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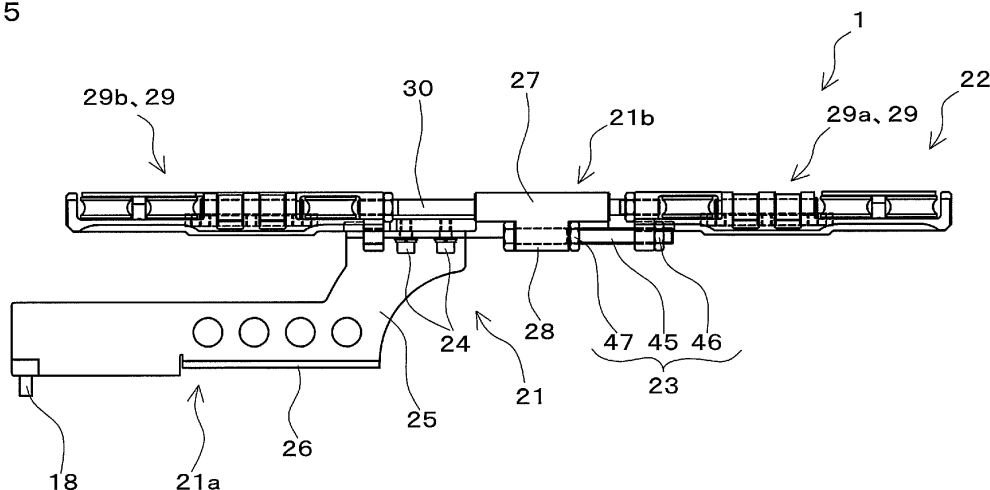
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(54) **DOOR SUSPENSION APPARATUS AND DOOR APPARATUS EQUIPPED WITH THE SAME**

(57) Disclosed is a door suspension apparatus that is capable of adjusting the position of a door in the opening and closing direction thereof without adjusting the positions of a locking portion and a locked portion of a locking device. A drive connection portion (21) is provided with one of a locking portion (17) and a locked portion (18) of a locking device (13) for locking a door (11) to a structure in a fully closed position through locking between the locking portion (17) and the locked portion (18), and is connected to an open-close drive mechanism (12).

A door roller portion (22) is connected to the door (11) and provided with door rollers (36a, 36b, 36c) that travel on a rail (19) fixed in the structure, and that supports the door (11) in a state in which the door (11) is suspended to the rail (19) so as to be slidably moved. A variable connection portion (23) connects the drive connection portion (21) to the door roller portion (22) such that the relative position between the drive connection portion (21) and the door roller portion (22) along the lengthwise direction of the rail (19) can be changed

FIG. 5



Description

Disclosure of the Invention

Technical Field

Problem to be Solved by the Invention

[0001] The present invention relates to a door suspension apparatus that holds a door provided in a structure and driven to be opened and closed by an open-close drive mechanism, in a state in which the door is suspended to the structure so as to be slidably moved, and that is connected to the open-close drive mechanism, and a door apparatus equipped with the door suspension apparatus.

Background Art

[0002] Conventionally, door suspension apparatuses that hold a door provided in a structure and driven to be opened and closed by an open-close drive mechanism, in a state in which the door is suspended to the structure so as to be slidably moved, and that is connected to the open-close drive mechanism are known (for example, see Patent Documents 1 and 2). Patent Documents 1 and 2 disclose door suspension apparatuses in each of which, in a railroad vehicle as a structure, a door suspended by the door suspension apparatus is driven to be opened and closed by an open-close drive mechanism connected to the door suspension apparatus. In the door suspension apparatuses disclosed in Patent Documents 1 and 2, door rollers that travel on a rail are provided, and the door is held in a state in which the door is suspended to the structure, which is a side wall of the railroad vehicle, so as to be slidably moved.

[0003] As disclosed in Patent Document 2, when the door is suspended by the door suspension apparatus are a side door through which passengers get on and off from the railroad vehicle, a locking device is provided that locks the door on the structure side in a fully closed position through locking between a locking portion and a locked portion. In the locking device disclosed in Patent Document 2, the locking portion is configured as a pivot member provided pivotably on the structure side. Also, the locking portion is configured to be engaged with a locked portion provided as an engagement pin attached to the door via a bracket on the door leading end side of the door (the side on which the end in the opening direction of the door is located).

Citation List

Patent Documents

[0004]

Patent Document 1: JP 2002-309849A

Patent Document 2: JP 2002-89109A

[0005] When a door that can be locked by a locking device as disclosed in Patent Document 2 in the fully closed position is installed in a structure, a worker performing the installation operation first adjusts the position of the door in the up-down direction (height direction). Next, the worker moves the door together with the door suspension apparatus such that the opening of the door is fully closed in the fully closed position of the open-close drive mechanism, thus adjusting the position of the door in the opening and closing direction. In a state in which the adjustment of the door position is completed in this manner, the positional relationship between the locking portion and the locked portion that are provided on the structure side and the door side, respectively, still remains in a displaced state. Therefore, it is necessary to cause the locking portion and the locked portion to be appropriately locked to each other in the fully closed position of the door such that the locking device can be operated. Accordingly, the operation of adjusting the positions between the locking portion and the locked portion is further performed.

[0006] When the door is installed in the structure together with the door suspension apparatus, as described above, the operation of adjusting the positions of the locking portion and the locked portion of the locking device is also necessary in addition to the operation of adjusting the position of the door in the opening and closing direction. However, the space in which the door suspension apparatus and the locking device are housed above the opening is usually very small, and therefore it is considerably difficult to further perform the positional adjustment operation between the locking portion and the locked portion of the locking device in a state in which the positional adjustment of the door has been completed. Furthermore, in a method that is usually adopted to perform the positional adjustment between the locking portion and the locked portion, it is often the case that the positions of predetermined members are adjusted with respect to a long hole and then the positions are fixed by fastening bolts. Especially in such a case, it is likely that the positions of the predetermined members with respect to the long hole are displaced when the bolts are fully tightened. This results in a problem in that the positional adjustment between the locking portion and the locked portion is considerably difficult and requires great time and effort.

[0007] In view of the foregoing circumstances, an object of the present invention is to provide a door suspension apparatus that is capable of, when a door that can be locked to a fully closed position by a locking device is installed in a structure, performing the positional adjustment operation of the door in the opening and closing direction without performing the positional adjustment operation between a locking portion and a locked portion

of the locking device, and another object thereof is to provide a door apparatus equipped with the door suspension apparatus.

Means for Solving the Problem

[0008] A first aspect of a door suspension apparatus of the present invention for achieving the above-described objects relates to a door suspension apparatus that supports a door provided in a structure and driven to be opened and closed by an open-close drive mechanism, in a state in which the door is suspended to the structure so as to be slidably moved, and that is connected to the open-close drive mechanism. The door suspension apparatus of the first aspect includes: a drive connection portion that is provided with one of a locking portion and a locked portion of a locking device for locking the door to the structure in a fully closed position through locking between the locking portion and the locked portion, and that is connected to the open-close drive mechanism; a door roller portion that includes a door roller traveling on a rail fixed in the structure, that is connected to the door, and that supports the door in a state in which the door is suspended to the rail so as to be slidably moved; and a variable connection portion that connects the drive connection portion to the door roller portion such that a relative position between the drive connection portion and the door roller portion in a direction along a lengthwise direction of the rail can be changed.

[0009] According to this aspect of the invention, when a door is installed in a structure, the worker performing the installation operation first adjusts the position of the door in the up-down direction. Then, the worker causes one of the locking portion and the locked portion provided in the drive connection portion to be locked to the other of the locking portion and the locked portion provided on the structure side, thus bringing about a state that is the same as a state in which the locking device has been operated. In this state, the worker causes the door roller portion supporting the door in a suspended manner to be slidably moved relative to the rail together with the door, while adjusting, with the variable connection portion, the relative position between the drive connection portion and the door roller portion in a direction along the lengthwise direction of the rail. Then, the worker adjusts the position of the door in the opening and closing direction such that the opening of the door is fully closed in the fully closed position of the open-close drive mechanism. Finally, in a state in which the door has reached an appropriate position in the opening and closing direction, the position of the drive connection portion and the door roller portion to each other is fixed, completing the positional adjustment operation of the door in the opening and closing direction. At this time, the locking device is in a state in which the locking portion and the locked portion remain locked throughout the positional adjustment operation of the door in the opening and closing direction. Accordingly, concurrently with completion of

the positional adjustment operation of the door in the opening and closing direction, a state is realized in which the locking portion and the locked portion are appropriately locked to each other and the locking device can be operated in the fully closed position of the door. Accordingly, it is not necessary to further perform, after completion of the positional adjustment operation of the door in the opening and closing direction, a conventionally required troublesome operation in which the positional adjustment between the locking portion and the locked portion of the locking device is performed in a considerably small space. This makes it possible to perform the positional adjustment of the door in the opening and closing direction without performing the positional adjustment between the locking portion and the locked portion. Accordingly, when the door is installed in a structure, for example, during installation in which the door is newly attached or when the open-close drive mechanism, the door, and the like are re-attached after maintenance, it is possible to significantly reduce the burden of the operation, thus reducing the operation time.

[0010] Therefore, according to the present invention, it is possible to provide a door suspension apparatus that enables, when the door that can be locked in the fully closed position by the locking device is installed in a structure, the positional adjustment operation of the door in the opening and closing direction to be performed without performing the positional adjustment operation between the locking portion and the locked portion of the locking device.

[0011] According to a second aspect of a door suspension apparatus of the present invention, in the door suspension apparatus of the first aspect, the door roller portion includes a first hole portion that is formed there-through so as to extend along the lengthwise direction of the rail, the drive connection portion includes a second hole portion that extends along the lengthwise direction of the rail and that is formed therethrough so as to face the first hole portion, and the variable connection portion includes a fastening mechanism that includes a member passing through the first hole portion and the second hole portion and that is capable of fixing the door roller portion and the drive connection portion to each other such that a relative position therebetween can be changed.

[0012] According to this aspect of the invention, the variable connection portion includes the fastening mechanism that includes the member passing through the first hole portion and the second hole portion provided in the door roller portion and the drive connection portion, respectively, and extending along the lengthwise direction of the rail, and that is capable of fixing the door roller portion and the drive connection portion to each other such that their relative position can be changed. Accordingly, when the positional adjustment operation of the door in the opening and closing direction is performed, it is possible to directly generate fastening force along the lengthwise direction of the rail, which is the opening and closing direction in which the door is slidably moved,

thus fixing the door roller portion and the drive connection portion to each other. Accordingly, unlike a fastening method in which the door roller portion and the drive connection portion are fixed to each other via frictional force by generating fastening force in a direction perpendicular to the lengthwise direction of the rail, it is not necessary to manage the fastening force for ensuring a predetermined frictional force, thus making it possible to further reduce the burden of the operation and the operation time. In the case of a method in which fastening is achieved with a long hole that is open in a direction perpendicular to the lengthwise direction of the rail and extends along the lengthwise direction of the rail, fastening force is generated in a direction perpendicular to the lengthwise direction of the rail as described above, and the position of the door roller portion and the drive connection portion to each other is retained by frictional force (contact pressure) generated between predetermined two members. For this reason, it is necessary to perform fixation after managing the fastening force such that the frictional force (contact pressure) has a predetermined magnitude or greater. However, according to the present invention, the door roller portion and the drive connection portion can be fixed by directly generating fastening force along the lengthwise direction of the rail as described above, and therefore it is not necessary to manage the fastening force, making it possible to further reduce the burden of the operation.

[0013] According to a third aspect of a door suspension apparatus of the present invention, in the door suspension apparatus of the second aspect, the fastening mechanism includes a bolt that is provided as the member passing through the first hole portion and the second hole portion and whose bolt head is engaged with one of the door roller portion and the drive connection portion, and a first nut that is threadedly engaged with the bolt and is engaged with the other of the door roller portion and the drive connection portion, and the first hole portion is disposed on a door trailing end side, which is the side on which the end of the door in an opening direction is located, with respect to the second hole portion.

[0014] With this aspect of the invention, the fastening mechanism includes the bolt that are engaged with the drive connection portion and the door roller portion and that passes through the first and second hole portions, and the first nut that is threadedly engaged with the bolt. Also, the first hole portion on the door roller portion side that supports the door is disposed on the door trailing end side with respect to the second hole portion on the drive connection portion side, and therefore the door is moved toward the door leading end side when the variable connection portion is adjusted by operating the bolt and the first nut in the fastening direction. Accordingly, the direction in which one of the bolt and the first nut engaged on the door roller portion side is fastened and caused to approach toward the other of the bolt and the first nut engaged on the drive connection portion side can be made coincident with the direction in which the

door is moved toward the door leading end side. This makes it possible to fasten the bolt or the first nut while moving the door in the same direction to adjust the position. Therefore, the worker is likely to feel, as a sensation during operation, that the direction of the direct operation and the direction of adjustment of the door are coincident and thus can perform the operation more easily and smoothly, enabling the operability to be improved.

[0015] According to a fourth aspect of a door suspension apparatus of the present invention, in the door suspension apparatus of the third aspect, the fastening mechanism further includes a second nut that is threadedly engaged with the bolt, the bolt is inserted into the second hole portion from a door leading end side, which is the side on which the end of the door in the closing direction is located, and the bolt head is engaged with the drive connection portion, the second nut is disposed on the side opposite to the bolt head via the second hole portion and is engaged with the drive connection portion from the door trailing end side, and the first nut is engaged with the door roller portion from the door trailing end side.

[0016] According to this aspect of the invention, fastening the second nut threadedly engaged with the bolt allows the bolt to be easily fixed to the drive connection portion by the fastening force acting between the bolt head and the second nut on the door leading end side. Also, the structure that eventually fixes the bolt to the drive connection portion can be realized with a simple configuration in which only the second nut is provided. Accordingly, in the fastening mechanism with good operability in which the direction in which the first nut is fastened to the bolt and the movement direction of the door are coincident, it is also possible to realize a structure that is capable of easily fixing the bolt to the drive connection portion with a simple configuration.

[0017] According to a fifth aspect of a door suspension apparatus of the present invention, in the door suspension apparatus of any of the second to fourth aspects, the door roller portion further includes a guide portion for guiding movement of the drive connection portion along the lengthwise direction of the rail, and a direction in which the first hole portion and the second hole portion extend in the lengthwise direction of the rail and a direction in which the guide portion is disposed along the lengthwise direction of the rail are displaced parallel to each other.

[0018] According to this aspect of the invention, the drive connection portion is supported to the door roller portion so as to be movable along the lengthwise direction of the rail via the bolt of the fastening mechanism of the variable connection portion, and is supported so as to be movable along the lengthwise direction of the rail also in the guide portion disposed in a position displaced parallel to the bolt. Accordingly, it is possible to prevent the drive connection portion from being pivoted about the member of the fastening mechanism when the worker performs the operation of adjusting the position of the door in the opening and closing direction, and therefore

the worker does not need to retain the drive connection portion so as not to pivot about the member of the fastening mechanism during the operation. This can further reduce the burden of the operation.

[0019] According to a sixth aspect of a door suspension apparatus of the present invention, in the door suspension apparatus of the fifth aspect, the guide portion is formed as a shaft-like member extending along the lengthwise direction of the rail, and is slidably inserted into a guide hole portion that is formed through the drive connection portion, and the door roller is disposed on either side in a direction along the lengthwise direction of the rail with respect to the guide portion.

[0020] According to this aspect of the invention, the guide portion is formed as a shaft-like member extending along the lengthwise direction of the rail, and therefore the guide portion can be disposed along the rail in a compact manner, making it possible to reduce the size of the door roller portion. Also, the guide portion is disposed between the door rollers in a direction along the lengthwise direction of the rail. Therefore, in the door roller portion, the guide portion can be linearly disposed between the structures that support the plurality of door rollers aligned along the lengthwise direction of the rail. Accordingly, it is possible to achieve space saving and weight reduction, compared to a configuration in which the guide portion is provided in a position displaced parallel to the structures that support the plurality of door rollers to achieve integration.

[0021] According to a seventh aspect of a door suspension apparatus of the present invention, in the door suspension apparatus of the sixth aspect, a direction in which the first hole portion and the second hole portion extend along the lengthwise direction of the rail and a direction in which the guide portion and the door roller are disposed along the lengthwise direction of the rail are arranged side by side in the horizontal direction and displaced parallel to each other.

[0022] According to this aspect of the invention, the direction in which the first hole portion and the second hole portion extend along the lengthwise direction of the rail and the direction in which the guide portion and the door rollers are disposed along the lengthwise direction of the rail are arranged side by side in the horizontal direction and displaced parallel to each other. Accordingly, the door rollers and the guide portion will not be disposed on the opposite sides in a direction along the lengthwise direction of the rail with respect to the bolt and the first nut of the fastening mechanism. This can ensure a sufficient space for the worker to operate the fastening mechanism around the fastening mechanism, and therefore the worker can easily operate the fastening mechanism without being obstructed by the door rollers and the guide portion. Accordingly, it is possible to improve the operability during the operation of the fastening mechanism, thus further reducing the burden of the operation.

[0023] According to an eighth aspect of a door suspension apparatus of the present invention, in the door

suspension apparatus of any of the first to seventh aspects, the door roller portion includes a pivot shaft that is disposed extending along the lengthwise direction of the rail, and a pivot member that is provided pivotably about the pivot shaft and on which the door can be suspended.

[0024] According to this aspect of the invention, in the door roller portion, the door is suspended directly to the pivot member or indirectly via the hanger member, and is supported pivotably about the pivot shaft. Accordingly, it is possible to achieve a structure in which, when an inclination occurs in the door installed in the structure, the influence of the inclination of the door tend not to be transferred to the door rollers. This can reduce the harmful effect on the door rollers by an inclination of the door, including, for example, uneven wear of the door rollers resulting from unbalanced load from the door side acting on the door rollers, unusual sound during travel of the door rollers, and a phenomenon in which the door rollers travel in an unstable manner (bouncing of the door rollers). Conventionally, in the case of a door with a structure having a curved portion, a portion disposed in an inclined manner is provided, and therefore, it was necessary to provide a predetermined gap serving as a play between the door rollers and the rail in order to mitigate, for example, generation of unbalanced load acting on the door rollers from the door side, or unusual sound during travel of the door rollers. However, when the present invention is applied to a door with a structure having a curved portion, it is possible to maintain the state of contact between the door rollers and the rail in an optimum state even if the above-described gap serving as a play is not provided, thus preventing unbalanced load from acting on the door rollers from the door side, and unusual sound from being generated during travel of the door rollers.

[0025] According to a ninth aspect of a door suspension apparatus of the present invention, in the door suspension apparatus of the eighth aspect, the door roller portion further includes a rotational shaft for rotatably supporting the door roller, a first housing member in which a through hole passing through the pivot shaft is formed, a second housing member to which the rotational shaft is attached and that is disposed facing the first housing member, the pivot shaft is provided with a notched portion that is recessed so as to be notched in a groove shape along the circumferential direction thereof, at least one of the first housing member and the second housing member is provided with a notch engaging portion that is engaged with the notched portion, and the first housing member and the second housing member are fixed to each other with a single externally threaded member that is threadedly engaged with an internally threaded hole formed in the rotational shaft.

[0026] According to this aspect of the invention, the housing structure that supports the door roller in the door roller portion is formed by combining the second housing member with the first housing member to which the rotational shaft of the door roller is attached. Also, the first

housing member and the second housing member are fixed integrally by causing a single externally threaded member to be threadably engaged with the internally threaded hole of the rotational shaft of the door roller in a state in which the pivot shaft serving as the pivot center of the pivot member is engaged, at its notched portion, with the notch engaging portion provided in at least one of the first and second housing members. Therefore, at the time of performing maintenance after installation, the housing structure of the door roller portion can be easily disassembled by removing a single externally threaded member from the internally threaded hole. Accordingly, in the door roller portion that suspends the door to the pivot member and that supports the door pivotably about the pivot shaft, the housing structure of the door roller portion can be easily disassembled by simply removing a single externally threaded member, making it possible to reduce the burden of the maintenance operation.

[0027] According to a tenth aspect of a door suspension apparatus of the present invention, in the door suspension apparatus of the second aspect, a door leading end-side first hole portion that is disposed on a door leading end side, which is the side on which the end of the door in the closing direction is located, with respect to the second hole portion is provided as the first hole portion, the fastening mechanism includes a member passing through the first hole portion and the second hole portion, and is capable of fixing the door roller portion and the drive connection portion such that a relative position therebetween can be changed, the variable connection portion further includes a push-back mechanism that biases the door roller portion to the drive connection portion in a closing direction of the door, and the push-back mechanism maintains a relative position of the door roller portion with respect to the drive connection portion until a force of a predetermined magnitude or greater acts on the door roller portion in an opening direction of the door, and permits a relative movement of the door roller portion with respect to the drive connection portion in the opening direction of the door within a predetermined distance range when a force of a predetermined magnitude or greater acts on the door roller portion in the opening direction of the door.

[0028] According to this aspect of the invention, during the positional adjustment operation of the door in the opening and closing direction, the position of the door leading end-side first hole portion, which is disposed on the door leading end side than the second hole portion, with respect to the second hole portion is changed by the fastening mechanism, and thereby the relative position of the drive connection portion with respect to the door roller portion is adjusted. After installation, the door roller portion is maintained in the same relative position by being constantly biased to the drive connection portion in the closing direction (to the door leading end side) by the push-back mechanism, and is maintained in the same relative position also when the locking device is operating with the door in the fully closed position. However, if some

foreign object is caught on the door leading end side of the door when the door is being closed and a force of a predetermined magnitude or greater acts on the door roller portion in the opening direction, a relative movement of the door roller portion to the drive connection portion in the opening direction is permitted even if the locking device is operating, as long as the size of the foreign object is within a predetermined size range. Therefore, the foreign object caught in the door can be pulled out by slightly moving the door in the opening direction in a forceful manner within a predetermined distance range that does not cause a safety problem in a state in which the locking device is kept in operation.

[0029] According to an eleventh aspect of a door suspension apparatus of the present invention, in the door suspension apparatus of the tenth aspect, the push-back mechanism includes a coil spring that is disposed between the door leading end-side first hole portion and the second hole portion and through which the member passing through the door leading end-side first hole portion and the second hole portion passes, and biases the door roller portion to the drive connection portion in the closing direction of the door with a biasing force of the coil spring.

[0030] According to this aspect of the invention, the push-back mechanism is provided as the coil spring disposed between the door leading end-side first hole portion and the second hole portion, and the member passing through the door leading end-side first hole portion and the second hole portion is disposed so as to pass through the coil spring. Accordingly, it is possible to dispose the push-back mechanism around the fastening mechanism in a compact manner, thus preventing an increase in the size of the variable connection portion even if the push-back mechanism is provided.

[0031] According to another aspect of the present invention, it is possible to configure a door apparatus including any of the above-described door suspension apparatuses. That is, according to a twelfth aspect of a door apparatus of the present invention, there is provided a door apparatus including: the door suspension apparatus of any of the first to eleventh aspects; a door that is provided in a structure and is supported by the door suspension apparatus in a state of being suspended to the structure so as to be slidably moved; an open-close drive mechanism that is connected to the door suspension apparatus and that drives the door to be opened and closed.

[0032] According to this aspect of the invention, when the door that can be locked in the fully closed position by the locking device is installed in a structure, it is possible to perform the positional adjustment operation of the door in the opening and closing direction without performing the positional adjustment operation between the locking portion and the locked portion of the locking device.

Effects of Invention

[0033] According to the present invention, it is possible to provide a door suspension apparatus that is capable

of, when a door that can be locked to a fully closed position by a locking device is installed in a structure, performing the positional adjustment operation of the door in the opening and closing direction without performing the positional adjustment operation between a locking portion and a locked portion of the locking device, and it is also possible to provide a door apparatus equipped with the door suspension apparatus.

Brief Description of the Drawings

[0034]

[FIG. 1] FIG. 1 is a front view showing a door apparatus according to one embodiment of the present invention.

[FIG. 2] FIG. 2 is a front view showing the state of a fully opened position in which doors are opened in the door apparatus shown in FIG. 1

[FIG. 3] FIG. 3 is a partial enlarged view showing, in enlargement, locking devices of the door apparatus shown in FIG. 1 and the vicinity thereof.

[FIG. 4] FIG. 4 is a front view showing a door suspension apparatus of the door apparatus shown in FIG. 1.

[FIG. 5] FIG. 5 is a plan view showing the door suspension apparatus shown in FIG. 4.

[FIG. 6] FIG. 6 is a partial enlarged view showing, in enlargement, part of the door suspension apparatus shown in FIG. 5.

[FIG. 7] FIG. 7 is a plan view showing a door roller unit of the door suspension apparatus shown in FIG. 5.

[FIG. 8] FIG. 8 is an exploded view of the door roller unit shown in FIG. 7.

[FIG. 9] FIG. 9 is an enlarged view showing, in enlargement, the door roller unit and the vicinity thereof together with a rail in a state in which the door suspension apparatus shown in FIG. 5 is installed in a structure, as viewed from the door trailing end side.

[FIG. 10] FIG. 10 is a diagram showing a pivot shaft and a pivot member of the door roller unit shown in FIG. 9, together with a rail, with illustration of other elements being omitted.

[FIG. 11] FIG. 11 is a plan view showing a door suspension apparatus according to a modification.

[FIG. 12] FIG. 12 is a partial enlarged view showing, in enlargement, part of the door suspension apparatus shown in FIG. 11.

[FIG. 13] FIG. 13 is a partial enlarged view showing, in enlargement, part of a door suspension apparatus according to a modification.

[FIG. 14] FIG. 14 is a front view showing a door apparatus according to a modification.

[FIG. 15] FIG. 15 is a front view showing a door apparatus according to a modification.

Description of Embodiments

[0035] Hereinafter, an embodiment for carrying out the present invention will be described with reference to the accompanying drawings. The present invention is applicable as a door suspension apparatus that holds a door provided in a structure and driven to be opened and closed by an open-close drive mechanism, in a state in which the door is suspended to the structure so as to be slidably moved, and that is connected to the open-close drive mechanism, and as a door apparatus including the door suspension apparatus. Although this embodiment will be described, taking, as an example, a door suspension apparatus and a door apparatus that are used in a railroad vehicle, the present invention is not limited to this example and is widely applicable as a door suspension apparatus and a door apparatus that can be provided in a variety of structures.

[0036] FIG. 1 is a front view showing a door apparatus 2 according to one embodiment of the present invention. The door apparatus 2 shown in FIG. 1 can be used, for example, for a side wall of a railroad vehicle as a structure. Note that FIG. 1 shows a front view of the door apparatus 2, as viewed from the inside of the railroad vehicle. In addition, illustration of the side wall of the railroad vehicle is omitted in FIG. 1, and the door apparatus 2 is schematically illustrated. The door apparatus 2 includes, for example, door suspension apparatuses 1 according to one embodiment of the present invention, doors 11 (partly shown in FIG. 1), an open-close drive mechanism 12, and locking devices 13.

[0037] A door 11 is formed as a sliding door provided at a side wall of a railroad vehicle (hereinafter, referred to as "structure"), and constitutes a side door provided in the railroad vehicle for loading and unloading of passengers. Two doors 11 are provided, and each of the doors 11 is supported by the door suspension apparatus 1 in a state in which it is suspended to the structure so as to be slidably moved. Additionally, a rail 19 including an upper rail 19a and a lower rail 19b that linearly extend parallel to each other in the horizontal direction is fixed to the structure. The two doors 11 are supported by the respective door suspension apparatuses 1 at their upper ends, and are configured to be closed by approaching each other along the rail 19 and coming into contact and to be opened by moving away from each other.

[0038] The open-close drive mechanism 12 is installed in the structure, and is provided as a mechanism that is connected to the door suspension apparatuses 1 and that drives the doors 11 to be opened and closed. The open-close drive mechanism 12 shown in FIG. 1 includes, for example, a drive motor (not shown), a drive pulley 14, a driven pulley 15, and a belt 16. The belt 16 is configured as an endless belt that is wound around the drive pulley 14 and the driven pulley 15 in a freely rotatable manner. Rotation of the drive pulley 14 connected to the drive motor causes the belt 16 wound around the drive pulley 14 to be rotated, thus causing the driven pul-

ley 15 to rotate together with the belt 16.

[0039] The drive motor is controlled to be rotated by a predetermined amount in forward and reverse directions, in accordance with a command from a controller, which is not shown. Accordingly, the two doors 11 that are supported in a state in which they are suspended via the door suspension apparatuses 1 connected to the belt 16 of the open-close drive mechanism 12 are driven in the opening direction and the closing direction. FIG. 1 shows the state of a fully closed position in which the two doors 11 are closed, and FIG. 2 shows the state of a fully opened position in which the two doors 11 are opened. By operating the open-close drive mechanism 12 such that the belt 16 is rotated in the direction indicated by the arrow A in FIG. 1, the door suspension apparatuses 1 are moved in directions away from each other, and the state of the two doors 11 is shifted to the state of the fully opened position shown in FIG. 2. On the other hand, by operating the open-close drive mechanism 12 such that the belt 16 is rotated in the direction indicated by the arrow B shown in FIG. 2, the door suspension apparatuses 1 are moved in directions approaching each other, and the state of the two doors 11 is shifted to the state of the fully closed position shown in FIG. 1.

[0040] FIG. 3 is a partial enlarged view showing, in enlargement, the locking devices 13 shown in FIG. 1 and the vicinity thereof. As clearly shown in FIG. 3, each of the locking devices 13 includes, for example, a lock member 17 provided on the structure side, and a lock pin 18 provided on the door suspension apparatus 1 side. Each of the locking devices 13 is configured to lock the door 11 to the lock structure in the fully closed position shown in FIG. 1 through locking between the lock member 17 provided as a locking portion and the lock pin 18 provided as a locked portion. This prevents the door 11 from being accidentally opened in the fully closed position. By releasing the locking between the lock member 17 and the lock pin 18, the doors 11 are brought into a state in which they can be opened with operation of the open-close drive mechanism 12 (see FIG. 2). Although FIGS. 1 to 3 show, as an example, the configuration in which the locking devices 13 are respectively provided for the two doors 11, this need not be the case. That is, it is possible to adopt a configuration in which the locking device 13 is provided for only one of two doors 11, and the two doors 11 are locked in the fully closed position by the single locking device 13.

[0041] The lock pin 18 is configured as a columnar pin member provided protruding toward the inside of the door 11 (toward the inside of the structure) in the door suspension apparatus 1, which will be described later. Accordingly, the lock pin 18 is moved with the movement of the door suspension apparatus 1 by operation of the open-close drive mechanism 12.

[0042] The lock member 17 is provided as a member pivotably attached on the structure side, and has an opening portion that can be locked to the lock pin 18 so as to be fitted from the side to the lock pin 18. When the

two doors 11 are moved in the closing direction and reach the vicinity of the fully closed position, the lock member 17 comes into contact with the lock pin 18 and is pivotably moved. In the fully closed position of the doors 11, the lock member 17 is fitted from the side to the lock pin 18, thus locking the lock pin 18. In this state, for example, a lock retention mechanism (not shown) that includes an electrical driving source such as a solenoid and is capable of holding the pivot position of the lock member 17 is operated in accordance with a command from the controller, and thereby the locking state between the lock member 17 and the lock pin 18 is maintained. On the other hand, when the operation of opening the doors 11 is performed, the retention of the pivot position of the lock member 17 by the above-described lock retention mechanism is released in accordance with a command from the controller, and thereby the lock member 17 is brought into a state in which it can be pivoted with the movement of the lock pin 18. Then, the door suspension apparatus 1 is moved in the opening direction together with the door 11 by operation of the open-close drive mechanism 12, and thereby the locking between the lock member 17 and the lock pin 18 is released.

[0043] Note that the configuration of the locking device is not limited to the configuration of the locking device 13 described above as an example, and various configurations may be adopted. That is, it is possible to adopt any configuration in which the door 11 is locked on the structure side in the fully closed position through locking between the locking portion and the locked portion, with one of the locking portion and the locked portion being provided in the door suspension apparatus 1 and the other of the locking portion and the locked portion being provided on the structure side (or the open-close drive mechanism 12 side). For example, it is possible to use locking devices having the configurations disclosed in JP 2008-121242A, JP 2008-121243A, and JP 2008-121244A.

[0044] FIG. 4 is a front view showing a door suspension apparatus 1, and FIG. 5 is a plan view of the door suspension apparatus 1. As shown in FIG. 1, the door suspension apparatus 1 is provided for each of the doors 11, and the door suspension apparatuses 1 hold the respective doors 11 in a state in which the doors are suspended to the structure so as to be slidably moved, and are each connected to the belt 16 of the open-close drive mechanism 12. As clearly shown in FIGS. 4 and 5, the door suspension apparatus 1 includes, for example, a drive connection portion 21, a door roller portion 22, and a variable connection portion 23. Of the two door suspension apparatuses 1 shown in FIG. 1, the door suspension apparatus 1 disposed on the drive pulley 14 side is shown in FIGS. 4 and 5. The door suspension apparatus 1 disposed on the driven pulley 15 side is configured in the same manner, except that its devices are arranged line-symmetric about the intermediate position between the two doors 11 with respect to the devices of the door suspension apparatus 1 disposed on the drive pulley 14

side, and therefore, only the door suspension apparatus 1 disposed on the drive pulley 14 is described in the following.

[0045] As illustrated in FIGS. 4 and 5, the drive connection portion 21 is configured by fixing a door-side connecting member 21a and a door roller-side connecting member 21b to each other with a plurality of fixing bolts 24. The door-side connecting member 21a is provided with the lock pin 18 constituting the locked portion described above, a main body portion 25, a connecting plate portion 26, and so forth. The main body portion 25 is formed in the shape of a flat plate, and its end is fixed to the door roller-side connecting member 21b with the fixing bolts 24. Further, the main body portion 25 is formed such that it protrudes from the door roller-side connecting member 21b to which the end is fixed, is bent, and then extends parallel to the lengthwise direction of the door roller portion 22, which will be described later, and is disposed extending along the horizontal direction. The lock pin 18 is fixed to the end of the main body portion 25 that is opposite from the end connected to the door roller-side connecting member 21b. The connecting plate portion 26 is formed as a flat plate-shaped portion extending in the up-down direction, which is approximately perpendicular to the main body portion 25, and is fixed and connected, on its upper end side, to the belt 16 of the open-close drive mechanism 12.

[0046] FIG. 6 is a partial enlarged view showing, in enlargement, the vicinity of the door roller-side connecting member 21b shown in FIG. 5. As shown in FIGS. 4 to 6, the door roller-side connecting member 21b includes a first block portion 27 and a second block portion 28 that are each formed in the shape of a rectangular solid extending from the end to which the door-side connecting member 21a is fixed with the fixing bolts 24, parallel to the lengthwise direction of the door roller portion 22. The first and second block portions (27, 28) are integrally formed. The first block portion 27 is provided with a guide hole portion 27a of this embodiment that is formed therethrough so as to extend along the lengthwise direction of the rail 19, which is the direction parallel to the direction in which the lengthwise direction of the door roller portion 22 is arranged. The second block portion 28 is provided with a second hole portion 28a of this embodiment that is formed therethrough so as to extend along the lengthwise direction of the rail 19.

[0047] The door roller portion 22 shown in FIGS 4 to 6 is provided as a mechanism that includes the door rollers (36a, 36b, 36c) traveling on the rail 19 fixed in the structure, that is connected to the doors 11, and that supports the doors 11 in a state in which the door 11 is suspended to the rail 19 so as to be slidably moved. Also, the door roller portion 22 includes a pair of door roller units 29, a guide portion 30, and so forth. The pair of door roller units 29 includes a door roller unit 29a and a door roller unit 29b, and the door roller units (29a, 29b) are linearly connected to each other via the guide portion 30, and are disposed along the lengthwise direction of the

rail 19. Additionally, the door roller unit 29a is disposed on the door trailing end side (the side on which the end of the door 11 in the opening direction is located) with respect to the guide portion 30, and the door roller unit 29b is disposed on the door leading end side (the end on which the end of the door 11 in the closing direction is located) with respect to the guide portion 30.

[0048] FIG. 7 is a plan view showing the door roller unit 29a, and FIG. 8 is an exploded view of the door roller unit 29a. Note that the door roller unit 29b is configured in the same manner except that its devices are arranged line-symmetric about the intermediate position of the guide portion 30 and that the variable connection portion 23, which will be described later, is not connected. Therefore, in the following, the description of the door roller unit 29b is omitted, and only the door roller unit 29a will be described.

[0049] As clearly shown in FIGS. 7 and 8, the door roller unit 29a include, a first housing member 31, a second housing member 32, a third housing member 33, a pivot shaft 34, a pivot member 35, a plurality of door rollers (36a, 36b, 36c), rotational shafts (37a, 37b, 37c), externally threaded members (38a, 38b, 38c), and so forth.

[0050] FIG. 9 is an enlarged view showing, in enlargement, the door roller unit 29a and the vicinity thereof together with the rail 19 in a state in which the door suspension apparatus 1 shown in FIG. 5 is installed in a structure, as viewed from the door trailing end side. As shown in FIGS. 7 to 9, the plurality of door rollers (36a, 36b, 36c) are aligned in series in the door roller unit 29a along the lengthwise direction of the door roller unit 29a (that is, along the lengthwise direction of the rail 19), and are provided so as to travel on the rail 19. Additionally, the door roller 36a, which is disposed on the door leading end side in the door roller unit 29a, and the door roller 36b, which is disposed in the middle, are disposed so as to come into contact with the lower rail 19b from above, and are provided as door rollers for ensuring the traveling function. On the other hand, the door roller 36c, which is disposed on the door trailing end side, is disposed so as to come into contact with the upper rail 19b from below, and is provided as a door roller for ensuring the anti-bouncing function for suppressing vibrations in the door roller portion 22 during travel. In this manner, the placement of the door rollers (36a, 36b, 36c) allows the door roller portion 22 to travel on the rail 19 in a stable manner. Additionally, the surfaces of the door rollers (36a, 36b, 36c) and the upper and lower rails (19a, 19b) that come into contact with each other are formed to have a circular-arc cross section.

[0051] The first to third housings (31, 32, 33) are configured to form an integrated housing structure that supports the door rollers (36a, 36b, 36c) and the pivot member 35, when combined into one unit. The second housing member 32 and the third housing member 33 are disposed facing the first housing member 31 (see FIG. 7). Also, the rotational shaft 37a that rotatably supports the door roller 36a is attached to the second housing member

32, and the rotational shaft 37b and the rotational shaft 37c that rotatably support the door roller 36b and the door roller 36c, respectively, are attached to the third housing member 33.

[0052] Further, a plurality of (in this embodiment, three) through holes 31a, through which the pivot shaft 34, which will be described later, passes through are formed in the first housing member 31 so as to be aligned in series in positions displaced from the second and third housing members (32, 33) on the side face on which the second and third housing members (32, 33) are combined. The portions in which the plurality of through holes 31a are formed are formed as plurality of portions protruding in the shape of comb teeth on the side face of the first housing member 31. The second housing member 32 is provided, on its end on the door leading end side, with a first hole portion 32a and a guide connecting hole portion 32b of this embodiment that are formed there-through so as to extend along the lengthwise direction of the rail 19 and are disposed parallel to each other. Additionally, an internally threaded portion is formed on the inner circumference of the first hole portion 32a and the guide connecting hole portion 32b.

[0053] FIG. 10 is a diagram showing the pivot shaft 34 and the pivot member 35 shown in FIG. 9, together with the rail 19, with illustration of other elements being omitted. As shown in FIGS. 7 to 10, the pivot shaft 34 is provided as a columnar pin member, and is disposed extending along the lengthwise direction of the rail 19 in the door roller unit 29a. The pivot shaft 34 is inserted into the plurality of through holes 31a that are formed in alignment in the first housing member 31, and is rotatably supported to the first housing member 31. Also, the pivot shaft 34 is provided, at its end of the door leading end side, with a notched portion 34a that is recessed so as to be notched in the shape of a groove along the circumferential direction. The second housing member 32 is provided with a notch engaging portion 32c that is formed as a semicircular-arc recess so as to be fitted along the half of the outer circumference of the notched portion 34a and to be engaged with the notched portion 34a.

[0054] The pivot member 35 shown in FIGS. 7 to 10 is provided with portions in which the plurality of through holes 35a through which the pivot shaft 34 passes through are formed, and a suspension supporting member 35b that is formed in the shape of an integral plate below the portion in which the through holes 35a are formed and on which the door 11 is suspended via a hanger member 41. Additionally, the hanger member 41 is fixed to the suspension supporting member 35b via fixing bolts 42 on the upper end side, and is fixed to the door 11 via fixing bolts 43 on the lower end side (see FIG. 3, FIG. 4, FIG. 9).

[0055] The portions of the pivot member 35 in which the plurality of (in this embodiment, two) through holes 35a are formed are disposed facing the first housing member 31. In a state in which the through holes 31a of the first housing member 31 and the through holes 35a

of the pivot member 35 are alternately disposed in series, the pivot shaft 34 is inserted into all of the plurality of through holes (31a, 35a). Thereby, the pivot member 35 is also rotatably supported to the pivot shaft 34 rotatably supported to the first housing member 31, and the pivot member 35 is provided pivotably about the pivot shaft 34. In FIG. 10, the pivot member 35 in a state in which the suspension supporting member 35b is located along the vertical direction is indicated by the solid line, and the pivot member 35 in a state in which it is pivoted from the aforementioned state is indicated by the two-dot chain line.

[0056] The externally threaded member 38a shown in FIG. 8 is provided as a thread member for assembling and fixing the first housing member 31 and the second housing member 32 together. The externally threaded member 38a is formed so as to pass through a through hole 40a that is formed through the first housing member 31 and to be engaged with the first housing member 31 at its end. Also, the externally threaded member 38a is configured to be threadedly engaged, at an externally threaded portion on its outer circumference, with an internally threaded hole 39a that is formed through the rotational shaft 37a in the axial direction and that has an internally threaded portion formed on its inner circumference, in a state in which the externally threaded member 38a is engaged with the first housing member 31. The threaded engagement of the externally threaded member 38a with the internally threaded hole 39a is performed in a state in which the notched portion 34a of the pivot shaft 34 passing through the plurality of through holes (31a, 35a) is engaged with the notch engaging portion 32c of the second housing member 32. Thereby, the first housing member 31 supporting, via the pivot shaft 34, the pivot member 35 on which the door 11 is suspended and the second housing member 32 supporting the pivot shaft 34 in the engaged state are fixed to each other with a single externally threaded member 38a in a state in which the door roller 36a is rotatably supported thereon.

[0057] The externally threaded members (38b, 38c) shown in FIG. 8 are provided as thread members for assembling and fixing the first housing member 31 and the third housing member 33 together. The externally threaded member 38b is formed so as to pass through a through hole 40b that is formed through the first housing member 31 and to be engaged with the first housing member 31 at its end. Also, the externally threaded member 38b is configured to be threadedly engaged, at an externally threaded portion on its outer circumference, with an internally threaded hole 39b that is formed through the rotational shaft 37b in the axial direction and that has an internally threaded portion formed on its inner circumference, in a state in which the externally threaded member 38b is engaged with the first housing member 31. The externally threaded member 38c is formed so as to pass through a through hole 40c that is formed through the first housing member 31 and to be engaged with the first housing member 31 at its end. Also, the

externally threaded member 38c is configured to be threadedly engaged, at an externally threaded portion on its outer circumference, with an internally threaded hole 39c that is formed through the rotational shaft 37c in the axial direction and that has an internally threaded portion formed on its inner circumference, in a state in which the externally threaded member 38c is engaged with the first housing member 31. In this manner, the externally threaded members (38b, 38c) are threadedly engaged with the internally threaded holes (39b, 39c) of the rotational shafts (37b, 37c), and thereby the first housing member 31 and the second housing member 33 are fixed, and the door rollers (36b, 36c) are rotatably supported thereon.

[0058] As clearly shown in FIG. 6, the guide portion 30 is formed as a shaft-like member extending along the lengthwise direction of the rail 19, and externally threaded portions are formed at its both ends (30a, 30b). The end portion 30a of the guide portion 30 on the door trailing end side is threadedly engaged with the guide connecting hole portion 32b formed in the second housing member 32 of the door roller unit 29a. At this time, a fixing nut 44a is threadedly engaged with the end portion 30a on the door trailing end side to the base side of the externally threaded portion before the end portion 30a is threadedly engaged with the guide connecting hole portion 32b. The guide portion 30 and the door roller unit 29a are fixed to each other by rotating the fixing nut 44a toward the second housing member 32 on the door trailing end side in the fastening direction in a state in which the end portion 30a on the door trailing end side is threadedly engaged with the fixing nut 44a.

[0059] On the other hand, the end portion 30b of the guide portion 30 on the door leading end side is threadedly engaged with the guide connecting hole portion 32b formed in the second housing member 32 of the door roller unit 29b. At this time, a fixing nut 44b is threadedly engaged with the end portion 30b on the door leading end side to the base side of the externally threaded portion before the end portion 30b is threadedly engaged with the guide connecting hole portion 32b. The guide portion 30 and the door roller unit 29b are fixed to each other by rotating the fixing nut 44b toward the second housing member 32 on the door leading end side in the fastening direction in a state in which the end portion 30b on the door leading end side is threadedly engaged with the fixing nut 44b. In this manner, in the door roller portion 22, the door roller unit 29a and the door roller unit 29b are connected and fixed to each other via the guide portion 30, and the door rollers (36a, 35b, 36c) are disposed on each of the opposite sides along the lengthwise direction of the rail 19 with respect to the guide portion 30.

[0060] The guide portion 30 is connected to the pair of door roller units 29 as described above in a state in which it is slidably inserted into the guide hole portion 27a formed in the first block portion 27 of the drive connection portion 21. Thereby, the guide portion 30 is configured to guide the movement of the drive connection portion

21 in a direction along the lengthwise direction of the rail 19. By provision of the guide portion 30 in this manner, the door suspension apparatus 1 is configured such that the direction in which the guide portion 30 and the door rollers (36a, 36b, 36c) are disposed along the lengthwise direction of the rail 19 and the direction in which the first hole portion 32a and the second hole portion 28a extend along the lengthwise direction of the rail 19 are arranged side by side in the horizontal direction and displaced parallel to each other.

[0061] The variable connection portion 23 shown in FIGS. 4 to 6 is provided as a connecting structure that connects the drive connection portion 21 to the door roller portion 22 such that the relative position between the drive connection portion 21 and the door roller portion 22 in a direction along the lengthwise direction of the rail 19 can be changed. Also, the variable connection portion 23 includes a fastening mechanism including a bolt 45, a first nut 46, and a second nut 47.

[0062] As clearly shown in FIG. 6, the bolt 45 is provided as a member that passes through the first hole portion 32a formed in the first housing member 32 of the door roller unit 29a of the door roller portion 22 and the second hole portion 28a formed in the second block portion 28 of the drive connection portion 21. The bolt 45 is inserted into the second hole portion 28a extending along the lengthwise direction of the rail 19 from the door leading end side, and is disposed such that a bolt head 45a thereof is engaged with the second block portion 28 of the drive connection portion 21. The first hole portion 32a extends along the lengthwise direction of the rail 19, is disposed on the door trailing end side with respect to the second hole portion 28a, and is formed so as to face the second hole portion 28a. Also, the internally threaded portion is formed in the first hole portion 32a as described above, and the bolt 45 is disposed so as to pass through the first hole portion 32a by its externally threaded portion inserted into the first hole portion 32a from the door leading end side and threadedly engaged with the internally threaded portion.

[0063] The first nut 46 is disposed so as to be threadedly engaged with the bolt 45 from its end on the door trailing end side toward the door leading end side, and to be engaged with the second housing member 32 of the door roller portion 22 from the door trailing end side. The second nut 47 is attached to the bolt 45 in a state in which the bolt has passed through the second hole portion 28a and has not passed through the first hole portion 32a such that the second nut 47 is threadedly engaged with the bolt 45 from its end on the door trailing end side toward the door leading end side. Also, the second nut 47 is disposed on the side opposite from the bolt head 45a with the second hole portion 28a disposed in between, and is disposed so as to be engaged with the second block portion 28 of the drive connection portion 21 from the door trailing end side. In this manner, the fastening mechanism including the bolt 45, the first nut 46, and the second nut 47 is configured to be capable of

fixing the door roller portion 22 and the drive connection portion 21 to each other such that their relative position along the lengthwise direction of the rail 19 can be changed.

[0064] The following describes the operation of the door suspension apparatus 1 when a worker performs the positional adjustment operation for a door 11 after the door apparatus 2 provided with the door suspension apparatus 1 described above has been installed in a structure. Note that the same positional adjustment operation is performed for the door 11 disposed on the drive pulley 14 side and the door 11 disposed on the driven pulley 15 side, and therefore, only a case where the positional adjustment operation is performed for one of the doors 11 will be described in the following.

[0065] When the positional adjustment operation is performed for the door 11 after the door apparatus 2 has been installed in a structure, the worker first adjusts the position of the door 11 in the up-down direction. Then, the worker causes the lock pin 18 provided in the drive connection portion 21 and the lock member 17 provided on the structure side to be locked to each other in a state in which the open-close drive mechanism 12 is in a position corresponding to the fully closed position, thus bringing about a state that is the same as a state in which the locking device 13 has been operated. At this time, the door 11 is disposed in a state in which the adjustment of its position in the opening and closing direction can be started in the state of being located slightly toward the door trailing end side than toward the fully closed position. This allows the worker to adjust the position of the door 11 in the opening and closing direction, while moving the door 11 toward the door leading end side (that is, while moving the door 11 toward the fully closed position).

[0066] As described above, in a state in which the lock pin 18 and the lock member 17 are locked to each other, the worker rotates the first nut 46 on the bolt 45 in a direction in which the bolt head 45a and the first nut 46 are caused to approach each other to fasten the bolt 45 and the first nut 46 together. At this time, due to the locking between the lock pin 18 and the lock member 17, the position in the opening and closing direction (the position along the lengthwise direction of the rail 19) of the bolt head 45a engaged with the drive connection portion 21 will not change. Accordingly, as described above, by relatively rotating the bolt 45 and the first nut 46 in the fastening direction, the door roller portion 22 and the first nut 46 are moved so as to approach the drive connection portion 21 and the bolt head 45a whose positions in the opening and closing direction will not change. Thereby, the door rollers (36a, 36b, 36c) slowly travel on the rail 19, and the door 11 is gradually moved, together with the door roller portion 22, toward the door leading end side (toward the fully closed position). At this time, in order to allow the door roller portion 22 to be moved along the lengthwise direction of the rail 19 by rotation of the bolt 45 threadedly engaged with the first hole portion 32a, the second nut 47 is appropriately loosen so as not to gen-

erate fastening force.

[0067] In a state in which the door 11 has appropriately reached the fully closed position, the worker fastens the second nut 47 to the drive connection portion 21. Thereby, the relative position between the door roller portion 22 and the drive connection portion 21 is fixed, completing the positional adjustment of the door 11 in the opening and closing direction. At this time, the locking device 13 is in a state in which the lock pin 18 and the lock member 17 remain locked throughout the positional adjustment operation of the door 11 in the opening and closing direction. Accordingly, concurrently with completion of the positional adjustment operation of the door 11 in the opening and closing direction, a state is realized in which the lock pin 18 and the lock member 17 are appropriately locked to each other and the locking device 13 can be operated in the fully closed position of the door 11.

[0068] With the door suspension apparatus 1 and the door apparatus 2 described thus far, it is not necessary to further perform, after completion of the positional adjustment operation of the door in the opening and closing direction, a conventionally required troublesome operation in which the positional adjustment between the locking portion and the locked portion of the locking device is performed in a considerably small space. This makes it possible to perform the positional adjustment of the door 11 in the opening and closing direction without performing the positional adjustment between the lock member (locking portion) 17 and the lock pin (locked portion) 18. Accordingly, when the door 11 is installed in a structure, for example, during installation in which the door 11 is newly attached or when the open-close drive mechanism 12, the door 11, and the like are re-attached after maintenance, it is possible to significantly reduce the burden of the operation, thus reducing the operation time.

[0069] Therefore, according to this embodiment, when the door 11 that can be locked in the fully closed position by the locking device 13 is installed in a structure, it is possible to perform the positional adjustment operation of the door 11 in the opening and closing direction without performing the positional adjustment operation between the lock member 17 and the lock pin 18 of the locking device 13.

[0070] With the door suspension apparatus 1 and the door apparatus 2, the variable connection portion 23 includes the fastening mechanism that includes the bolt 45 passing through the first hole portion 32a and the second hole portion 28a provided in the door roller portion 22 and the drive connection portion 21, respectively, and extending along the lengthwise direction of the rail 19, and that is capable of fixing the door roller portion 22 and the drive connection portion 21 to each other such that their relative position can be changed. Accordingly, when the positional adjustment operation of the door 11 in the opening and closing direction is performed, it is possible to directly generate fastening force along the lengthwise direction of the rail 19, which is the opening and closing direction in which the door 11 is slidably moved, thus

fixing the door roller portion 22 and the drive connection portion 21 to each other. Accordingly, unlike a fastening method in which the door roller portion 22 and the drive connection portion 21 are fixed to each other via frictional force by generating fastening force in a direction perpendicular to the lengthwise direction of the rail 19, it is not necessary to manage the fastening force for ensuring a predetermined frictional force, thus making it possible to further reduce the burden of the operation and the operation time.

[0071] With the door suspension apparatus 1 and the door apparatus 2, the fastening mechanism includes the bolt 45 that are engaged with the drive connection portion 21 and the door roller portion 22 and that passes through the first and second hole portions (32a, 38a), and the first nut 46 that is threadedly engaged with the bolt 45. Also, the first hole portion 32a on the door roller portion 22 side that supports the door 11 is disposed on the door trailing end side with respect to the second hole portion 28a on the drive connection portion 21 side, and therefore the door 11 is moved toward the door leading end side when the variable connection portion 23 is adjusted by operating the bolt 45 and the first nut 46 in the fastening direction. Accordingly, the direction in which the first nut 46 engaged on the door roller portion 22 side is fastened and caused to approach toward the bolt 45 engaged on the drive connection portion 21 side can be made coincident with the direction in which the door 11 is moved toward the door leading end side. This makes it possible to fasten the first nut 46 on the bolt 45 while moving the door 11 in the same direction to adjust the position. Therefore, the worker is likely to feel, as a sensation during operation, that the direction of the direct operation and the direction of adjustment of the door 11 are coincident and thus can perform the operation more easily and smoothly, enabling the operability to be improved.

[0072] With the door suspension apparatus 1 and the door apparatus 2, fastening the second nut 47 threadedly engaged with the bolt 45 allows the bolt 45 to be easily fixed to the drive connection portion 21 by the fastening force acting between the bolt head 45a and the second nut 47 on the door leading end side. Also, the structure that eventually fixes the bolt 45 to the drive connection portion 21 can be realized with a simple configuration in which only the second nut 47 is provided. Accordingly, in the fastening mechanism with good operability in which the direction in which the first nut 46 is fastened to the bolt 45 and the movement direction of the door 11 are coincident, it is also possible to realize a structure that is capable of easily fixing the bolt 45 to the drive connection portion 21 with a simple configuration.

[0073] With the door suspension apparatus 1 and the door apparatus 2, the drive connection portion 21 is supported to the door roller portion 22 so as to be movable along the lengthwise direction of the rail 19 via the bolt 45 of the fastening mechanism of the variable connection portion 23, and is supported so as to be movable along the lengthwise direction of the rail 19 also in the guide

portion 30 disposed in a position displaced parallel to the bolt 45. Accordingly, it is possible to prevent the drive connection portion 21 from being pivoted about the bolt 45 when the worker performs the operation of adjusting the position of the door 11 in the opening and closing direction, and therefore the worker does not need to retain the drive connection portion so as not to pivot about the bolt 45 during the operation. This can further reduce the burden of the operation.

[0074] With the door suspension apparatus 1 and the door apparatus 2, the guide portion 30 is formed as a shaft-like member extending along the lengthwise direction of the rail 19, and therefore the guide portion 30 can be disposed along the rail 19 in a compact manner, making it possible to reduce the size of the door roller portion 22. Also, in the door roller portion 22, the guide portion 30 is linearly disposed between the door roller units (29a, 29b), which are the structures that support the plurality of door rollers aligned along the lengthwise direction of the rail 19. Accordingly, it is possible to achieve space saving and weight reduction, compared to a configuration in which the guide portion is provided in a position displaced parallel to the structures that support the plurality of door rollers to achieve integration.

[0075] With the door suspension apparatus 1 and the door apparatus 2, the direction in which the first hole portion 32a and the second hole portion 28a extend along the lengthwise direction of the rail 19 and the direction in which the guide portion 30 and the door rollers (36a, 36b, 36c) are disposed along the lengthwise direction of the rail 19 are arranged side by side in the horizontal direction and displaced parallel to each other. Accordingly, the door rollers (36a, 36b, 36c) and the guide portion 30 will not be disposed on the opposite sides in a direction along the lengthwise direction of the rail 19 with respect to the bolt 45 and the first nut 46 of the fastening mechanism. This can ensure a sufficient space for the worker to operate the fastening mechanism around the fastening mechanism, and therefore the worker can easily operate the fastening mechanism without being obstructed by the door rollers (36a, 36b, 36c) and the guide portion 30. Accordingly, it is possible to improve the operability during the operation of the fastening mechanism, thus further reducing the burden of the operation.

[0076] With the door suspension apparatus 1 and the door apparatus 2, in the door roller portion 22, the door 11 is suspended to the pivot member 35 via the hanger member 41, and is supported pivotably about the pivot shaft 34. Accordingly, it is possible to achieve a structure in which, when an inclination occurs in the door 11 installed in the structure, the influence of the inclination of the door 11 tend not to be transferred to the door rollers (36a, 36b, 36c). This can reduce the harmful effect on the door rollers (36a, 36b, 36c) by an inclination of the door 11, including, for example, uneven wear of the door rollers (36a, 36b, 36c) resulting from unbalanced load from the door 11 side acting on the door rollers (36a, 36b, 36c), unusual sound during travel of the door rollers (36a,

36b, 36c), and a phenomenon in which the door rollers (36a, 36b, 36c) move upward and thus come near to be detached from the rail 19 (bouncing of the door rollers). Further, when this embodiment is applied to a door with a structure having a curved portion, it is possible to maintain the state of contact between the door rollers and the rail in an optimum state even if a gap serving as a play for mitigating generation of unbalanced load or unusual sound is not provided, thus preventing unbalanced load from acting on the door rollers from the door side, and unusual sound from being generated during travel of the door rollers.

[0077] With the door suspension apparatus 1 and the door apparatus 2, the housing structure that supports the door roller 36a in the door roller portion 22 is formed by combining the second housing member 32 with the first housing member 31 to which the rotational shaft 37a of the door roller 36a is attached. Also, the first housing member 31 and the second housing member 32 are fixed integrally by causing a single externally threaded member 38a to be threadedly engaged with the internally threaded hole 39a of the rotational shaft 37a of the door roller 36a in a state in which the pivot shaft 34 serving as the pivot center of the pivot member 35 is engaged, at its notched portion 34a, with the notch engaging portion 32c provided in the second housing member 32. Therefore, at the time of performing maintenance after installation, the housing structure of the door roller portion 22 can be easily disassembled by removing a single externally threaded member 38a from the internally threaded hole 39a. Accordingly, in the door roller portion 22 that suspends the door 11 to the pivot member 35 and that supports the door 11 pivotably about the pivot shaft 34, the housing structure of the door roller portion 22 can be easily disassembled by simply removing a single externally threaded member 38a, making it possible to reduce the burden of the maintenance operation.

[0078] Although an embodiment of the present invention has been described thus far, the present invention is not limited to the above-described embodiment, and various modifications may be made within the scope recited in the claims. For example, a single door 11 may be provided, and the following variations may also be made.

[0079] (1) Although this embodiment has been described, taking, as an example, a fastening mechanism made up of a bolt and nuts as the fastening mechanism of the variable connection portion, this need not be the case; it is possible to adopt a fastening mechanism made up of members other than a bolt and nuts. That is, the member that passes through the first hole portion and the second hole portion may be a configuration other than a bolt, and it is possible to use various configurations, including, for example, a member formed in the shape of a shaft or column. The member that adjusts the relative position between the drive connection portion and the door roller portion by changing the relative position with respect to the member passing through the first

hole portion and the second hole portion may be a configuration other than a nut, and it is possible to use various configurations, including, for example, a configuration that utilizes the biasing force of an elastic member.

[0080] (2) Although this embodiment has been described, taking, as an example, a configuration in which the bolt is engaged with the drive connection portion and the first nut is engaged with the door roller portion in the fastening mechanism of the variable connection portion, this need not be the case. That is, it is possible to provide a fastening mechanism in which the bolt is engaged with the door roller unit and the first nut is engaged with the drive connection portion.

[0081] (3) Although this embodiment has been described, taking, as an example, a configuration in which the first hole portion is disposed on the door trailing end side with respect to the second hole portion, this need not be the case; it is possible to adopt a configuration in which a door leading end-side first hole portion that is disposed on the door leading end side with respect to the second hole portion is provided as the first hole portion. Further, the variable connection portion may include a push-back mechanism that biases the door roller portion to the drive connection portion in the closing direction of the door. FIG. 11 is a plan view showing a door suspension apparatus 3 according to a modification in which a door leading end-side first hole portion is provided as the first hole portion and a push-back mechanism is provided, corresponding to FIG. 5 of this embodiment. FIG. 12 is an enlarged view showing, in enlargement, part of the door suspension apparatus 3 shown in FIG. 11, corresponding to FIG. 6 of this embodiment. Note that the description of those elements of the door suspension apparatus 3 that are configured in the same manner as the door suspension apparatus 1 of this embodiment is omitted by using the same reference numerals in the drawings. Similarly, the description of those elements that are the same as the elements of this embodiment and not shown in FIGS. 11 and 12 and is also omitted by using the same reference numerals in the drawings.

[0082] In the door suspension apparatus 3 shown in FIGS. 11 and 12, a door leading end-side first hole portion 52 that is disposed on the door leading end side with respect to the second hole portion 28a is provided as the first hole portion. The door leading end-side first hole portion 52 is provided in the second housing member 32 of the door roller unit 29b, and is formed through the second housing member 32 so as to extend along the lengthwise direction of the rail 19. In the door suspension apparatus 3, a variable connection portion 50 includes a fastening mechanism capable of fixing the door roller portion 22 and the drive connection portion 21 to each other such that their relative position in the direction along the lengthwise direction of the rail 19 can be changed, and a push-back mechanism that biases the door roller portion 22 to the drive connection portion 21 in the closing direction of the door 11.

[0083] The fastening mechanism of the variable con-

nection portion 50 includes a bolt 45 serving as a member that passes through the door leading end-side first hole portion 52 and the second hole portion 28a and a first nut 46 that is threadedly engaged with the bolt 45, and does not include the second nut as in this embodiment. The bolt 45 of the variable connection portion 50 is disposed so as to be inserted into the second hole portion 28a from the door trailing end side such that the bolt head 45a is engaged with the second block portion 28 of the drive connection portion 21. On the other hand, the first nut 46 of the variable connection portion 50 is disposed so as to be threadedly engaged with the end on the door leading end side of the bolt 45 that passes through the door leading end-side first hole portion 52 and to be engaged with the second housing member 32 of the door roller unit 29b of the door roller portion 22 from the door leading end side.

[0084] The push-back mechanism of the variable connection portion 50 is disposed between the door leading end-side first hole portion 52 and the second hole portion 28a, and is configured by a coil spring 51 through which the bolt 45 passes through. In the compressed state, both ends of the coil spring 51 are in contact with the second housing member 32 and the second block portion 28 of the door roller unit 29b. Accordingly, the push-back mechanism is configured to bias the door roller portion 22 to the drive connection portion 21 in the closing direction of the door 11 with the biasing force of the coil spring 51. Also, the push-back mechanism maintains the relative position of the door roller portion 22 with respect to the drive connection portion 21 until a force of a predetermined magnitude or greater acts on the door roller portion 22 in the opening direction of the door 11. On the other hand, when a force of a predetermined magnitude or greater acts on the door roller portion 22 in the opening direction of the door 11, the push-back mechanism permits a relative movement of the door roller portion 22 with respect to the drive connection portion 21 in the opening direction of the door 11 within a predetermined distance range.

[0085] With the door suspension apparatus 3 according to this modification and a door apparatus including the same, during the positional adjustment operation of the door 11 in the opening and closing direction, the position of the door leading end-side first hole portion 52, which is disposed on the door leading end side than the second hole portion 28a, with respect to the second hole portion 28a is changed by the fastening mechanism, and thereby the relative position of the drive connection portion 21 with respect to the door roller portion 22 is adjusted. After installation, the door roller portion 22 is maintained in the same relative position by being constantly biased to the drive connection portion 21 in the closing direction (to the door leading end side) by the push-back mechanism, and is maintained in the same relative position also when the locking device 13 is operating with the door 11 in the fully closed position. However, if some foreign object is caught on the door leading end side of

the door 11 when the door 11 is being closed and a force of a predetermined magnitude or greater acts on the door roller portion 22 in the opening direction, a relative movement of the door roller portion 22 to the drive connection portion 21 in the opening direction is permitted even if the locking device 13 is operating, as long as the size of the foreign object is within a predetermined size range. Therefore, the foreign object caught in the door 11 can be pulled out by slightly moving the door 11 in the opening direction in a forceful manner within a predetermined distance range that does not cause a safety problem in a state in which the locking device 13 is kept in operation.

[0086] With the door suspension apparatus 3 and the door apparatus including the same, the push-back mechanism is provided as the coil spring 51 disposed between the door leading end-side first hole portion 52 and the second hole portion 28a, and the bolt 45 passing through the door leading end-side first hole portion 52 and the second hole portion 28a is disposed so as to pass through the coil spring 51. Accordingly, it is possible to dispose the push-back mechanism around the fastening mechanism in a compact manner, thus preventing an increase in the size of the variable connection portion 50 even if the push-back mechanism is provided. Although the above modification has been described, taking, as an example, a case where the push-back mechanism includes a coil spring, this need not be the case. For example, it is possible to provide a push-back mechanism including an elastic member having any of various configurations, including, for example, sponge rubber formed in a cylindrical shape.

[0087] (4) In a door suspension apparatus that includes a variable connection portion including a push-back mechanism as illustrated in FIGS. 11 and 12, the push-back mechanism may further include a regulating member that regulates the amount of the relative movement of the door roller portion to the drive connection portion in the opening direction of the door. FIG. 13 is a diagram showing a modification in which the push-back mechanism of the variable connection portion 50 includes a collar 53 serving as the above-described regulating member in the door suspension apparatus 3 shown in FIGS. 11 and 12, in addition to the coil spring 51, and the drawing corresponds to FIG. 12. The collar 53 is formed as a cylindrical member, and is disposed between the second housing member 32 of the door roller unit 29b and the second block portion 27 of the drive connection portion 21 in a state in which the guide portion 30 is inserted therethrough. Accordingly, even if an excessive force of a predetermined magnitude or greater acts on the door roller portion 22 in the opening direction of the door 11, the fixing nut 44b that fixes the guide portion 30 to the door roller unit 29b comes into contact with the end of the collar 53 on the door leading end side upon movement of the door roller portion 22 in the opening direction. This enables the amount of the relative movement of the door roller portion 22 with respect to the drive connection portion 21 in the opening direction of the door 11 to be

regulated within a preset range, and the door 11 is prevented from being excessively opened with the push-back mechanism. Also, it is possible to dispose the regulating member around the guide portion 30 in a compact manner, thus realizing space saving.

[0088] The configuration of the regulating member is not limited to the above-described configuration, and various modifications may be made. For example, a regulating member formed as a cylindrical member as in the case of the collar 53 may be disposed between the second housing member 32 of the door roller unit 29b and the first block portion 28 of the drive connection portion 21 in a state in which the bolt 45 is inserted therethrough. In this case, the regulating member may be disposed on the outer circumferential side of the coil spring 51, or may be disposed on the inner circumference side of the coil spring 51. With this configuration as well, it is possible to prevent the door 11 from being excessively opened with the push-back mechanism, and dispose the regulating member around the bolt 45 in a compact manner, thus realizing space saving.

[0089] (5) Although this embodiment has been described, taking, as an example, a configuration in which the guide portion of the door roller portion is formed as a shaft-like member, this need not be the case; various modifications may also be made to the shape. Further, various modifications may be made to the arrangement of the guide portion.

[0090] (6) Although this embodiment has been described, taking, as an example, a configuration in which the second housing member of the door roller portion is provided with the notch engaging portion that is engaged with the notched portion of the pivot shaft, this need not be the case. That is, it is possible to adopt a configuration in which the first housing member is provided with the notch engaging portion, or both the first housing member and the second housing member may be provided with the notch engaging portion.

[0091] (7) Although this embodiment has been described, taking, as an example, the door apparatus in which the open-close drive mechanism includes the drive motor, the drive pulley, the driven pulley, and the belt, this need not be the case; various modifications may be made as long as the open-close drive mechanism is a mechanism that can be provided in a structure and is capable of driving a door to be opened and closed. FIGS. 14 and 15 are front views respectively showing a door apparatus 4 and a door apparatus 5 according to modifications in which open-close drive mechanisms different from that of this embodiment are provided, and the drawings correspond to FIG. 1 of this embodiment. Note that the description of those elements of the door apparatus 4 shown in FIG. 14 and the door apparatus 5 shown in FIG. 15 that are configured in the same manner as the door apparatus 2 of this embodiment is omitted by using the same reference numerals in the drawings.

[0092] In the door apparatus 4 shown in FIG. 14, an open-close drive mechanism 60 includes a drive motor

(not shown), a pinion 61, an upper rack 62, a lower rack 63, and so forth. The pinion 61 is connected to the drive motor, and is rotationally driven with rotation of the drive motor. Also, the pinion 61 is disposed so as to be meshed with the upper rack 62 that is disposed thereabove so as to extend horizontally and the lower rack 63 that is disposed therebelow so as to extend horizontally. The upper rack 62 and the lower rack 63 are supported to the structure so as to be slidably moved parallel to the lengthwise direction of the rail 19. The upper rack 62 and the lower rack 63 are configured to be slidably moved in opposite directions to each other by rotation of the pinion 61. Further, the upper rack 62 is connected to a door suspension apparatus 1 that supports one of two doors 11 in a suspended state, and the lower rack 63 is connected to a door suspension apparatus 1 that supports the other of the two doors 11 in a suspended state. Accordingly, rotations of the pinion 61 with a forward operation and a reverse operation of the drive motor cause the two doors 11 to be driven to be moved in the opening direction and the closing direction.

[0093] In the door apparatus 5 shown in FIG. 15, an open-close drive mechanism 70 includes a drive motor 71, a screw shaft 72, a rotation receiving portion 73, nut members (74a, 74b), and so forth. The screw shaft 72 is connected to the drive motor 71 at its one end, and is rotatably supported by the rotation receiving portion 73 at the other end. Accordingly, the screw shaft 72 is rotationally driven with rotation of the drive motor 71. Further, in the screw shaft 72, an externally threaded portion 72a formed from the center portion to one end and an externally threaded portion 72b formed from the center portion to the other end are formed as threaded portions in reverse directions. The nut members (74a, 74b) are provided as members that are threadedly engaged with the screw shaft 72 and are connected to the door suspension apparatus 1. Note that the nut member 74a is threadedly engaged with one of the externally threaded portions of the screw shaft 72, namely the externally threaded portion 72a, and is connected to a door suspension apparatus 1 that supports one of two doors 11 in a suspended state. The nut member 74b is threadedly engaged with the other externally threaded portion of the screw shaft 72, namely the externally threaded portion 72b, and is connected to a door suspension apparatus 1 that supports the other of the two doors 11 in a suspended state. Accordingly, rotations of the screw shaft 72 with a forward operation and a reverse operation of the drive motor 71 cause the two doors 11 to be driven to be moved in the opening direction and the closing direction.

Industrial Applicability

[0094] The present invention is widely applicable as a door suspension apparatus that supports a door provided in a structure and driven to be opened and closed by an open-close drive mechanism, in a state in which the door is suspended to the structure so as to be slidably moved,

and that is connected to the open-close drive mechanism, and a door apparatus including the door suspension apparatus.

Description of the Reference Numerals

[0095]

1	Door suspension apparatus	
11	Door	10
12	Open-close drive mechanism	
13	Locking device	
17	Lock member (Locking portion)	
18	Lock pin (Locked portion)	
19	Rail	15
21	Drive connection portion	
22	Door roller portion	
23	Variable connection portion	
36a, 36b, 36c	Door roller	20

Claims

1. A door suspension apparatus that supports a door provided in a structure and driven to be opened and closed by an open-close drive mechanism, in a state in which the door is suspended to the structure so as to be slidably moved, and that is connected to the open-close drive mechanism, the apparatus comprising:
 - a drive connection portion that is provided with one of a locking portion and a locked portion of a locking device for locking the door to the structure in a fully closed position through locking between the locking portion and the locked portion, and that is connected to the open-close drive mechanism;
 - a door roller portion that includes a door roller traveling on a rail fixed in the structure, that is connected to the door, and that supports the door in a state in which the door is suspended to the rail so as to be slidably moved and
 - a variable connection portion that connects the drive connection portion to the door roller portion such that a relative position between the drive connection portion and the door roller portion in a direction along a lengthwise direction of the rail can be changed
2. The door suspension apparatus according to claim 1, wherein the door roller portion comprises a first hole portion that is formed therethrough so as to extend along the lengthwise direction of the rail, the drive connection portion comprises a second hole portion that extends along the lengthwise direction of the rail and that is formed therethrough so as to face the first hole portion, and

the variable connection portion comprises a fastening mechanism that includes a member passing through the first hole portion and the second hole portion and that is capable of fixing the door roller portion and the drive connection portion to each other such that a relative position therebetween can be changed.

3. The door suspension apparatus according to claim 2, wherein the fastening mechanism comprises a bolt that is provided as the member passing through the first hole portion and the second hole portion and whose bolt head is engaged with one of the door roller portion and the drive connection portion, and a first nut that is threadedly engaged with the bolt and is engaged with the other of the door roller portion and the drive connection portion, and the first hole portion is disposed on a door trailing end side, which is the side on which the end of the door in an opening direction is located, with respect to the second hole portion.
4. The door suspension apparatus according to claim 3, wherein the fastening mechanism further comprises a second nut that is threadedly engaged with the bolt, the bolt is inserted into the second hole portion from a door leading end side, which is the side on which the end of the door in the closing direction is located, and the bolt head is engaged with the drive connection portion, the second nut is disposed on the side opposite to the bolt head via the second hole portion and is engaged with the drive connection portion from the door trailing end side, and the first nut is engaged with the door roller portion from the door trailing end side.
5. The door suspension apparatus according to any one of claims 2 to 4, wherein the door roller portion further comprises a guide portion for guiding movement of the drive connection portion along the lengthwise direction of the rail, and a direction in which the first hole portion and the second hole portion extend in the lengthwise direction of the rail and a direction in which the guide portion is disposed along the lengthwise direction of the rail are displaced parallel to each other.
6. The door suspension apparatus according to claim 5, wherein the guide portion is formed as a shaft-like member extending along the lengthwise direction of the rail, and is slidably inserted into a guide hole portion that is formed through the drive connection portion, and the door roller is disposed on either side in a direction along the lengthwise direction of the rail with respect to the guide portion.

7. The door suspension apparatus according to claim 6, wherein a direction in which the first hole portion and the second hole portion extend along the lengthwise direction of the rail and a direction in which the guide portion and the door roller are disposed along the lengthwise direction of the rail are arranged side by side in the horizontal direction and displaced parallel to each other. 5
8. The door suspension apparatus according to any one of claims 1 to 7, wherein the door roller portion comprises a pivot shaft that is disposed extending along the lengthwise direction of the rail, and a pivot member that is provided pivotably about the pivot shaft and on which the door can be suspended. 10 15
9. The door suspension apparatus according to claim 8, wherein the door roller portion further comprises a rotational shaft for rotatably supporting the door roller, a first housing member in which a through hole passing through the pivot shaft is formed, a second housing member to which the rotational shaft is attached and that is disposed facing the first housing member, 20 25 the pivot shaft is provided with a notched portion that is recessed so as to be notched in a groove shape along the circumferential direction thereof, at least one of the first housing member and the second housing member is provided with a notch engaging portion that is engaged with the notched portion, and 30 35 the first housing member and the second housing member are fixed to each other with a single externally threaded member that is threadedly engaged with an internally threaded hole formed in the rotational shaft.
10. The door suspension apparatus according to claim 2, wherein a door leading end-side first hole portion that is disposed on a door leading end side, which is the side on which the end of the door in the closing direction is located, with respect to the second hole portion is provided as the first hole portion, 40 45 the fastening mechanism includes a member passing through the door leading end-side first hole portion and the second hole portion, and is capable of fixing the door roller portion and the drive connection portion such that a relative position therebetween can be changed, 50 55 the variable connection portion further comprises a push-back mechanism that biases the door roller portion to the drive connection portion in a closing direction of the door, and the push-back mechanism maintains a relative position of the door roller portion with respect to the drive connection portion until a force of a predetermined magnitude or greater acts on the door roller portion in an opening direction of the door, and permits a relative movement of the door roller portion with respect to the drive connection portion in the opening direction of the door within a predetermined distance range when a force of a predetermined magnitude or greater acts on the door roller portion in the opening direction of the door.
11. The door suspension apparatus according to claim 10, wherein the push-back mechanism comprises a coil spring that is disposed between the door leading end-side first hole portion and the second hole portion and through which the member passing through the door leading end-side first hole portion and the second hole portion passes, and biases the door roller portion to the drive connection portion in the closing direction of the door with a biasing force of the coil spring.
12. A door apparatus comprising: the door suspension apparatus according to any one of claims 1 to 11; a door that is provided in a structure and is supported by the door suspension apparatus in a state of being suspended to the structure so as to be slidably moved; an open-close drive mechanism that is connected to the door suspension apparatus and that drives the door to be opened and closed.

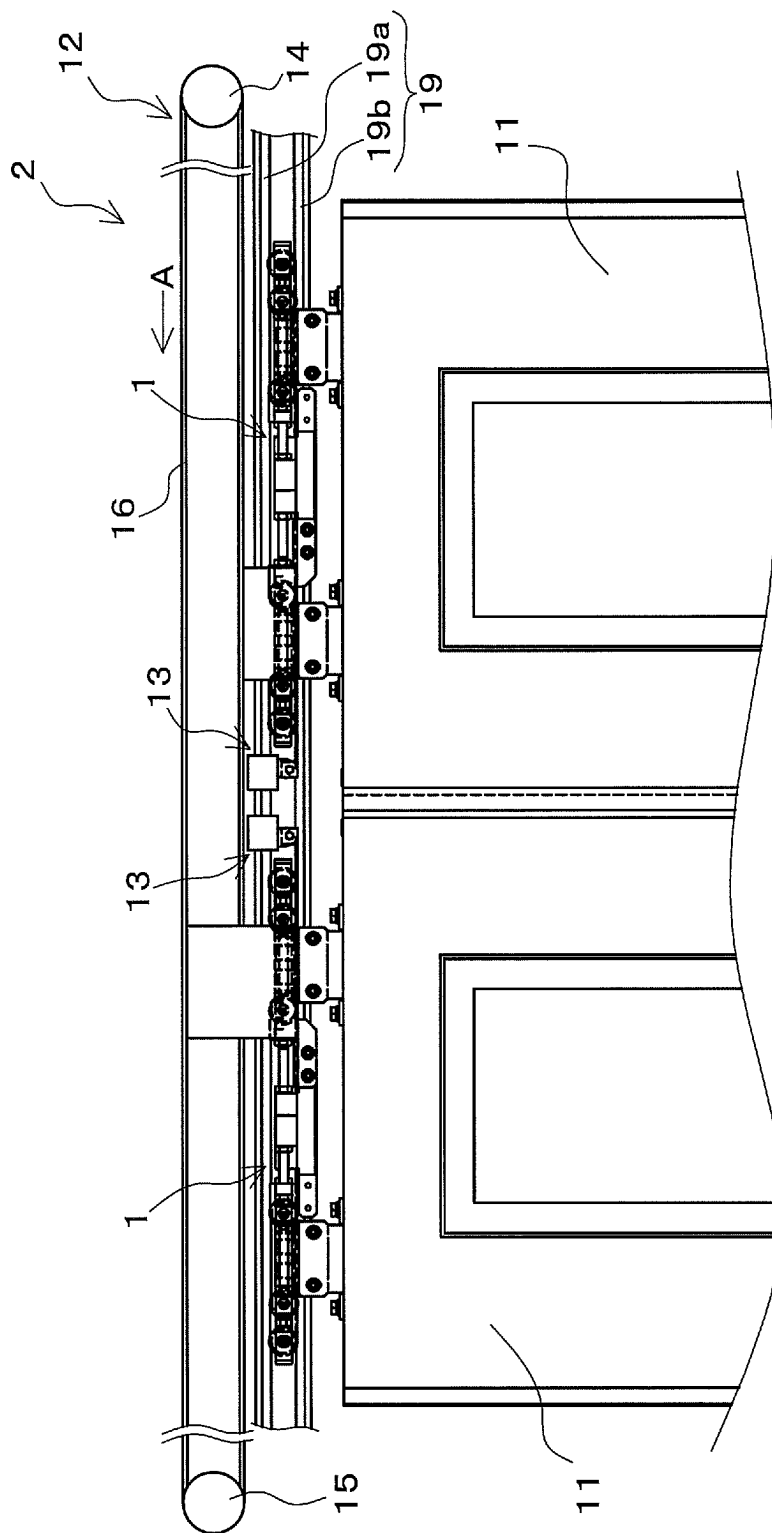


FIG. 1

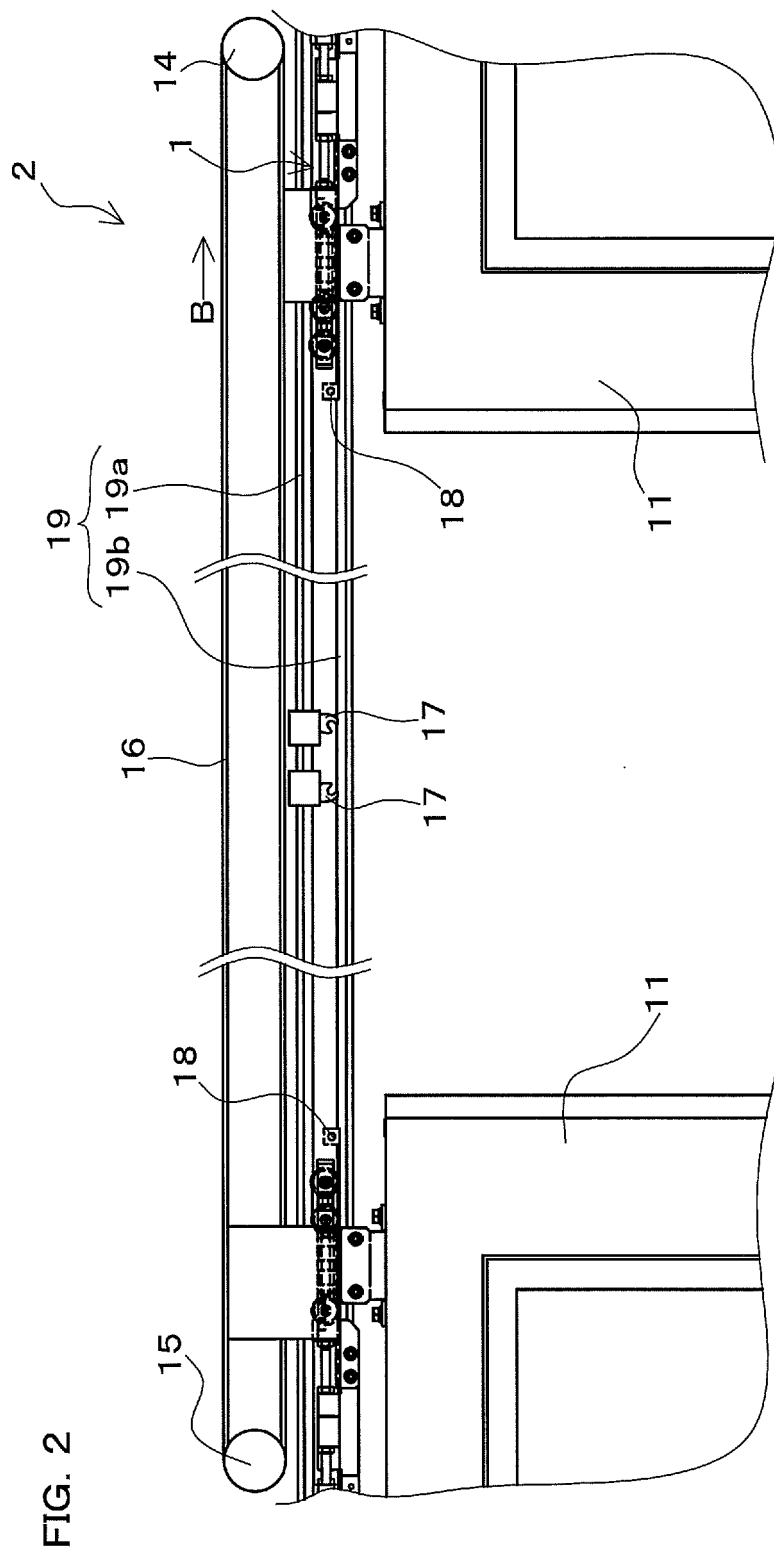


FIG. 3

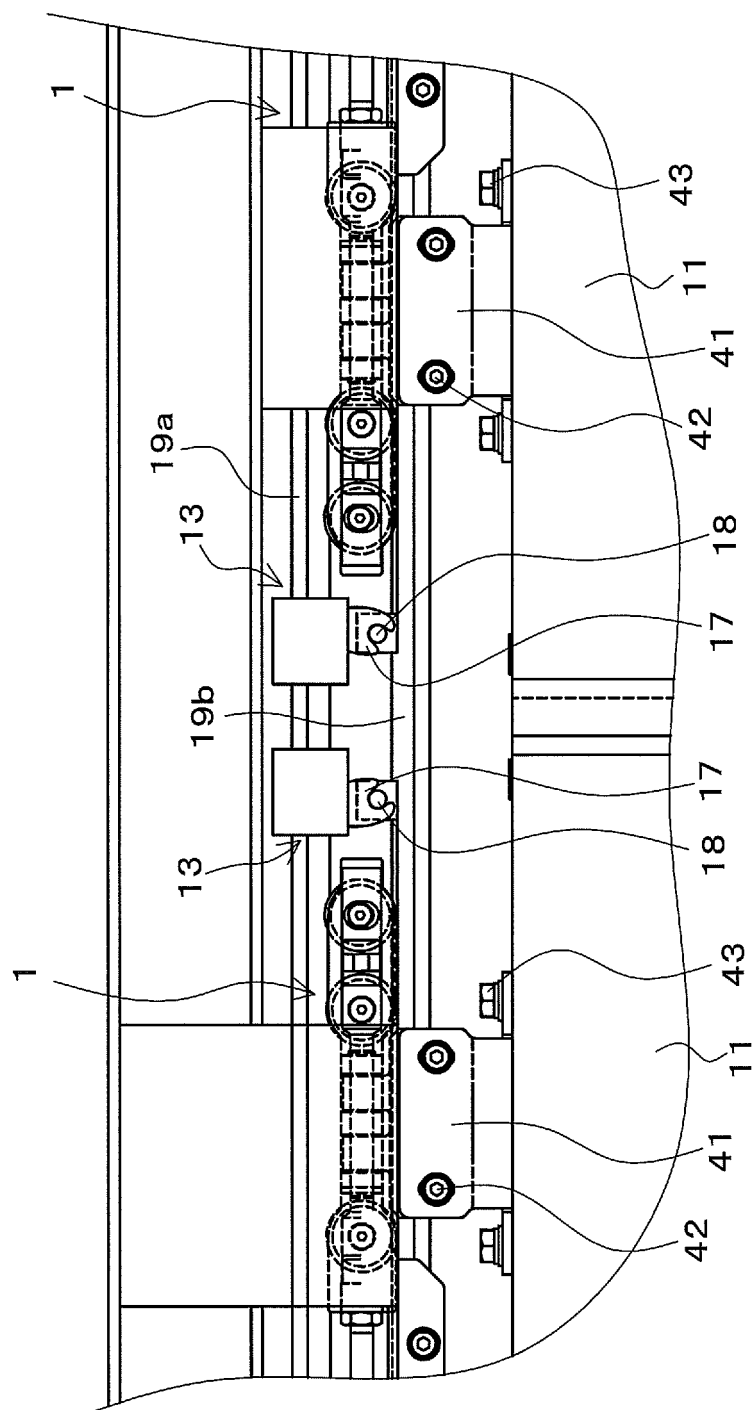
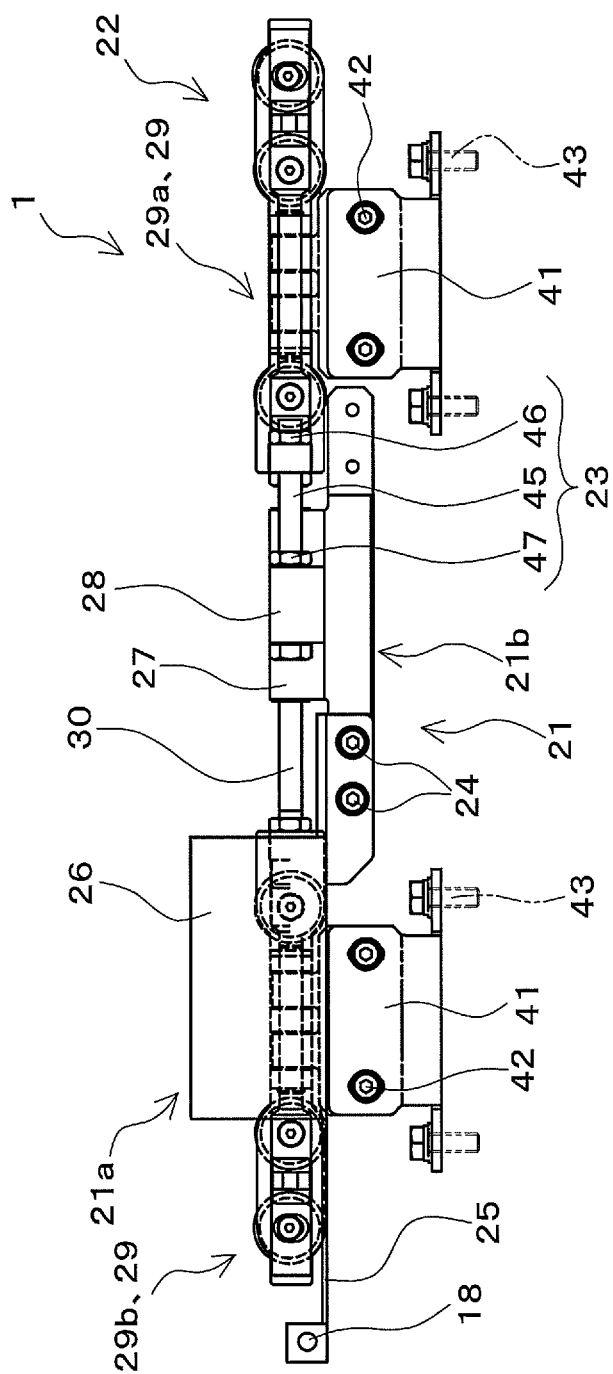
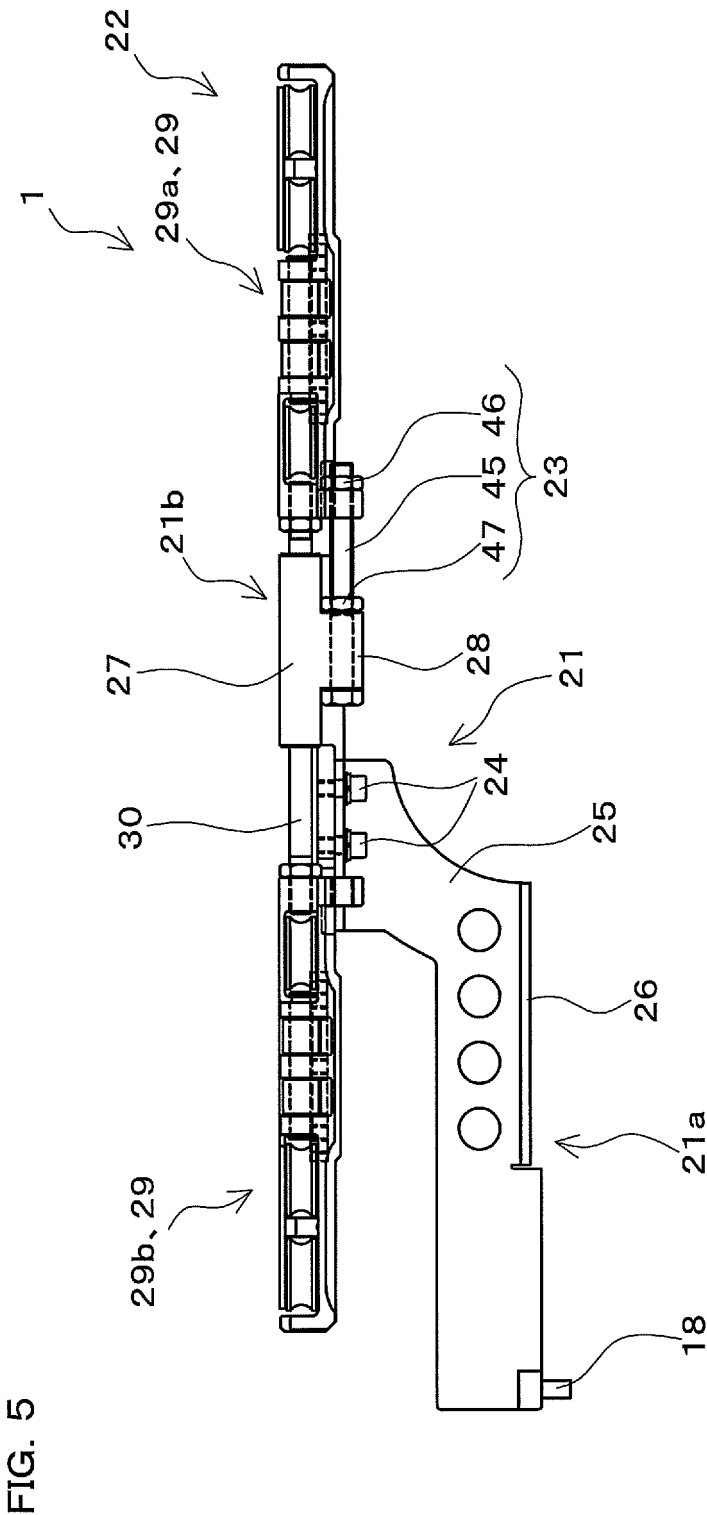


FIG. 4





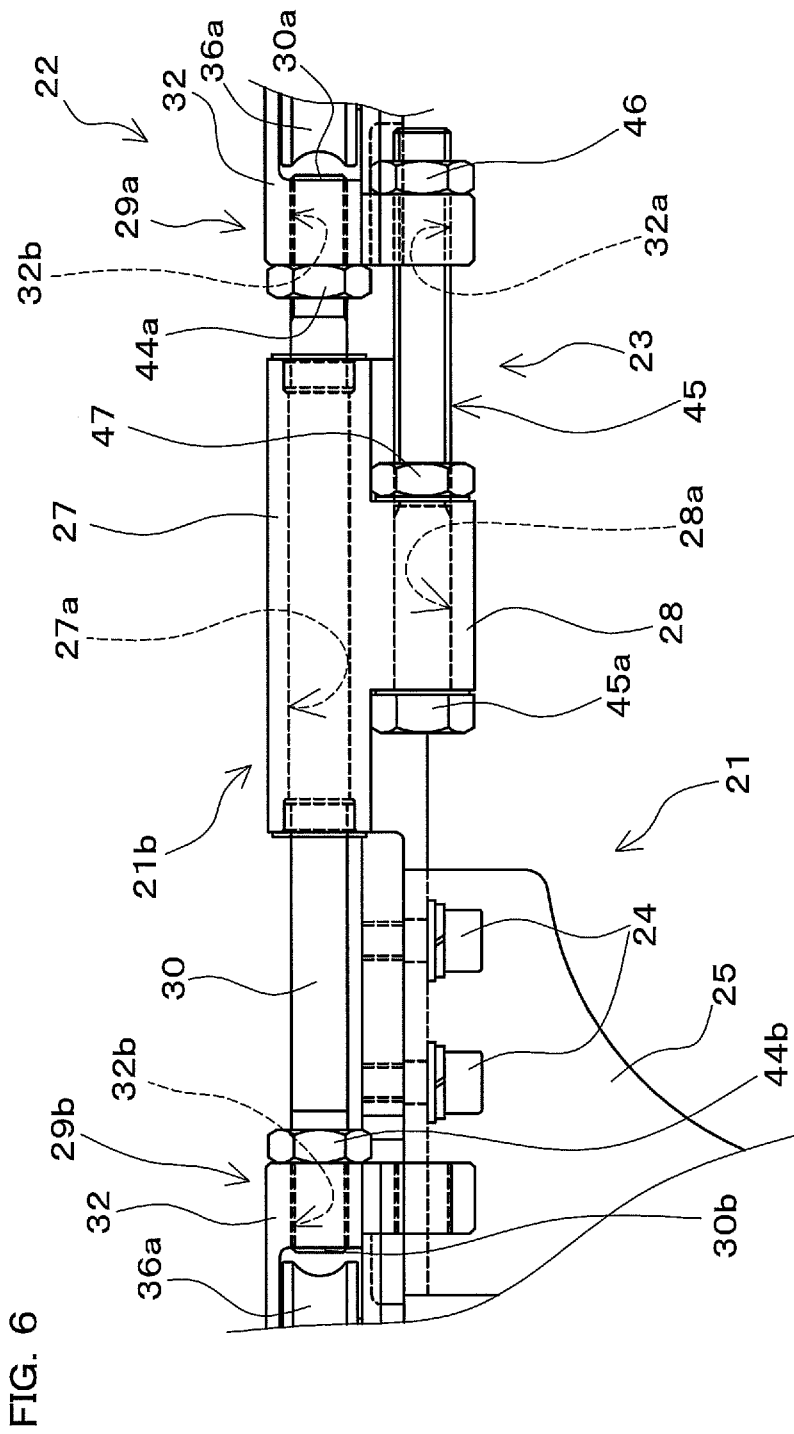
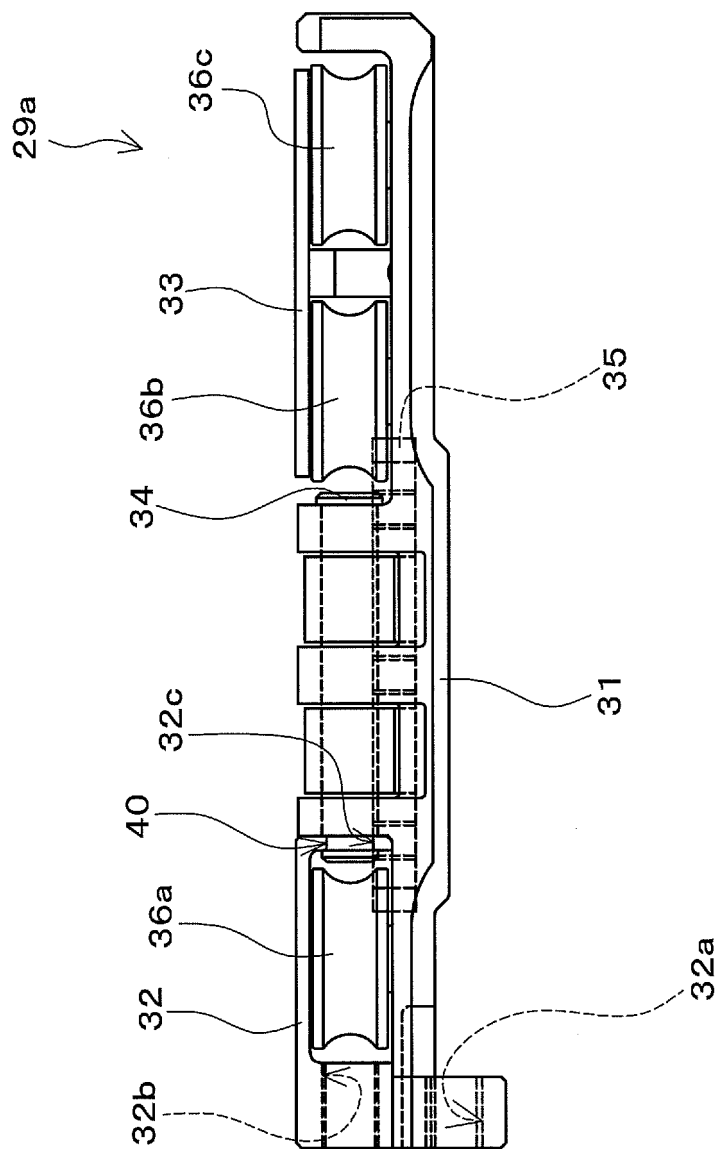


FIG. 7



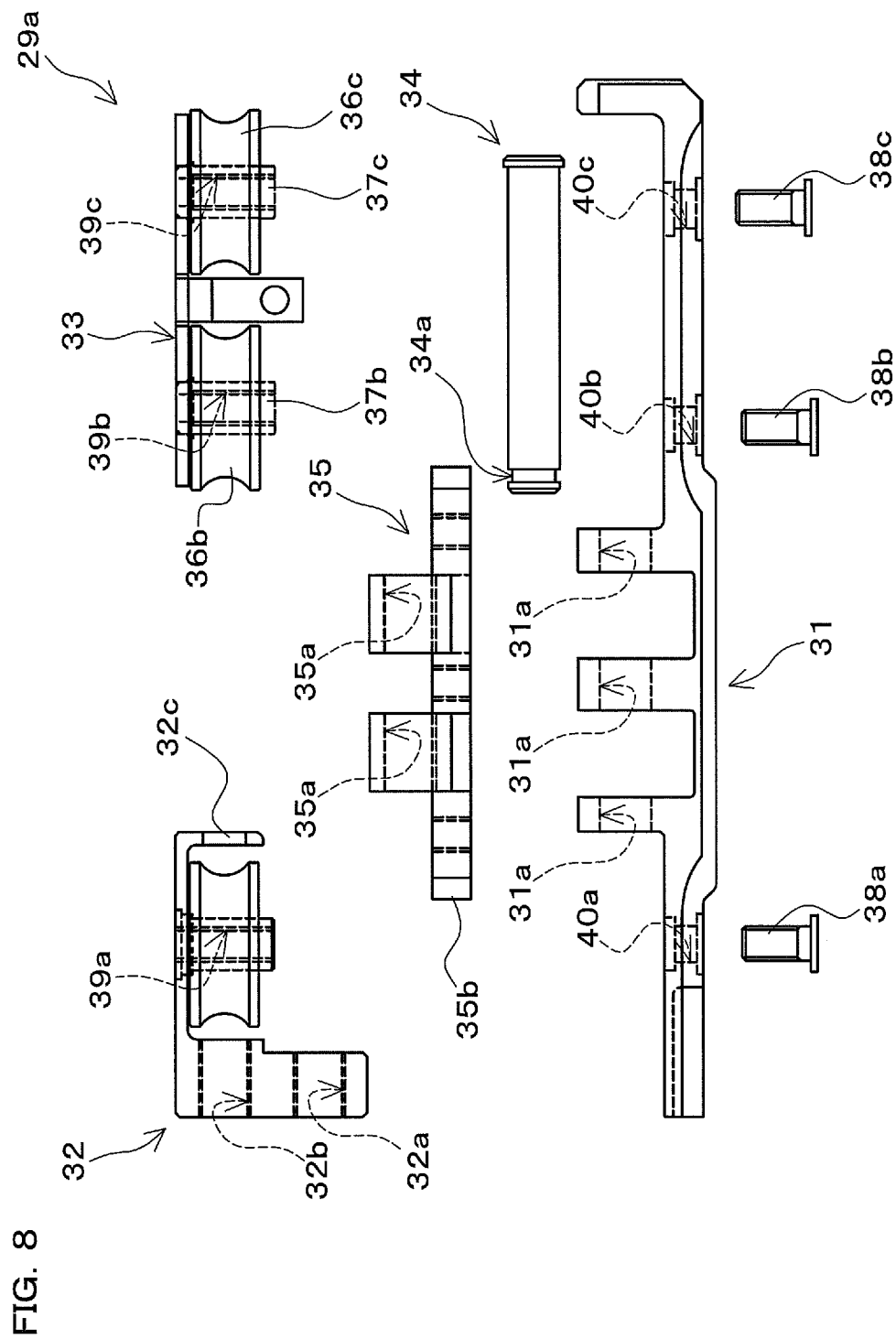


FIG. 9

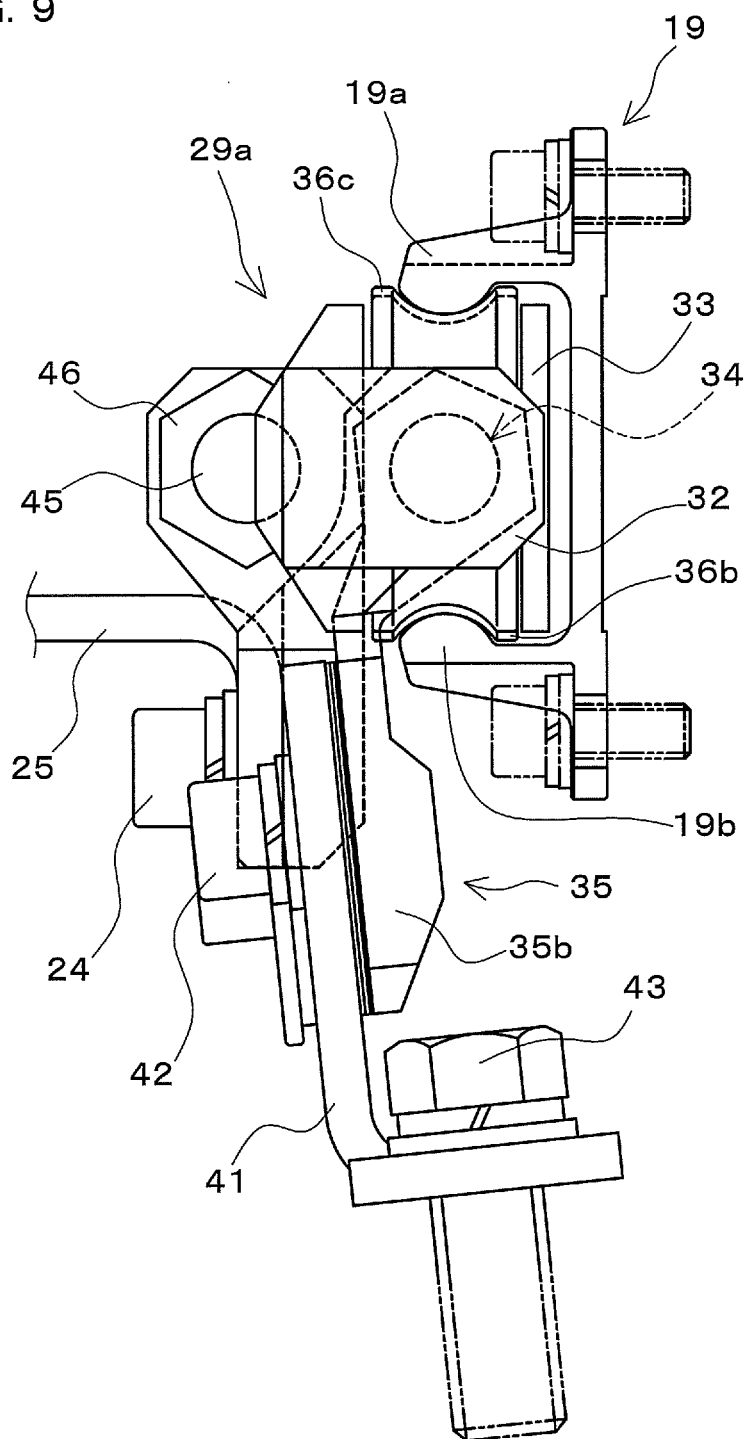
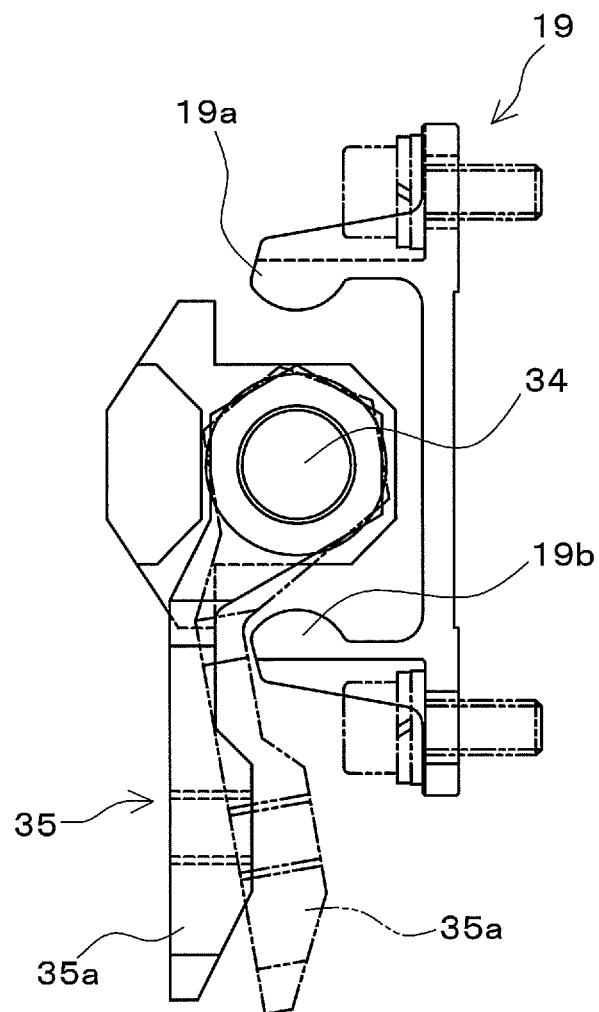
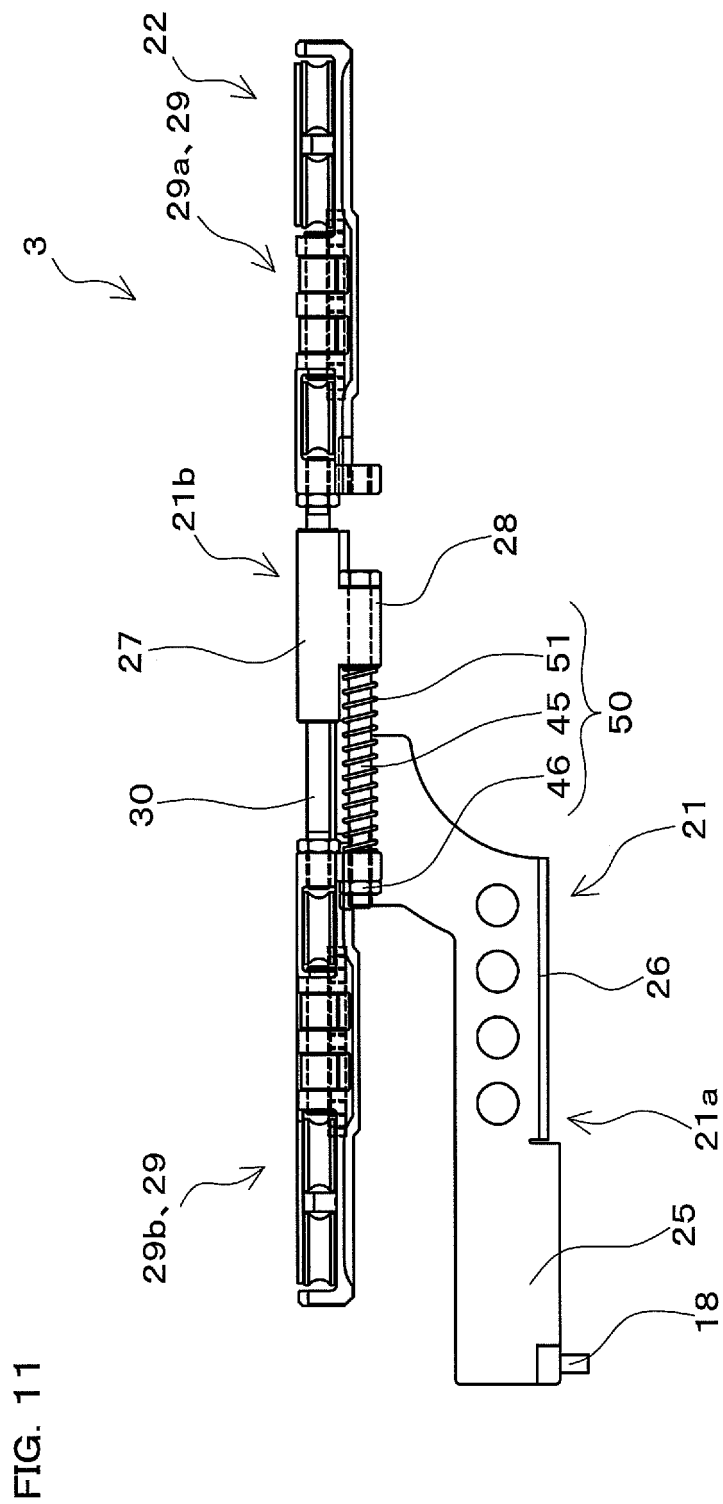


FIG. 10





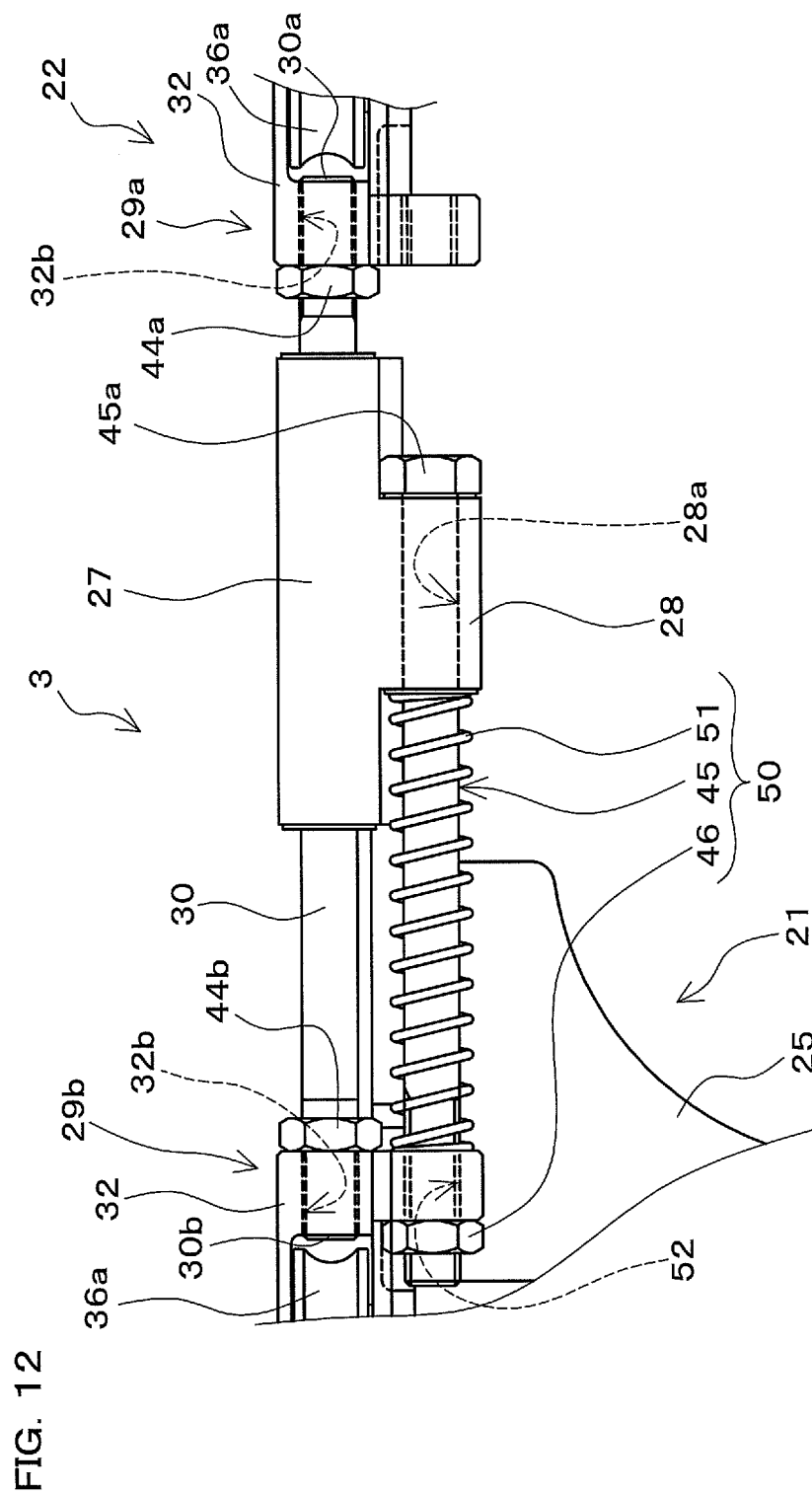
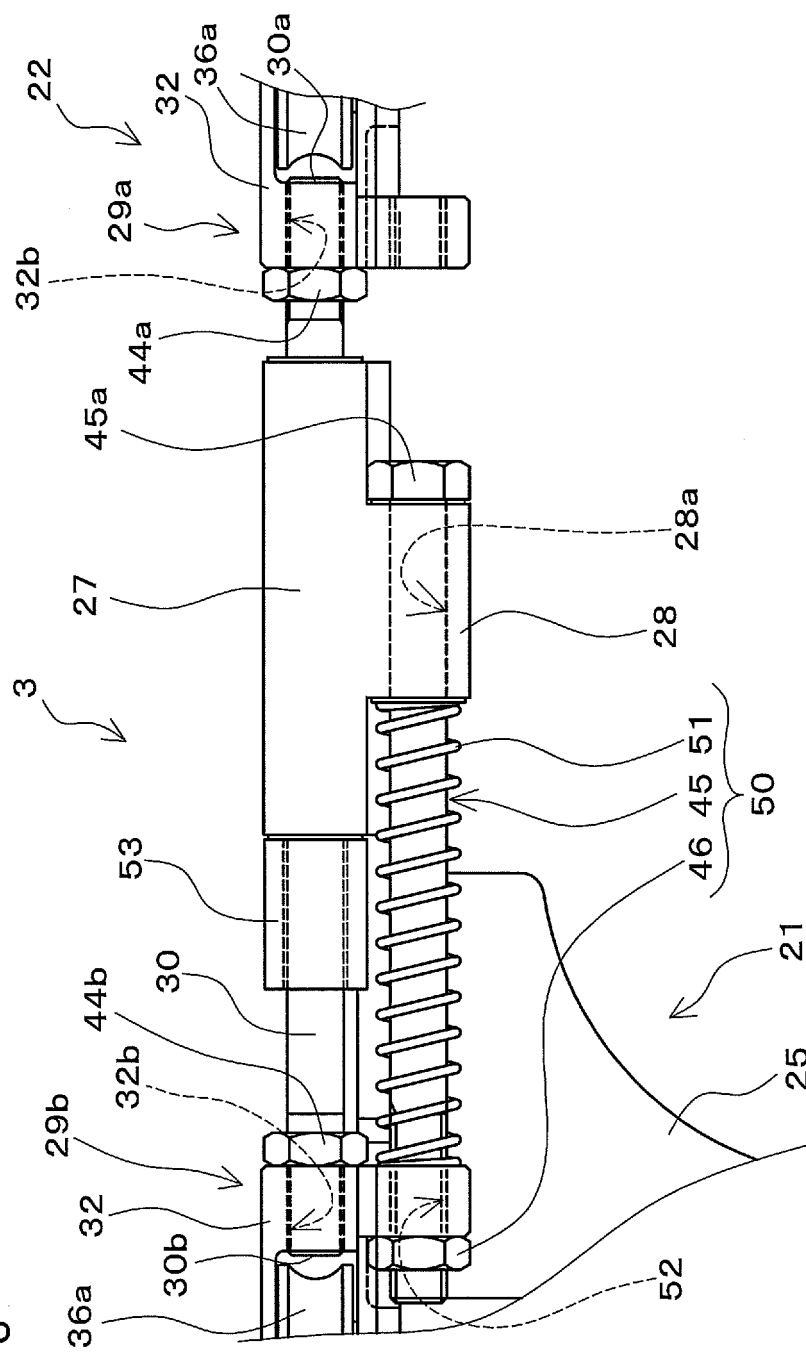
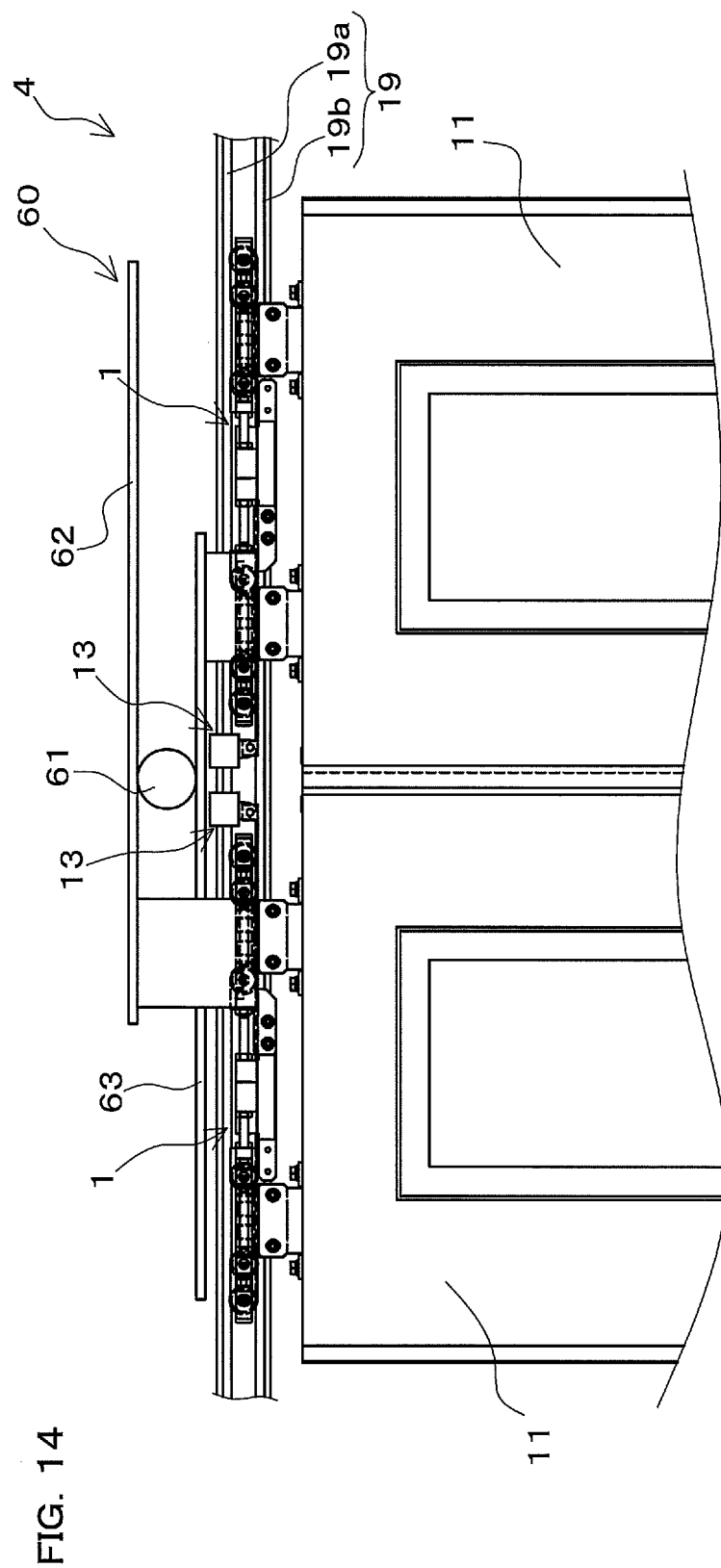
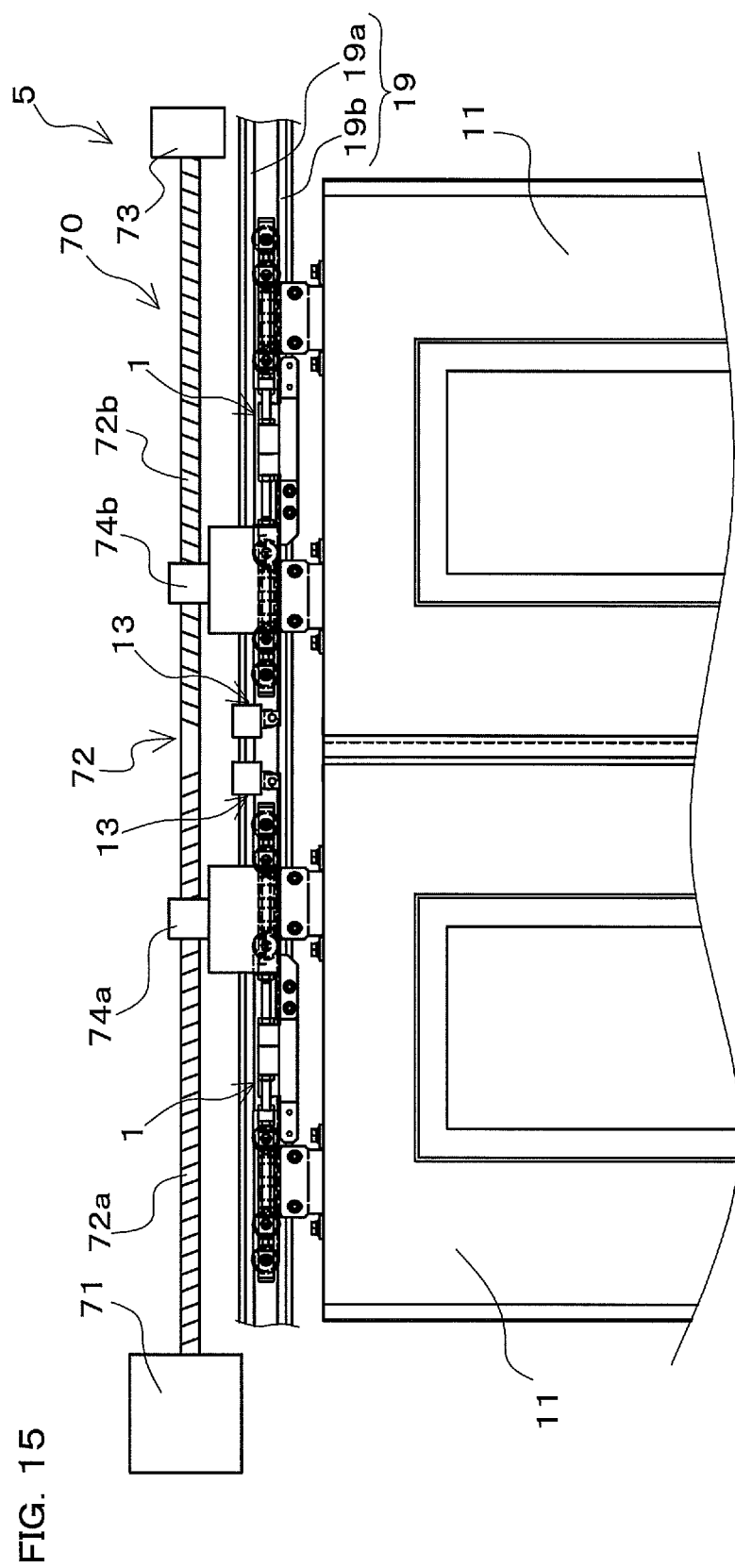


FIG. 13







INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/064326

A. CLASSIFICATION OF SUBJECT MATTER <i>E05F15/14</i> (2006.01) i, <i>B61D19/00</i> (2006.01) i, <i>E05D15/06</i> (2006.01) i, <i>E05F11/54</i> (2006.01) i According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) <i>E05F15/14</i> , <i>B61D19/00</i> , <i>E05D15/06</i> , <i>E05F11/54</i> Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010 Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2008-121243 A (Nabtesco Corp.), 29 May 2008 (29.05.2008), entire text; fig. 1 to 11 & EP 2079894 A & WO 2008/056620 A1	1, 8, 12 2-7, 9-11
Y A	JP 2006-152612 A (Chikura Industry Co., Ltd.), 15 June 2006 (15.06.2006), entire text; fig. 1 to 7 (Family: none)	1, 8, 12 2-7, 9-11
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 17 November, 2010 (17.11.10)		Date of mailing of the international search report 30 November, 2010 (30.11.10)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/064326

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings	8
A	annexed to the request of Japanese Utility Model Application No. 197074/1985 (Laid-open No. 103984/1987) (Nippon Air Brake Co., Ltd.), 02 July 1987 (02.07.1987), entire text; fig. 1 to 5 (Family: none)	9
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