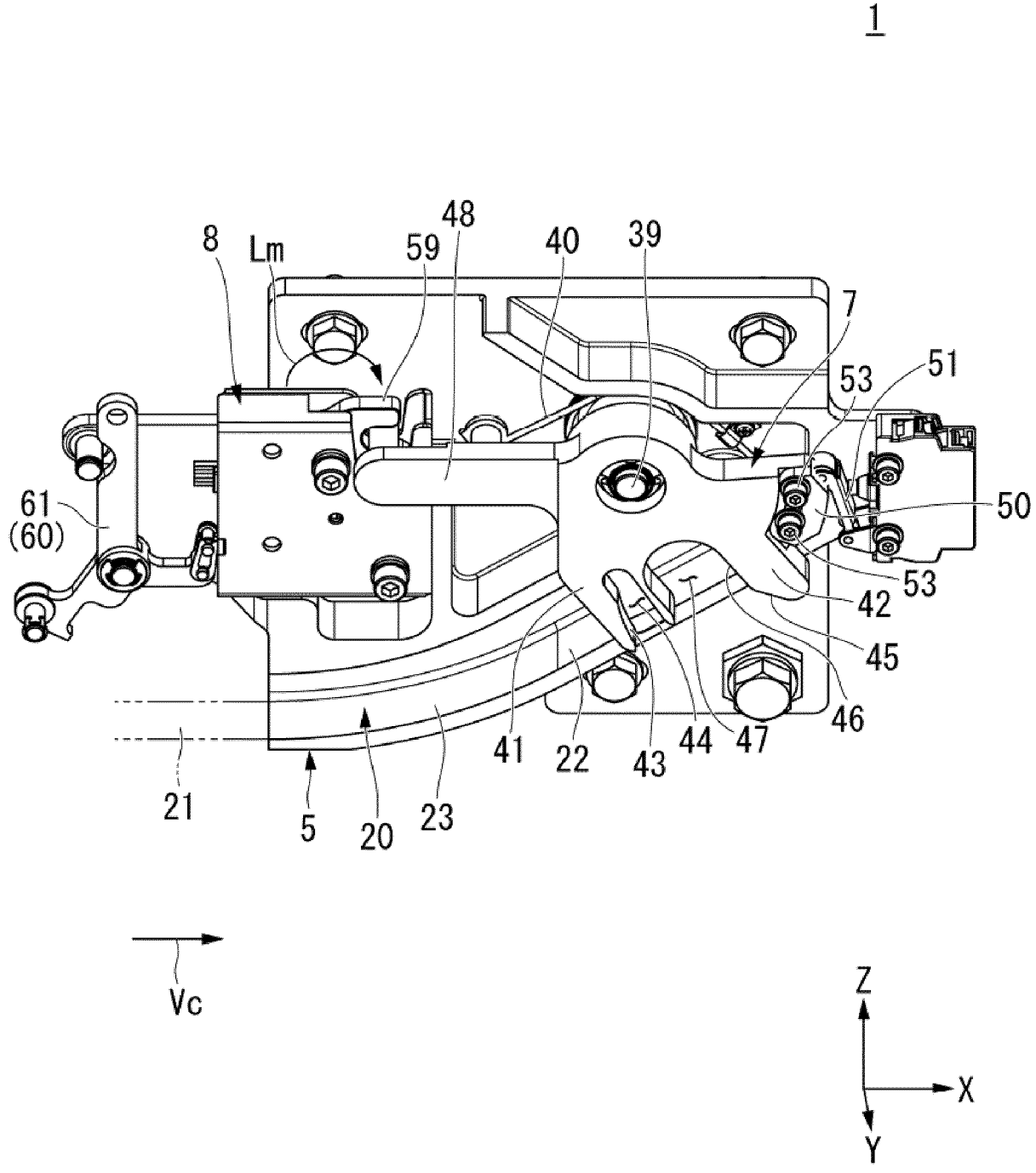
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Fig. 2

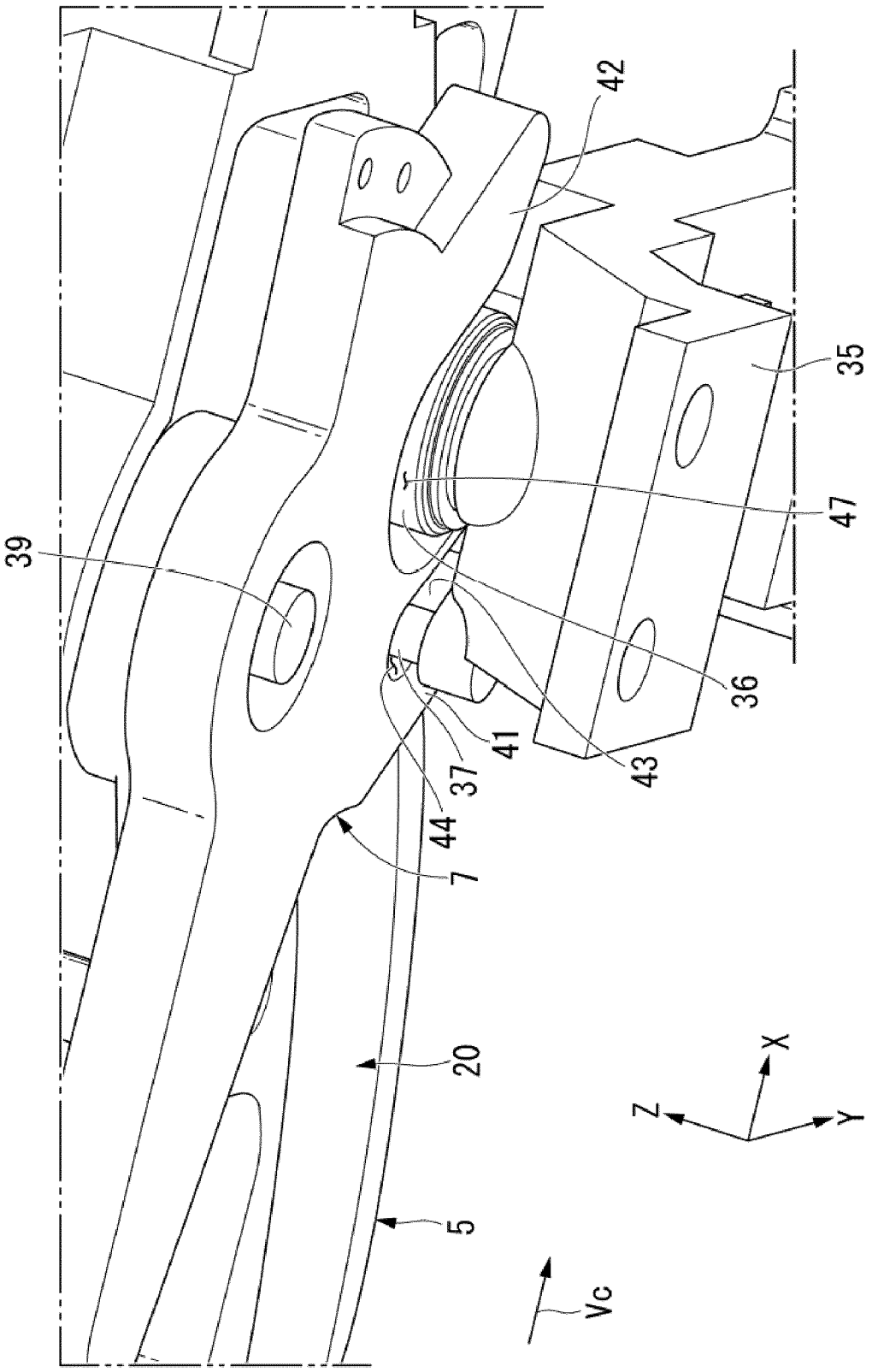

Fig. 3

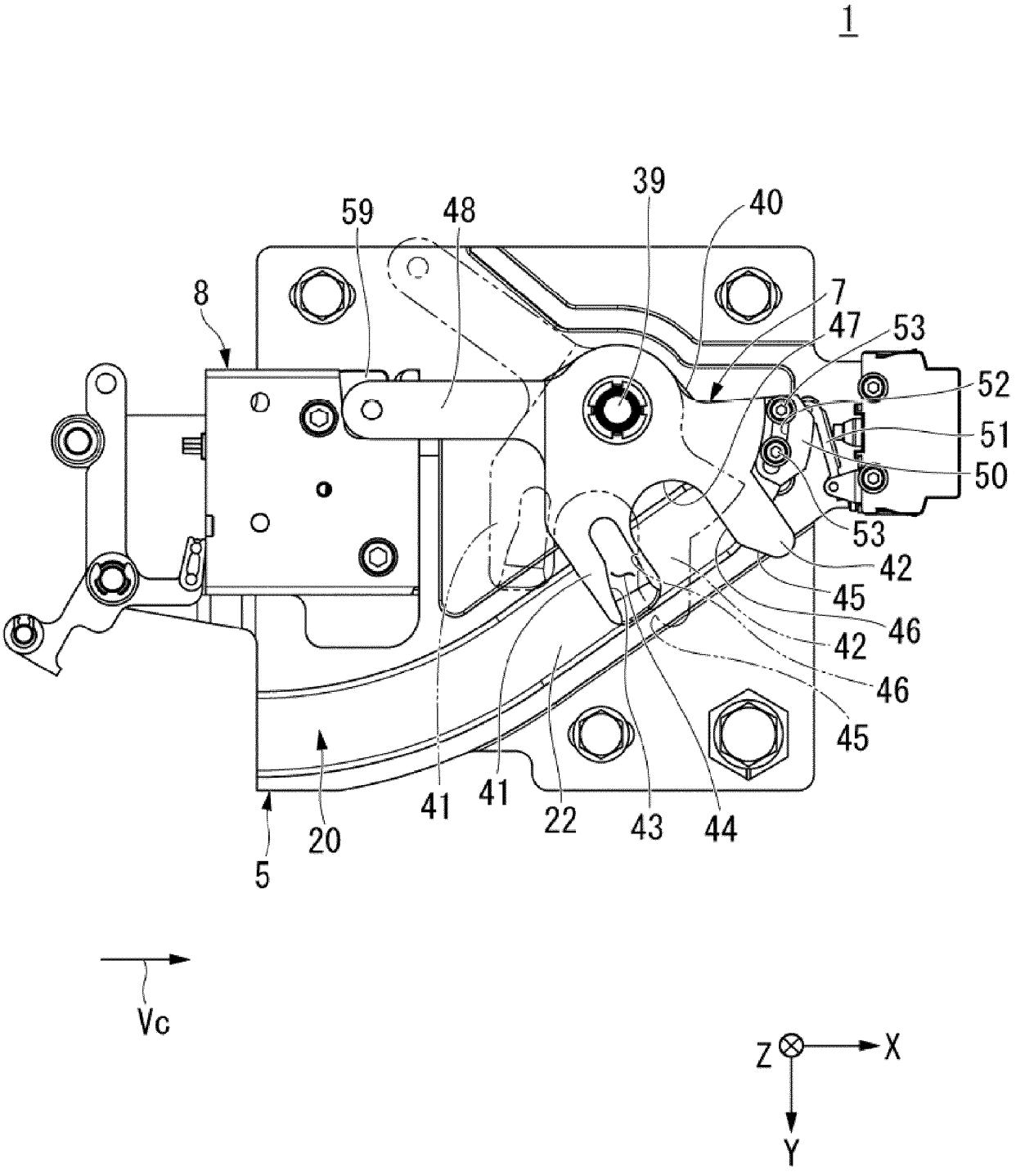
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Fig. 4

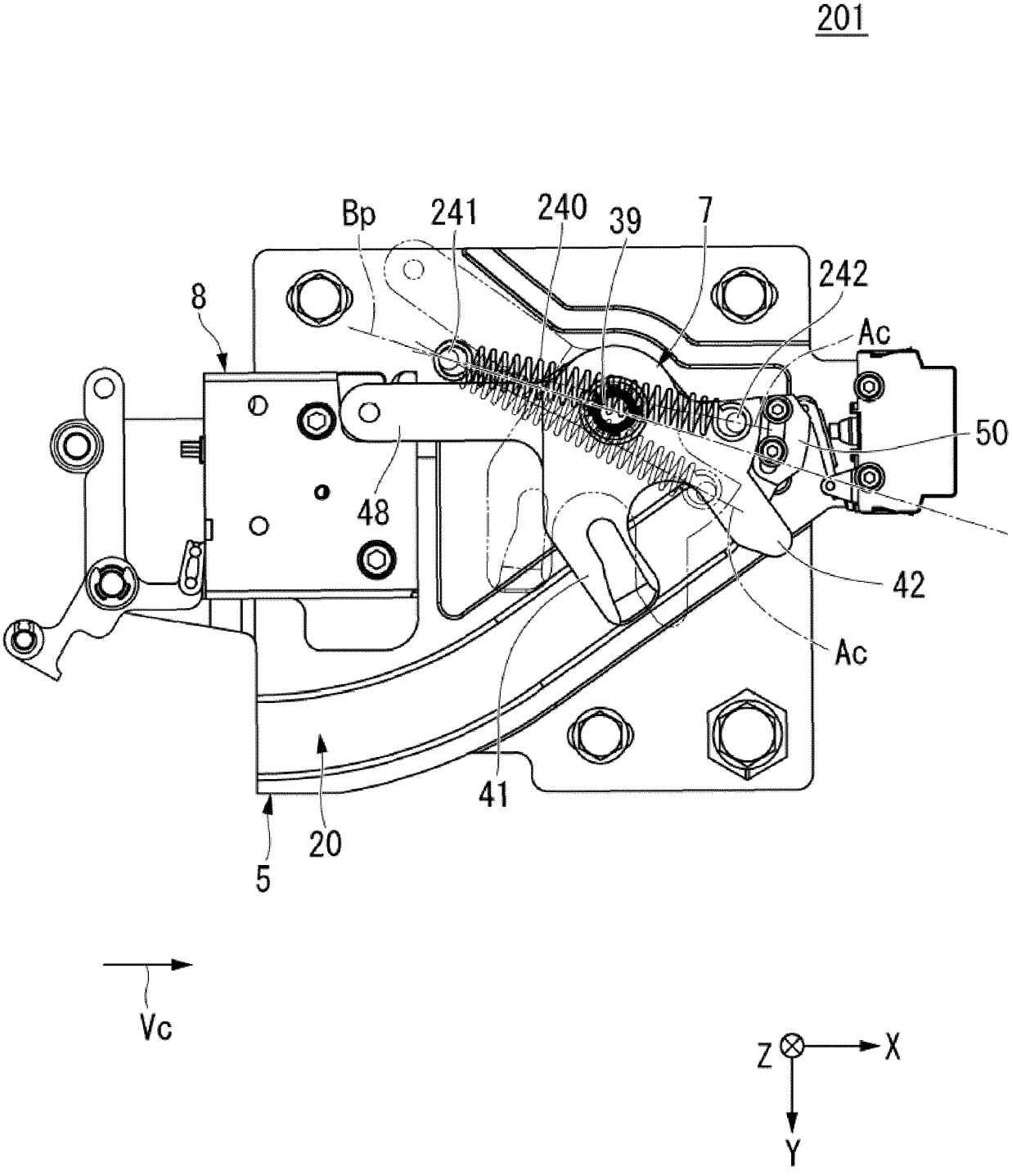

Fig. 5

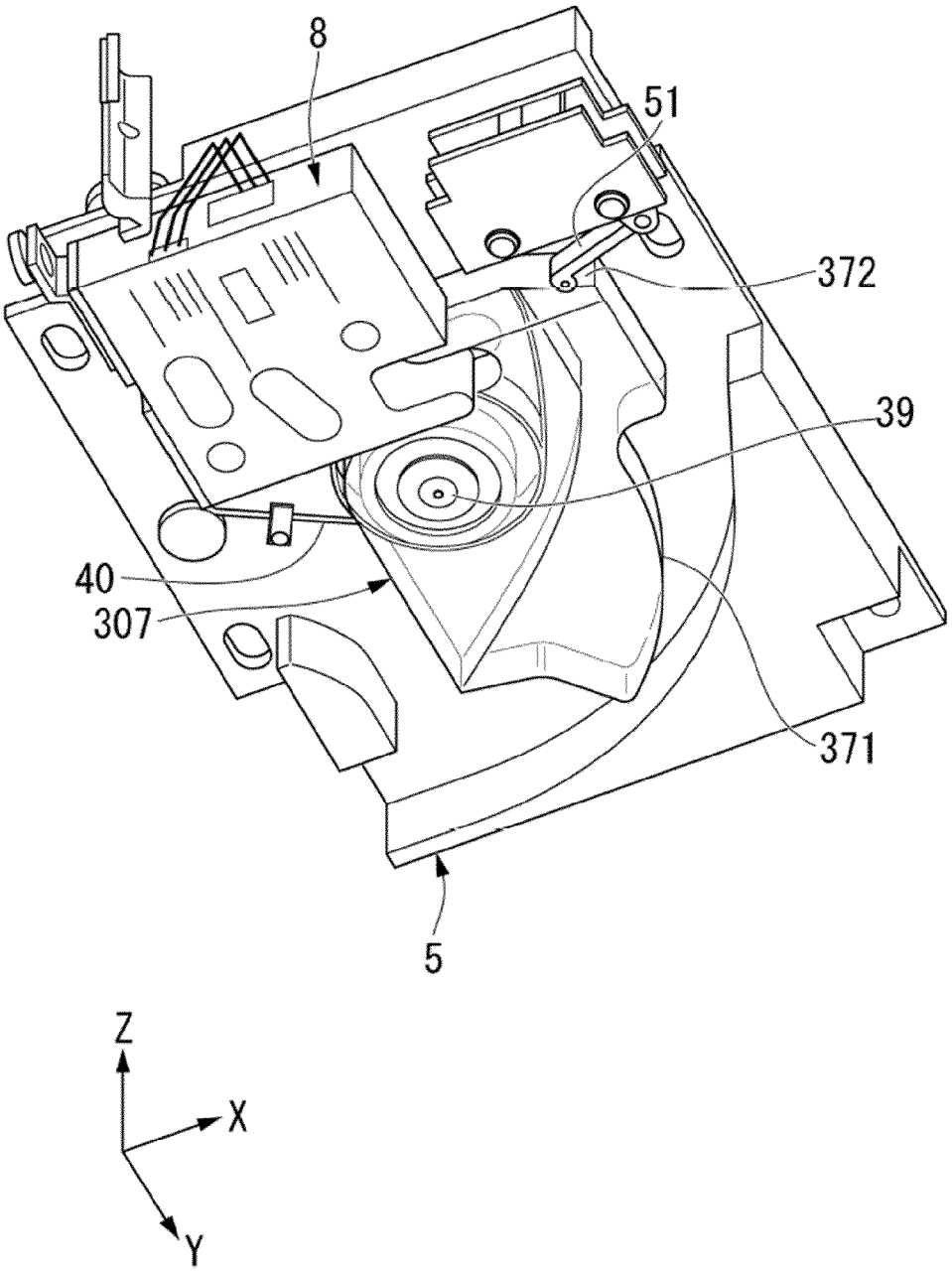

Fig. 6

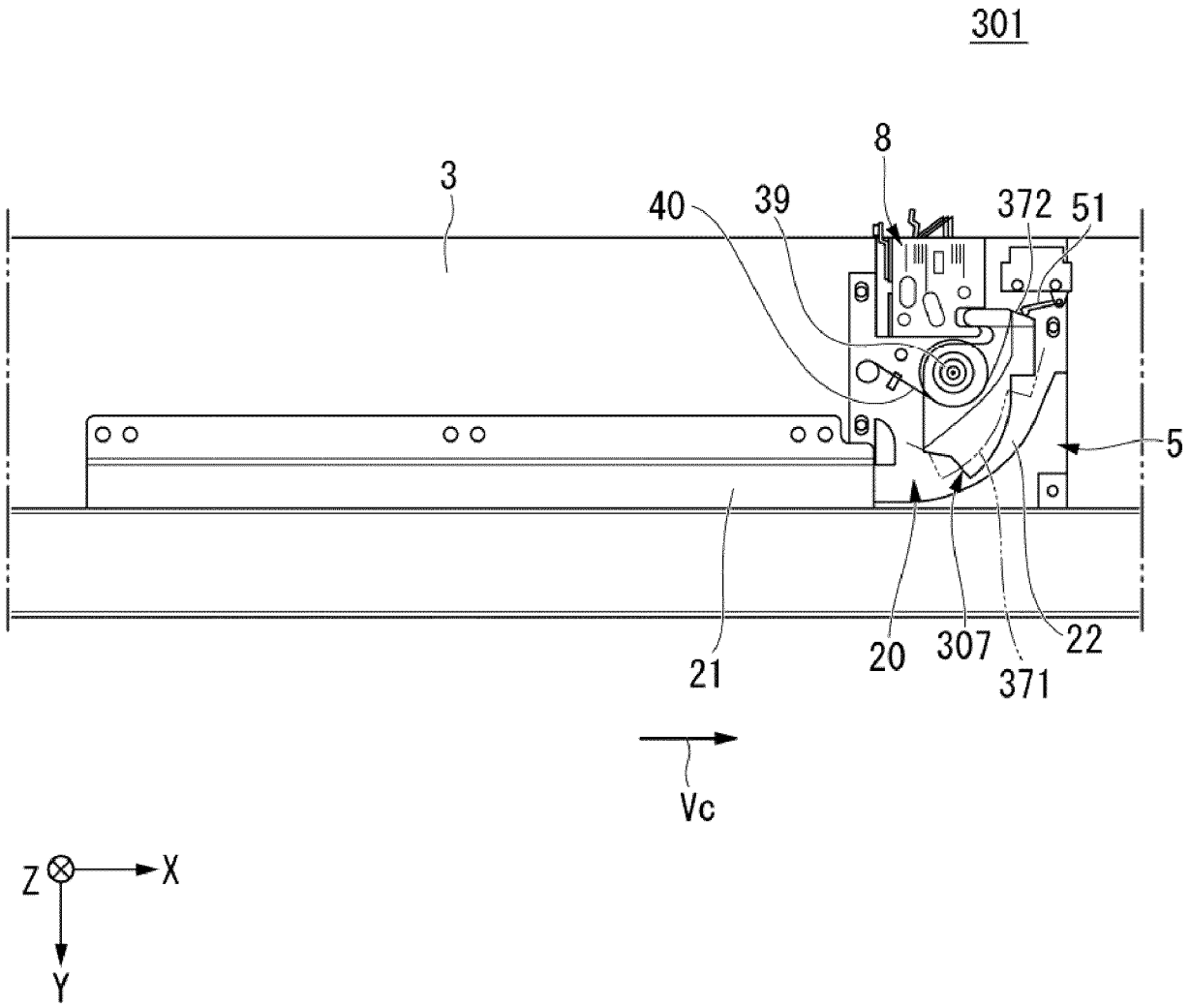

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 21 20 1674

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 March 2022	Klemke, Beate

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