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(54) DOOR OPENING-CLOSING DEVICE, DOOR CONTROL DEVICE, DOOR CONTROL METHOD, AND PROGRAM

(57) A door opening-closing device (2) includes: a drive unit (19) for driving a door (11A, 11B) that opens and closes a doorway (8); a lock pin (14A, 14B) that is moved together with the door (11A, 11B) by a driving force of the drive unit(19); a lock unit (60) movable between a lock position where the lock unit (60) engages with the lock pin (14A, 14B) at the fully closed position of the door (11A, 11B) and an unlock position where the lock unit (60) is disengaged from the lock pin (14A, 14B); a DCS 51 that obtains a position signal indicating the position of the door (11A, 11B); a DLS 52 that obtains a lock signal indicating that the lock unit (60) is situated at the lock position; and a determination unit (111) that determines whether a predetermined condition is satisfied, the predetermined condition being that the position signal indicates that the door (11A, 11B) is not at the fully closed position and the lock signal indicates that the lock unit (60) is at the lock position.

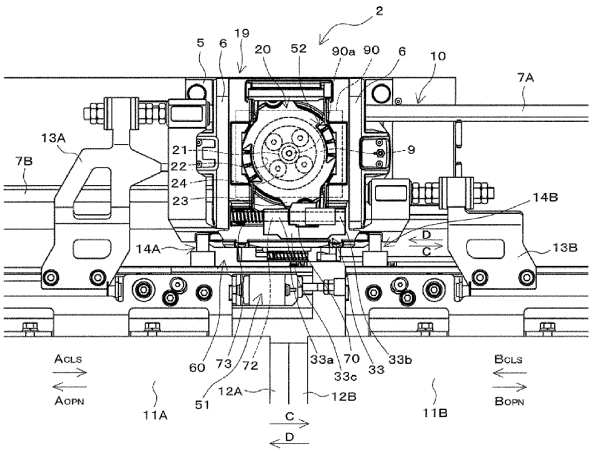

Fig. 2

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Description

TECHNICAL FIELD

[0001] The present invention relates to a door opening-closing device, a door control device, a door control method, and a program.

BACKGROUND

[0002] Conventionally door opening-closing devices for moving doors to open and close are known. For example, Patent Literature 1 discloses a configuration of such a device having an upper rail for guiding the door, a rack connected to the top of the door, and a pinion that engages the rack and is rotated by a motor to move the door. A door close switch detecting that the door is closed is provided on a lower surface of the upper rail at a middle portion of the upper rail. Near the top of the rack, provided is a door lock switch detecting that the door is locked. In the door opening-closing device of Patent Literature 1, conditions are set in consideration of misalignment of installation positions of the door close switch and door lock switch. Door opening and closing operations are repeatedly performed to collect data on the door position and a motor drive current value. The collected data is analyzed and processed to detect an abnormality that may lead to a failure.

RELEVANT REFERENCES

LIST OF RELEVANT PATENT LITERATURE

[0003] Patent Literature 1: Japanese Patent Application Publication No. 2020-82993

SUMMARY

[0004] When grease is dried out or a lock unit operates unsmoothly or is seized, the door may not move to a fully closed position even when the motor is controlled to move the door in its close direction. It is desired to detect the state in which the door does not move due to lack of grease, sticking of the lock and the like.

[0005] The present invention has been made in view of the above, and one object of the invention is to detect the state in which the door becomes immovable due to lack of grease, sticking of the lock and the like.

[0006] To achieve the above object, aspects of the invention may include the following configurations. (1) A door opening-closing device according to one aspect of the invention includes: a drive unit for driving a door that opens and closes a doorway; an engaging portion moving together with the door by receiving a driving force of the drive unit; an engaging portion moving together with the door by receiving a driving force of the drive unit; a position signal acquisition unit obtaining a position signal that indicates the position of the door; a lock signal acquisition unit obtaining a lock signal indicating that the lock unit is situated at the lock position; and a determination unit determining whether a predetermined condition is satisfied, the predetermined condition being that the position signal indicates that the door is unsituated at the fully closed position and the lock signal indicates that the lock unit is situated at the lock position.

[0007] In the normal state, the position signal indicates that the door is situated at the fully closed position after the door is moved in the close direction, and the lock signal indicates that the lock unit is at the lock position. However, when grease is dried out or a lock is stuck or seized, the door may not move to a fully closed position even when the motor is controlled to move the door to its close direction. With the above configuration, by determining whether the predetermined condition (it is indicated that the door is not situated at the fully closed position and the lock unit is situated at the lock position) is satisfied, it is possible to determine whether the door is unable to move. In this way, it is possible to detect the state in which the doors do not move due to lack of grease, unsmooth operation or stuck of the lock unit or the like.

[0008] (2) In the door opening-closing device described in the above (1), when the door is stopped after the door is moved to the close direction, the lock unit is moved from the unlock position to the lock position by receiving a driving force from the drive unit, wherein the determination unit may determine whether the predetermined condition is satisfied when the door is stopped to determine whether the lock unit has moved to the lock position even though the lock unit is not engaged with the engaging portion.

[0009] (3) In the door opening-closing device described in the above (1) or (2), the lock unit may include a rotation shaft that extends in a vertical direction, and a rotating member that rotates and moves around the rotation shaft between the unlock position and the lock position. The drive unit may include a rack-and-pinion mechanism that includes a rack to which the door is attached and a pinion 9 that engages with the rack. The rotation shaft is situated under the rack in the vertical direction. The determination unit may determine whether the rotating member operates unsmoothly by determining whether the predetermined condition is satisfied.

[0010] (4) In the door opening-closing device described in the above (3), the drive unit includes: an actuator; and a planetary gear mechanism to which a driving force of the actuator is inputted. The planetary gear mechanism includes: a first output unit outputting a driving force to the pinion; and a second output unit outputting a driving force with which the lock unit is moved between the unlock position and the lock position when the door is stopped. The lock unit may further include: a lock slider being moved by receiving the driving force from the second output unit; and a link mechanism pushing the rotating member to rotate the rotating member in accordance with movement of the lock slider.

[0011] (5) A door control device according to another aspect of the invention includes: an actuator control unit controlling an actuator such that the drive unit is powered to move the door to be opened or closed when the running resistance of the door is less than a predetermined running resistance, and the lock unit is powered to lock the door at the fully closed position when the running resistance of the door is equal to or greater than the predetermined running resistance; a position signal acquisition unit obtaining a position signal that indicates the position of the door; a lock signal acquisition unit obtaining a lock signal indicating that the lock unit is situated at the lock position where the lock unit locks the door; and a determination unit determining whether a predetermined condition is satisfied when the door is moved in a close direction by controlling the actuator, the predetermined condition being that the position signal indicates that the door is unsituated at the fully closed position and the lock signal indicates that the lock unit is situated at the lock position.

[0012] In the normal state, the position signal indicates that the door is situated at the fully closed position after the door is moved in the close direction by controlling the actuator, and the lock signal indicates that the lock unit is at the lock position. However, when grease is dried out or a lock is stuck or seized, the door may not move to a fully closed position even when the actuator is controlled to move the door to its close direction. With the above configuration, by determining whether the predetermined condition (it is indicated that the door is not situated at the fully closed position and the lock unit is situated at the lock position) is satisfied, it is possible to determine whether the door is unable to move. In this way, it is possible to detect the state in which the door does not move due to lack of grease, unsmooth operation or stuck of the lock unit or the like.

[0013] (6) The door control device described in the above (5), a door catch determination unit determining, based on an operation signal of the drive unit, whether door catch has occurred at the doorway opened and closed by the door. When it is determined that the door catch has occurred, the determination unit may determine whether the predetermined condition is satisfied.

[0014] (7) In the door control device described in the above (6), when the door catch occurs, the actuator control unit may control the actuator in a different mode between when the predetermined condition is satisfied and when the predetermined condition is not satisfied.

[0015] (8) In the door control device of any one of the above (5) to (7), the actuator control unit may drive the actuator so as to move the lock unit situated at the lock position to the unlock position when it is determined that the predetermined condition is satisfied.

[0016] (9) The door control device of any one of the above (5) to (8) may further include an estimation unit estimating deterioration of the lock unit based on the number of times the predetermined condition is satisfied or frequency of occurrence of an event that satisfies the predetermined condition.

[0017] (10) In the door control device described in the above, the estimation unit may estimate the deterioration of the lock unit based on weather, humidity, air temperature, and environmental information of at least one of traveling points of a vehicle whose doorway is opened or closed by the door.

[0018] (11) The door control device of any one of the above (5) to (10) may further include an alarm unit informing an external device of information regarding a determination result, when it is determined that the predetermined condition is satisfied.

[0019] (12) In the door control device described in the above (11), when the number of times the predetermined condition is satisfied or frequency of occurrence of an event that satisfies the predetermined condition is equal to or greater than a predetermined value, the alarm unit may inform the external device of the information regarding the determination result.

[0020] (13) A door control method according to yet another aspect of the invention includes: a step of controlling an actuator such that the drive unit is powered to move the door to be opened or closed when the running resistance of the door is less than a predetermined running resistance, and the lock unit is powered to lock the door at the fully closed position when the running resistance of the door is equal to or greater than the predetermined running resistance; a step of obtaining a position signal that indicates the position of the door; a step of obtaining a lock signal indicating the lock unit is situated at the lock position where the lock unit locks the door; and a step of determining whether a predetermined condition is satisfied when the door is moved in a close direction by controlling the actuator, the predetermined condition being that the position signal indicates that the door is unsituated at the fully closed position and the lock signal indicates that the lock unit is situated at the lock position.

[0021] In the normal state, the position signal indicates that the door is situated at the fully closed position after the door is moved in the close direction by controlling the actuator, and the lock signal indicates that the lock unit is at the lock position. However, when grease is dried out or a lock is stuck or seized, the door may not move to a fully closed position even when the actuator is controlled to move the door to its close direction. With the above configuration, by determining whether the predetermined condition (it is indicated that the door is not situated at the fully closed position and the lock unit is situated at the lock position) is satisfied, it is possible to determine whether the door is unable to move. In this way, it is possible to detect the state in which the door does not move due to lack of grease, unsmooth operation or stuck of the lock unit or the like.

[0022] (14) A program according to still yet another aspect of the invention causing a computer to cause a drive unit to be powered to move the door to be opened or closed when the running resistance of the door is less

than a predetermined running resistance, and the lock unit to be powered to lock the door at the fully closed position when the running resistance of the door is equal to or greater than the predetermined running resistance. The program further causing the computer to perform: a step of obtaining a position signal that indicates the position of the door; the program further causing the computer to perform: a step of obtaining a position signal that indicates the position of the door; and a step of determining whether a predetermined condition is satisfied when the door is moved in a close direction, the predetermined condition being that the position signal indicates that the door is not situated at the fully closed position and the lock signal indicates that the lock unit is situated at the lock position.

[0023] In the normal state, the position signal indicates that the door is situated at the fully closed position after the door is moved in the close direction by controlling the actuator, and the lock signal indicates that the lock unit is at the lock position. However, when grease is dried out or a lock is stuck or seized, the door may not move to a fully closed position even when the actuator is controlled to move the door to its close direction. With the above configuration, by determining whether the predetermined condition (it is indicated that the door is not situated at the fully closed position and the lock unit is situated at the lock position) is satisfied, it is possible to determine whether the door is unable to move. In this way, it is possible to detect the state in which the door does not move due to lack of grease, unsmooth operation or stuck of the lock unit or the like.

ADVANTAGEOUS EFFECTS

[0024] According to the aspects of the invention, it is possible to provide the door opening-closing device, door control device, door control method, and program with which it is possible to detect the state in which the door does not move due to lack of grease, unsmooth operation or stuck of the lock unit or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

Fig. 1 is a front view of a door opening-closing device according to an embodiment.

Fig. 2 is a front view of the door opening-closing device in a locking state according to the embodiment.

Fig. 3 is a side view of the door opening-closing device of the embodiment, including a section of a lock unit.

Fig. 4 is a bottom view of the lock unit in an unlock state according to the embodiment.

Fig. 5 is another bottom view of the lock unit in a lock state according to the embodiment.

Fig. 6 is a bottom view of the lock that operates unsmoothly or is seized according to the embodiment.

Fig. 7 is a block diagram of a door control device according to the embodiment.

Fig. 8 is a flowchart of a door opening operation in the normal state.

Fig. 9 is a flowchart of a door closing operation in the normal state.

Fig. 10 is a flowchart of a door opening operation when rotating members are half-opened.

Fig. 11 is a flowchart of a door closing operation in a case where the door operates unsmoothly or is seized.

Fig. 12 is a flowchart of a door control according to the embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0026] Embodiments of the present disclosure will now be described with reference to the attached drawings. The following description of the embodiments will be based on an example where a door opening-closing device is provided on a door of a railway vehicle (vehicle). In the following description, terms such as "parallel," "orthogonal," "centered" and "coaxial" describe relative or absolute positions. These terms are not only strictly used but also allow some tolerances and relative differences in angle and distance as long as the same effects can be still produced. In the drawings used for the following description, members are shown to different scales into recognizable sizes.

<Door Opening-Closing Device>

[0027] As shown in Fig. 1, a door opening-closing device 2 is provided on a vehicle opening-closing door 1. The vehicle opening-closing door 1 is configured as a door enabling to open and close a doorway 8 formed in a side wall of a vehicle such as a railway vehicle. The vehicle opening-closing door 1 includes a pair of doors 11A and 11B that are slid to left and right respectively to be apart from each other to open the door. The door opening-closing device 2 moves the doors 11A and 11B between a fully open position and a fully close position to open and close the door. The door opening-closing device 2 locks the doors 11A and 11B when they are at the fully close position. Fig. 1 shows the pair of the left and right doors 11A and 11B are situated at the fully close position respectively.

[0028] As shown in Fig. 2, the door opening-closing device 2 includes a drive unit 19, lock pins 14A, 14B (examples of an engaging portion), a lock unit 60, a door close detection switch 51 (an example of a position signal acquiring unit), a door lock detection switch 52 (an example of a lock signal acquiring unit), and a control unit 110 (an example of an actuator control unit, see Fig. 1). In the door opening-closing device 2, a motor 90 that serves as the drive unit 19 is driven in accordance with various commands from the control unit 110. With the motor driving the door, opening and closing operations

of the door leaves 11A and 11B, a locking operation of the door leaves 11A and 11B, and an unlocking (releasing the lock) operation of the door leaves 11A and 11B are performed.

[0029] As shown in Fig. 1, a guide rail 16 extending in the horizontal direction is provided on above the doorway 8. The doors 11A and 11B are configured to move backwards and forwards along the guide rail 16. The doors 11A and 11B include door leaves 11r and door hangers 3A and 3B respectively that are coupled to a corresponding upper edge of the door leaf 11r. The door leaf 11r has a thickness in the depth direction of the drawing. The door hangers 3A and 3B are supported by the guide rail 16 such that the door hangers 3A and 3B are movable in the horizontal direction relative to the guide rail 16. For example, the door hangers 3A and 3B have rollers 4 rollable on the guide rail 16.

<Drive Unit>

[0030] As shown in Fig. 2, the drive unit 19 includes the motor 90 (an example of an actuator), a rack-and-pinion mechanism 10, and a planetary gear mechanism 20. The motor 90 is disposed over the guide rail 16, near the center of the doorway 8 in the left-right direction. The motor 90 has a direct-drive output shaft 90a that can rotate forwards and backwards. The output shaft 90a of the motor 90 extends in the depth direction in the drawing.

[0031] The rack-and-pinion mechanism 10 includes racks 7A and 7B to which the doors 11A and 11B are attached respectively, and a pinion 9 that engages with the racks 7A and 7B. The two racks 7A and 7B are provided in the illustrated example. The racks 7A and 7B extend in the horizontal direction parallel to the guide rail 16. Above the doorway 8, a base 5 supporting components is fixed to the side wall of the vehicle. Rack supports 6 that support the racks 7A and 7B are fixed to the base 5. The racks 7A and 7B are supported by the rack supports 6 such that they are movable in the horizontal direction. The two racks 7A and 7B are vertically spaced apart and parallel to each other. Teeth of the two racks 7A and 7B are arranged to oppose each other.

[0032] The pinion 9 is disposed between the two racks 7A and 7B in the upper-lower direction (both sides thereof in the vertical direction facing the racks), and is located near the center of the passenger doorway 8 in the horizontal direction. The pinion 9 mesh with the respective teeth of the two racks 7A and 7B at the same time. The pinion 9 is freely rotatable around an axis along the depth direction in the drawing.

[0033] Arms 13A and 13B are respectively provided at one ends of the two racks 7A and 7B. The arms 13A and 13B are fixed to door hangers 3A and 3B via coupling members 15a and 15b, respectively. One ends of the racks 7A and 7B are coupled to the corresponding doors 11A and 11B via the arm members 13A and 13B, respectively.

[0034] As shown in Fig. 2, the two racks 7A and 7B and the pinion 9 form the rack-and-pinion mechanism 10. The rack-and-pinion mechanism 10 allows the two doors 11A and 11B are driven open and closed. By coupling the left and right doors 11A and 11B to each other with the rack-and-pinion mechanism 10, symmetrical opening and closing movements of the doors 11A and 11B are realized.

[0035] The doors 11A and 11B are movable along the guide rail 16 in close directions A_{CLS} and B_{CLS} in which the doors approach toward each other, and in open directions A_{OPN} and B_{OPN} in which the doors move away from each other. The open direction A_{OPN} of one door 11A and the open direction B_{OPN} of the other door 11B are opposite to each other. The close direction A_{CLS} of the one door 11A and the close direction B_{CLS} of the other door 11B are opposite to each other.

[0036] Elastic members 12Aand 12B are provided on leading edges of the doors 11A and 11B in the close directions A_{CLS} and B_{CLS} respectively (hereinafter may be referred to as "leading edges of the doors 11A and 11B). The elastic members 12A and 12B extend on the leading edges of the doors 11A and 11B from the upper to lower ends of the doors 11A and 11B. When the doors 11A and 11B are situated at the fully closed positions, the elastic members 12A and 12B contact each other. This fills the gap between the doors 11A and 11B in the horizontal direction. The elastic members 12A and 12B contact each other to close the doorway 8 where the doors 11A and 11B are located.

[0037] The planetary gear mechanism 20 is supported by the base 5. The planetary gear mechanism 20 transmits the output of the motor 90 alternatively to the rack and pinion mechanism 10 and the lock unit 60. The planetary gear mechanism 20 includes a sun gear 21, an internal gear 22 (an example of a first output portion), a carrier 23 (an example of a second output portion), and planetary gears 24.

[0038] The sun gear 21 is supported rotatably about an axis extending along the depth direction in the drawing by an unshown bearing or the like. Two or more (e.g., four) planetary gears 24 are arranged around the the sun gear 21. The planetary gears 24 are configured to spin and revolve around the sun gear. The internal gear 22 has internal teeth that engage with the planetary gear 24. The carrier 23 supports the planetary gears 24 rotatably around the sun gear 21.

[0039] The sun gear 21, the internal gear 22, and the carrier 23 are arranged on the same axis as the axis of the pinion 9. The sun gear 21, internal gear 22, and carrier 23 are arranged such that adjacent ones (members that mesh with each other) of them can rotate freely relative to each other.

[0040] The output shaft 90a of the motor 90 is connected to the sun gear 21. The output of the motor 90 is inputted to the sun gear 21. The sun gear 21 and the output shaft 90a are not necessarily directly connected to each other, but may be coupled to each other via a speed reducer or the like. The internal gear 22 is coupled

to the pinion 9 of the rack and pinion mechanism 10 by a fastening member such as a bolt. The internal gear 22 is capable of transmitting the output of the motor 90 to the pinion 9. With the above configuration, the rack and pinion mechanism 10 is able to move the doors 11A and 11B in the open directions A_{OPN} and B_{OPN} and the close directions A_{CLS} and B_{CLS} respectively by the output of the motor 90.

<Lock Pin>

[0041] The lock pins 14A and 14B are fixed to the door hangers 3A and 3B. The lock pins 14A and 14B extend vertically upward from the door hangers 3A and 3B toward the racks 7A and 7B, respectively. The lock pins 14A and 14B are movable integrally with the doors 11A and 11B. The lock pins 14A and 14B are moved together with the doors 11A and 11B by the driving force from the drive unit 19. When the doors 11A and 11B are at the fully closed positions, the lock pins 14A and 14B are caught by the lock unit 60. In this way, the doors 11A and 11B are locked to be prevented from moving in the horizontal direction (particularly the movement to the open directions A_{OPN} and B_{OPN}).

<Lock Unit>

[0042] The lock unit 60 is movable between a lock position where the lock unit 60 engages with the lock pins 14A and 14B to lock the doors 11A and 11B at the fully closed positions and an unlock position where the lock unit 60 does not engage with the lock pins 14A and 14B. The lock unit 60 is configured to operate by the output of the motor 90. The lock unit 60 functions as a lock mechanism that restricts the doors 11A and 11B from moving in the door open direction A_{OPN} and B_{OPN} when the doors 11A and 11B are situated at the fully closed positions. The lock unit 60 is arranged between the doors 11A and 11B and the planetary gear mechanism 20 in the vertical direction.

[0043] As shown in Fig. 4, the lock unit 60 includes rotation shafts 81A and 81B that extend in the vertical direction, rotating members 66A and 66B that are rotatable around the rotation shafts 81A and 81B and movable between a lock position and an unlock position, a lock slider 33 that is moved by a driving force of the carrier 23 (see Fig. 2), and a link mechanism 61 that pushes the rotating members 66A and 66B to rotate the rotating members 66A and 66B in accordance with the movement of the lock slider 33.

[0044] The rotation shafts 81A and 81B are situated below the racks 7A and 7B in the vertical direction. The rotating members 66A and 66B are supported by the base 5 via the rotation shafts 81A and 81B. The rotating members 66A and 66B are rotated around the rotation shafts 81A and 81B by contacting the lock pins 14A and 14B that move in the open directions A_{OPN} and B_{OPN} or the close directions A_{CLS} and B_{CLS}. The rotating members 66A and 66B have first concave portions 67A and 67B and second concave portions 68A and 68B that are recessed inward (towards the rotation shafts 81A and 81B) from the outer peripheral edges of the rotating members 66A and 66B as viewed from the vertical direction. The first concave portions 67A and 67B and the second concave portions 68A and 68B open toward the outside of the rotating members 66A and 66B as viewed from the vertical direction. The first concave portions 67A and 67B and the second recesses 68A and 68B are arranged such that they are spaced apart from each other in the circumferential directions of the rotating members 66A and 66B as viewed from the vertical direction.

[0045] The rotating members 66A and 66B each include a first wall portion situated between the first concave portions 67A and 67B and the second concave portions 68A and 68B in the circumferential direction of the rotating members 66A and 66B as viewed from the vertical direction. Each of the rotating members 66A and 66B further includes a second wall portion 66d situated on the side opposite to the first wall portion 66c with the first concave portions 67A and 67B interposed therebetween in the circumferential direction of the rotating members 66A and 66B. The first wall portions 66c and the second wall portions 66d are curved toward the outside of the rotating members 66A and 66B as viewed from the vertical direction.

[0046] The rotating members 66A and 66B are provided with bulging portions 69A and 69B that serve as retaining portions for the lock pins 14A and 14B. The bulging portions 69A and 69B project toward the direction in which the second concave portions 68A and 68B open in the vicinity of the second concave portions 68A and 68B of the first wall portions 66c.

[0047] The rotation shafts 81A and 81B are provided with return springs 74A and 74B for biasing the rotating members 66A and 66B to cause the first concave portions 67A and 67B of the rotating members 66A and 66B to face the open directions A_{OPN} and B_{OPN}. For example, the return springs 74A and 74B are torsion springs. One ends of the return springs 74A and 74B are attached to base-side mounting protrusions 82A and 82B respectively provided in the base 5. The other ends of the return springs 74A and 74B are attached to rotation-side mounting protrusions 83A and 83B provided in the first wall portions 66c of the rotating members 66A and 66B.

[0048] When the rotating members 66A and 66B are not receiving an external force, the first concave portions 67A and 67B of the rotating members 66A and 66B face the open direction A_{OPN} and B_{OPN} sides respectively and the second concave portions 68A and 68B are retained facing the close direction A_{CLS} and B_{CLS} sides respectively with the biasing force of the return springs 74A and 74B. When the lock pins 14A and 14B move in the close directions A_{CLS} and B_{CLS} and reach near the fully closed positions, the first wall portions 66c (the edges on the first concave portion 67A and 67B sides) of the rotating members 66A and 66B are pushed by the lock pins 14A

and 14B, respectively. As a result, the rotating members 66A and 66B rotate in the directions of arrows E1 and E2 around the rotation shafts 81A and 81B against the biasing force of the return springs 74A and 74B. Then, the second concave portions 68A and 68B of the rotating members 66A and 66B approach the link mechanism 61.

[0049] As shown in Fig. 5, when the doors 11A and 11B are at the fully closed positions where they are fully closed, the lock pins 14A and 14B are inserted in the first concave portions 67A and 67B of the rotating members 66A and 66B, respectively. Here, the lock pins 14A and 14B and the rotating members 66A and 66B are engaged with each other.

[0050] As shown in Fig. 2, the lock slider 33 is moved by receiving a driving force from the carrier 23. The lock slider 33 is a member that switches between the locked state and the unlocked state of the doors 11A and 11B. The carrier 23 is connected to a traction member 70 that pulls the lock slider 33. The carrier 23 can transmit the output of the motor 90 to the link mechanism 61 via the traction member 70 and the lock slider 33.

[0051] The traction member 70 and the lock slider 33 are movable along the guide shaft 72 extending in the horizontal direction in parallel with the racks 7A and 7B. Both ends of the guide shaft 72 in the horizontal direction are fixed to the rack supports 6. The traction member 70 and the lock slider 33 are provided such that they reciprocate in the horizontal direction along the guide shaft 72. The traction member 70 and the lock slider 33 serve as a switching mechanism that switches between the lock state and the unlock state. The traction member 70 is coupled to the carrier 23 such that it moves in a lock direction C and an unlock direction D as the carrier 23 rotates.

[0052] The lock slider 33 has shaft attachment portion 33a and 33b, a front portion 33c extending downward from the shaft attachment portions 33a and 33b, a bottom portion 33d (see Fig. 3) extending from a lower end of a lower extended portion toward the depth direction in the drawing, and a protruding shaft 33e (see Fig. 4) protruding upward from the bottom portion 33d. The shaft attachment portions 33a and 33b are provided in pairs on the left and right sides, spaced apart via the traction member 70 interposed therebetween. The traction member 70 is attached to the guide shaft 72 at a position between the pair of left and right shaft attachment portions 33a and 33b.

[0053] The guide shaft 72 is equipped with a lock spring 73 that exerts a biasing force on the lock slider 33 such that one shaft attachment portion 33a of the lock slider 33 is pushed in the lock direction C. For example, the lock spring 73 is a compression coil spring. The lock spring 73 prevents the lock slider 33 at the locked position from returning to the unlock position.

[0054] As shown in Fig. 4, the protruding shaft 33e of the lock slider 33 is able to contact a protruding portion 62d of a link 62a. For example, when the lock slider 33 moves in the unlock direction D, the protruding shaft 33e contacts the link 62a and changes the position of the link 62a. As a result, the attitude (position) of the link mechanism 61 changes. A roller may be rotatably mounted on the protruding shaft 33e with the protruding shaft 33e as a rotation center.

[0055] An insertion hole (not shown) through which a connecting pin 63a supported by the base 5 is inserted is formed in a bottom surface 33d of the lock slider 33. The insertion hole is an elongated hole having the size that allows the lock slider 33 is movable in the lock direction C and unlock direction D relative to the connecting pin 63a.

[0056] The link mechanism 61 changes its shape horizontally into a bent form (see Fig. 4) in which the link mechanism is bent zigzag (Z-shaped) with respect to the horizontal direction, and a straight-line form (see Fig. 5) in which the link mechanism extends straight in the left-right direction, when viewed from the vertical direction. The link mechanism 61 is formed by coupling a plurality of (for example, three) links 62a, 62b, and 62c. Of the three links 62a, 62b, and 62c, the central link 62a is coupled to the connecting pin 63a. Thus, the central link 62a is made rotatable relative to the base 5.

[0057] The central link 62a extends across the connecting pin 63a when viewed from the vertical direction. A first pin 63b extending in the vertical direction is provided at one end of the central link 62a. A second pin 63c extending in the vertical direction is provided at the other end of the central link 62a. The central link 62a is provided with the protruding portion 62d that protrudes toward the outside of the central link 62a as viewed from the vertical direction. The protruding portion 62d is formed between the connecting pin 63a and the first pin 63b in the central link 62a as viewed from the vertical direction.

[0058] Two links 62b and 62c provided besides the connecting pin 63a are connected to the central link 62a such that they are relatively rotatable. Of the two links 62b and 62c, the link 62b is rotatably connected to one end of the central link 62a via the first pin 63b. The other link 62c of the two links 62b and 62c is rotatably connected to the other end of the central link 62a via the second pin 63c.

[0059] The link 62b extends from the first pin 63b toward the one rotating member 66A viewed from the vertical direction. A third pin 63d extending in the vertical direction is provided in a portion of the link 62b closer to the rotating member 66A. The link 62c extends from the second pin 63c toward the other rotating member 66B viewed in the vertical direction. A fourth pin 63e extending in the vertical direction is provided in a portion of the link 62c closer to the rotating member 66B.

[0060] The third pin 63d and the fourth pin 63e are disposed at the ends of the link mechanism 61. Guide grooves 80A and 80B extending in parallel with the lock direction C are formed in the base 5. The pair of guide grooves 80A and 80B are disposed apart from each other in the horizontal direction. An upper end of the third pin

63d is inserted in the guide groove 80A. Thus, the third pin 63d can move in the horizontal direction along the one guide groove 80A. The upper end of the fourth pin 63e is inserted in the other guide groove 80B. Thus, the fourth pin 63e can move in the right and left directions along the other guide groove 80B. With the above configuration, the pins 63d and 63e are guided by the guide grooves 80A and 80B, respectively.

[0061] Rollers may be rotatably attached to the upper ends of the pins 63d and 63e (the portions inserted in the guide grooves 80A and 80B). In this case, frictional resistance of the pins 63d and 63e against the inner walls of the guide grooves 80A and 80B can be reduced, the pins 63d and 63e can be smoothly moved. Further, rollers may be rotatably attached to the lower ends of the pins 63d and 63e (the portions that come into contact with the rotating members 66A and 66B). In this case, the frictional resistance in the movement of the pins 63d and 63e relative to the rotating members 66A and 66B can be reduced, and the lock operation can be stabilized.

[0062] As shown in Fig. 5, when the doors 11A and 11B are located at the fully closed positions, the lock pins 14A and 14B thrust into the first concave portions 67A and 67B of the rotating members 66A and 66B, whereby the lock pins 14A and 14B engage with the rotating members 66A and 66B. Further, when the doors 11A and 11B are situated at the fully closed positions, the ends of the links 62b and 62c on the open direction A_{OPN} and B_{OPN} thrust into the second concave portions 68A and 68B of the rotating members 66A and 66B, whereby the links 62b and 62c engage with the rotating members 66A and 66B. At this time, the link mechanism 61 has the straight line form extending along the horizontal direction.

[0063] When the link mechanism 61 is in the straight-line form and a force acts on the lock pins 14A and 14B in the open directions A_{OPN} and B_{OPN}, rotation of the rotating members 66A and 66B is restricted as follows. Both ends of the link mechanism 61 in the straight-line form (the ends of the links 62b and 62c on the open direction A_{OPN} and B_{OPN} sides) are caught and held by edge portions of the second concave portions 68A and 68B of the rotating members 66A and 66B. For example, the bulging portion 69A and 69B are formed at the portions where the rotational force is transmitted from the links 62b and 62c to the rotating members 66A and 66B, when the rotating members 66A and 66B are going to rotate in the directions of the arrows F1 and F2 while the link mechanism 61 is in the straight-line form. This prevents the links 62b and 62c from coming off from the second concave portions 68A and 68B of the rotating members 66A and 66B. In this way, the movement of the lock pins 14A and 14B engaged with the rotating members 66A and 66B to the open directions A_{OPN} and B_{OPN} is restricted by the first concave portions 67A and 67B of the rotating members 66A and 66B.

<Door Close Detection Switch>

[0064] As shown in Fig. 2, the door close detection switch (hereinafter, also referred to as "DCS51") is provided above the doors 11A and 11B between the pair of left and right doors 11A and 11B. The DCS 51 is provided to detect whether the doors 11A and 11B are at the fully closed positions. For example, the DCS 51 is configured to be turned ON when the doors 11A and 11B are at the fully closed positions and turned OFF when the doors 11A and 11B are at the open positions.

[0065] The DCS 51 functions as a position signal acquisition unit that acquires a position signal indicating the position of the doors 11A and 11B through switching between the ON state and the OFF state. The door opening-closing device 2 includes a position sensor that acquires a position signal indicating the position of the doors 11A and 11B that move in the open directions A_{OPN} and B_{OPN} or the close directions A_{CLS} and B_{CLS} along the horizontal direction, and a stroke detection unit (an example of a position signal acquisition unit) that detects travel amount (stroke) of the doors 11A and 11B.

<Door Lock Detection Switch>

[0066] The door lock detection switch (hereinafter, also referred to as "DLS52") is fixed to the base 5. The DLS 52 is provided to detect whether the doors 11A and 11B have been locked by the lock unit 60. The DLS 52 is configured to switch between an ON state and OFF state by a permanent magnet fixed to the carrier 23. That is, the permanent magnet moves with the rotation of the carrier 23, which switches the DLS 52 on the base 5. The DLS 52 functions as a lock signal acquisition unit that acquires a lock signal indicating that the lock unit 60 is located at the lock position.

[0067] The DLS 52 is in the OFF state when the carrier 23 is situated at the position where the doors 11A and 11B are moving at a normal running resistance (moving resistance) (when the running resistance of the doors 11A and 11B is less than a predetermined resistance). At this position, the carrier 23 causes the traction member 70 to contact the shaft mounting portions 33a and 33b.

[0068] Whereas when the movements of the doors 11A and 11B are stopped and the output shaft 90a of the motor 90 further rotates, the sun gear 21 rotates the planetary gears 24. As a result, the carrier 23 becomes rotatable. When the carrier 23 rotates by a predetermined amount, the position of the permanent magnet fixed to the carrier 23 changes, which turns the DLS52 ON. That is, when the carrier 23 rotates by the predetermined amount as the moving resistance of the doors 11A and 11B increases (when the moving resistance of the doors 11A and 11B is equal to or higher than the predetermined resistance), the DLS 52 is turned on.

<Control Unit>

[0069] As shown in Fig. 1, the control unit 110 is housed in a control box 40. As shown in Fig. 2, the control unit 110 controls ON/OFF of the drive of the motor 90, switching of the rotational direction of the output shaft 90a of the motor 90, and the driving force of the motor 90. When the running resistance of the doors 11A and 11B is less than the predetermined running resistance, the control unit 110 allows the power to be supplied to the drive unit 19 to move the doors 11A and 11B open or close. When the running resistance of the doors 11A and 11B is equal to or higher than the predetermined running resistance, the control unit 110 allows the power to be supplied to the lock unit 60 to lock the doors 11A and 11B at the fully closed positions. The control unit 110 includes a CPU that operates according to a predetermined program, and a storage unit such as a RAM (Random Access Memory) in which the predetermined program is stored. As shown in Fig. 7, the control unit 110 serves as a controller 101 of a door control device 100.

<Door Control Device>

[0070] The door control device 100 includes a controller 101, the DCS 51 and DLS 52 described above, a manual unlock detection unit 53 which is a limit switch for determining whether the doors 11A and 11B can be manually unlocked, and an environmental information acquisition unit 54 (for example, a thermometer, a hygrometer, a timer, an image capturing device, etc.) that acquires environmental information. The door control device 100 further includes a motor monitor unit 55 that acquires various information about the motor 90, a stroke sensor unit 56 that senses a displacement (stroke) of the doors 11A and 11B, and an alarm unit 57 that includes a chime 57a and an indicator light 57b for indicating the opening operation or closing operation of the doors 11A and 11B.

[0071] The controller 101 includes the control unit 110, a signal input unit 120 including a signal input circuit for inputting signals from a signal line 102 to the control unit 110, and a transmission unit 121 as an interface for data communication (transmission and reception) with a communication line 103 that extends from a communication terminal. The controller 101 further includes a driver unit 122 including a motor drive circuit that supplies drive power to the motor 90, and a power supply 123 that converts power (voltage) supplied from a feed line 104 to generate a voltage to be supplied to components.

[0072] The controller 101 is connected to the motor 90 via a relay 105. The controller 101 is able to control the motor 90 when the relay 105 is closed (the state in which the controller 101 and the motor 90 are electrically connected). The relay 105 is controlled to be opened and closed according to a command from the controller 101.

[0073] The motor 90 includes a motor coil 91 and a Hall element 92. The motor coil 91 is connected to the driver unit 122 via the relay 105. The direction and speed of rotation of the motor 90 are controlled by the driver unit 122. The Hall element 92 is provided to detect rotational information of the motor 90 (e.g., rotation speed of the motor 90). The output from Hall element 92 is supplied to the control unit 110.

[0074] The control unit 110 is connected with the DCS51, the DLS52, the manual unlock detection unit 53, the environmental information acquisition unit 54, and the motor monitor unit 55. Outputs from the DCS51, the DLS52, the manual unlock detection unit 53, the environmental information acquisition unit 54, the motor monitor unit 55, and the stroke sensor unit 56 are supplied to the control unit 110. For example, the motor monitor unit 55 has a motor current sensor that senses the motor current and a motor voltage sensor that senses the voltage applied to the motor 90.

[0075] The control unit 110 is connected with the alarm unit 57 that includes the chime 57a and the indicator light 57b. The control of alarm through the chime 57a and the indicator light 57b is performed by the control unit 110.

[0076] The control unit 110 includes a determination unit 111, a position determination unit 112, a door catch determination unit 113, an estimation unit 114, and a storage unit 115. The determination unit 111 determines whether the predetermined condition is satisfied based on the information obtained through the DCS51 (the position signals of the doors 11A and 11B) and DLS52 (the lock signal). Here, the predetermined condition refers to the condition that the following conditions (S1) and condition (S2) are both satisfied.

S1: The position signal indicates that the doors 11A and 11B are not situated at the fully closed positions (DCS OFF).

S2: The lock signal indicates that the lock unit 60 is situated at the lock position (DLS ON).

[0077] The determination unit 111 determines whether the predetermined condition is satisfied, that is, whether the position signal indicates that the doors 11A, 11B are not at the fully closed positions and the lock signal indicates that the lock unit 60 is at the lock position. In this embodiment, the determination unit 111 determines whether the above predetermined conditions (S1 and S2) are satisfied when the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS}, respectively by controlling the motor 90.

[0078] When the doors 11A and 11B are stopped after the doors 11A and 11B are moved to the close directions A_{CLS} and B_{CLS}, the lock unit 60 receives the driving force from the driving unit 19 and moves from the unlock position to the lock position. The determination unit 111 determines whether the predetermined condition is satisfied when the doors 11A and 11B are stopped to determine whether the lock unit 60 has moved to the lock position even through it is not engaged with the lock pins 14Aand 14B. The determination unit 111 determines

whether the rotating members 66A and 66B are stuck or seized by determining whether the predetermined condition is satisfied.

[0079] The position determination unit 112 determines whether the doors 11A and 11B have reached predetermined positions during the closing operation of the doors 11A and 11B based on door information including at least one selected from the group consisting of the moving speeds of the doors 11A and 11B, the distances traveled, and the time taken for the doors 11A and 11B to move in the close directions A_{CLS} and B_{CLS}. The position determination unit 112 determines whether the doors 11A and 11B are at the positions where the doors are about to be fully closed. For example, the predetermined position is set to a position several centimeters before the fully closed positions.

[0080] The door catch determination unit 113 determines, based on an operation signal of the drive unit 19, whether anything is caught by the doors 11A and 11B at the doorway 8 where the doors 11A and 11B are closed and opened. For example, when it is determined that something is caught by the doors, the determination unit 111 determines whether the predetermined condition is satisfied.

[0081] For example, when the door catch occurs, the control unit 110 controls the motor 90 in different modes depending on whether the predetermined condition is satisfied or not. For example, when the door catch occurs, the control unit 110 controls the motor 90 with at least one selected from the group consisting of a different rotational speed of the motor 90, different rotational directions of the motor 90, and a different amount of rotation of the motor 90, depending on whether the predetermined condition is satisfied or not. Thus, when the door catch occurs, at least one selected from the group consisting of the moving speed of the doors 11A and 11B, the moving direction of the doors 11A and 11B, and the displacement (stroke) of the doors 11A and 11B is made different depending on whether the predetermined condition is satisfied or not.

[0082] For example, the door catch determination unit 113 detects door catch based on the moving speeds of the doors 11A and 11B (hereinafter, also referred to as "door speed"), the current flowing through the motor 90 (hereinafter, also referred to as "motor current"), the rotation speed of the motor 90 (hereinafter, also referred to as "motor speed"), and the like. When the door catch is detected with the door speed, it is determined that the door catch has occurred when the door speed becomes zero. When the door catch is detected with the motor current, it is determined that the door catch has occurred when the motor current exceeds a predetermined threshold value. This is because the motor current suddenly increases following the occurrence of door catch. When the door catch is detected with the motor speed, it is determined that the door catch has occurred when the motor speed exceeds a predetermined threshold value. This is because the motor speed suddenly increases following the occurrence of door catch.

[0083] For example, it is preferable that the door catch determination unit 113 detects door catch based on the door speed and the motor current. As described above, since the elastic members 12A and 12B are provided on the leading edges of the doors 11A and 11B, even if an obstacle such as a person or an object comes into contact with the elastic members 12A and 12B, the doors 11A and 11B continue to move while the elastic members 12A and 12B can be compressed. For the above reasons, whether door catch has occurred may not be swiftly and accurately detected only based on the door speed. To address this issue, the present embodiment refers not only to the door speed but also to the motor current in order to detect door catch. Accordingly, the embodiment can swiftly and accurately detect whether the door pinch has occurred.

[0084] The door catch determination unit 113 determines whether anything has been caught between the doors 11A and 11B based on the motor current in the period from when the doors 11A and 11B are determined to have reached a predetermined position to when the doors 11A and 11B reach the fully closed positions.

[0085] For example, the control unit 110 drives the motor 90 so as to move the lock unit 60 located at the lock position to the unlock position when it is determined that the predetermined condition is satisfied. For example, the determination unit 111 determines that the lock unit 60 does not operate properly or is broken when it is determined that the number of times the predetermined condition is satisfied reaches a predetermined number of times or more (for example, once or more).

[0086] The estimation unit 114 estimates deterioration of the lock unit 60 based on the number of times the predetermined condition is satisfied or the frequency of occurrence of the event that satisfies the predetermined condition. For example, the estimation unit 114 estimates that the lock unit 60 has deteriorated when the number of times the predetermined condition is satisfied exceeds a predetermined number.

[0087] The estimation unit 114 estimates the deterioration of the lock unit 60 based on the weather, humidity, air temperature, and environmental information of at least one of traveling points of the vehicle whose doorway 8 is opened or closed by the doors 11A and 11B. For example, the estimation unit 114 may determine the threshold value of the occurrence frequency of the event satisfying the predetermined condition based on the information (about the weather, humidity, temperature, traveling point) obtained through the environment information acquisition unit 54.

[0088] When it is determined that the predetermined condition is satisfied, the alarm unit 57 informs an external unit or device of information regarding the determination result. For example, when it is determined that the predetermined condition is satisfied, the chime 57a informs the determination result by audio or the like. For example, when it is determined that the predetermined

condition is satisfied, the indicator light 57b displays information on the determination result in text or the like. For example, when it is determined that the predetermined condition is satisfied, the information regarding the determination result is outputted from the transmission unit 121 to an upper-stream device (for example, the control unit 110, a brake control device, and a train central device that communicates with an air conditioner or the like).

[0089] When the number of times the predetermined condition is satisfied or the frequency of occurrence of the event satisfying the predetermined condition is equal to or greater than a predetermined value, the alarm unit 57 informs an external unit or device of the information regarding the determination result. For example, when the number of times the predetermined condition is satisfied becomes the predetermined value or more, or when the frequency of occurrence of the event satisfying the predetermined condition becomes the predetermined frequency or more, the alarm unit 57 informs the external unit of the information regarding the determination result.

<Operation of Each Unit in Unlock State>

[0090] As shown in Fig. 4, in the unlock state, the link mechanism 61 has the bent form in which the link mechanism is bent zigzag (Z-shaped) with respect to the horizontal direction. As shown in Fig. 2, for example, when the sun gear 21 of the planetary gear mechanism 20 is driven by the motor 90 in the unlock state, the driving force inputted to the sun gear 21 is transmitted as follows. The driving force inputted to the sun gear 21 is transmitted to the pinion 9 via the internal gear 22, or the driving force causes the planetary gears 24 to revolve and thus rotates the carrier 23. Upon the rotation of the carrier 23, the traction member 70 moves in the lock direction C.

[0091] During the normal closing operation of the doors 11A and 11B, the planetary gears 24 rotate with the rotation of the sun gear 21 of the planetary gear mechanism 20. In this way, the driving force inputted to the sun gear 21 is transmitted to the pinion 9 via the internal gear 22, and the pinion 9 rotates. The rotation of the pinion 9 causes the racks 7A and 7B to move in the open directions A_{OPN} and B_{OPN} or the close direction A_{CLS} and B_{CLS}, respectively. In this way, the doors 11A and 11B are driven to be opened and closed.

<Mechanical Operation of Door When Closing>

[0092] For example, an operation of moving the doors 11A and 11B from the fully opened positions to the fully closed positions and locking the doors 11A and 11B by the lock unit 60 is performed as follows. First, in order to move the doors 11A and 11B from the fully opened positions to the fully closed positions, the output shaft 90a of the motor 90 is rotated in one direction. The driving force of the motor 90 is transmitted to the sun gear 21, the planetary gears 24, and the internal gear 22 in this order. The driving force transmitted to the internal gear 22 rotates the pinion 9. The rotation of the pinion 9 causes the racks 7A and 7B and the doors 11A and 11B connected to the racks 7A and 7B to move in the close directions A_{CLS} and B_{CLS}, respectively.

[0093] Once the doors 11A and 11B move in the close directions A_{CLS} and B_{CLS}, the lock pins 14A and 14B also move in the close direction A_{CLS} and B_{CLS}. As shown in Fig. 4, the lock pins 14A and 14B then rotate the rotating members 66A and 66B in the directions of the arrows E1 and E2 around the rotation shafts 81A and 81B against the biasing force of the return springs 74A and 74B. Thus, the lock pins 14A and 14B go into the first concave portions 67A and 67B of the rotating members 66A and 66B.

[0094] The lock pins 14A and 14B eventually reach to the fully closed positions together with the the doors 11A and 11B. As shown in Fig. 5, at the fully closed positions of the doors 11A and 11B, the lock pins 14A and 14B engage with the rotating members 66A and 66B by being fitted into the first concave portions 67A and 67B of the rotating members 66A and 66B. At the fully closed positions of the doors 11A and 11B, both horizontal ends of the link mechanism 61 in the straight-line form (the ends of the links 62b and 62c on the opening direction A_{OPN} and B_{OPN} sides) engage with the rotating members 66A and 66B by being fitted into the second concave portions 68A and 68B of the rotating members 66A and 66B.

[0095] The ends of the link mechanism 61 are caught and held by the edge portions of the second concave portions 68A and 68B of the rotating members 66A and 66B. For example, the bulging portion 69A and 69B are formed at the portions where the rotational force is transmitted from the links 62b and 62c to the rotating members 66A and 66B, when the rotating members 66A and 66B are about to rotate in the directions of the arrows F1 and F2 by the biasing force of the return springs 74A and 74B. This prevents the links 62b and 62c from coming off from the second concave portions 68A and 68B of the rotating members 66A and 66B. In this way, the movement of the lock pins 14A and 14B engaged with the rotating members 66A and 66B to the open directions A_{OPN} and B_{OPN} is restricted by the first concave portions 67A and 67B of the rotating members 66A and 66B. Thus, the doors 11A and 11B are locked.

[0096] As described above, after the doors 11A and 11B are moved to the fully closed positions by the output force of the motor 90, the lock unit 60 is operated by the output force of the motor 90. As a result, the doors 11A and 11B are locked. As described above, by simply driving the sun gear 21 of the planetary gear mechanism 20 with the single motor 90, it is possible to realize the lock system linked to the closing operation of the doors 11A and 11B.

[0097] In addition, in the locked state, the embodiment provides a double lock, that is, the lock that prevents the rotations of the rotating members 66A and 66B by the link mechanism 61, and the lock that prevents the transformation of the link mechanism 61 from the straight-line

form to the bent form by the lock slider 33. Thus, for example, even when electric power is not supplied to the electric motor 90 due to power outage or malfunction, etc. in the vehicle and the rotation of the output shaft is uncontrolled, the opening of the doors 11A and 11B is prevented securely and reliably by the double lock. This means that even if a power outage, etc., occurs in the vehicle, unintentional opening of the doors 11A and11B due to wind pressure, etc., can be prevented.

<Mechanical Operation of Door When Opening>

[0098] For example, an operation of unlocking the doors 11A and 11B by the lock unit 60 and moving the doors 11A and 11B from the fully closed positions to the fully open position is performed as follows. As shown in Fig. 2, in order to move the doors 11A and 11B from the fully closed positions to the fully open position, the output shaft 90a of the motor 90 is rotated in the other direction (the direction opposite to the close operation). When the output shaft 90a of the motor 90 is rotated in the other direction in the locked state of the doors 11A and 11B, the carrier 23 rotates in the clockwise direction (clockwise direction in the drawing) in Fig. 2. Thus, the traction member 70 and the lock slider 33 move in the unlock direction D against the biasing force of the lock spring 73.

[0099] At this time, the protruding shaft 33e (see Fig. 5) of the lock slider 33 moves in the unlock direction D. Then, the link 62a in the middle of the link mechanism 61 rotates around the connecting pin 63a as the center of rotation. Consequently, the link mechanism 61 is transformed from the straight-line form of Fig. 5 to the bent form of Fig. 4. Then, the pins 63d and 63e situated at the corresponding ends of the link mechanism 61 are disengaged from the second concave portions 68A and 68B of the rotating members 66A and 66B, respectively, and thus the engagement with the rotating members 66A and 66B is released. Accordingly, the rotating members 66A and 66B are allowed to rotate, and the doors 11A and 11B are unlocked. The rotating members 66A and 66B are pushed by the biasing force of the return springs 74A and 74B in the directions of the arrows F1 and F2 centered on the rotation shafts 81A and 81B.

[0100] As shown in Fig. 2, for example, when the rotation amount of the carrier 23 reaches a predetermined amount, the lock slider 33 is prevented from moving further in the unlock direction D due to the deformation limit of the lock spring 73. The movement of the lock slider 33 in the unlock direction D may be limited by any other means, instead of the lock spring 73 compressed to the deformation limit. For example, the movement of the lock slider 33 in the unlock direction D may be limited by the carrier 23 coming into contact with the base 5 at a predetermined position. For example, the movement of the lock slider 33 in the unlock direction D may be limited by preventing the pins 63d and 63e of the link mechanism 61 from moving further by the walls of the guide grooves 80A and 80B by adjusting the lengths of the guide grooves 80A and 80B into which the pins 63d and 63e are inserted.

[0101] For example, once the lock slider 33 is prevented from moving in the unlock direction D, the driving force of the sun gear 21 is transmitted to the internal gear 22. The driving force transmitted to the internal gear 22 rotates the pinion 9. The rotation of the pinion 9 causes the racks 7A and 7B and the doors 11A and 11B connected to the racks 7A and 7B to move in the open directions A_{OPN} and B_{OPN}. As a result, the doors 11A and 11B move toward the fully opened positions.

[0102] The door opening-closing device 2 may include the lock slider 33, a lever provided at a position accessible from inside or outside the vehicle, and a connecting member such as a wire that connects the lock slider 33 and the lever. Thereby, for example, in an emergency, the lever may be operated by a person to move the lock slider 33 in the unlock direction D, unlock the lock, and then manually open the doors 11A and 11B. Further, the lever may be directly fixed to the lock slider 33. In this case, the connecting member such as a wire is not necessary and the configuration can be simplified.

<Mechanical Operation When Lock Unit Operate Unsmoothly>

[0103] In the door opening-closing device 2, grease may be dried out and/or the lock unit 60 may operate unsmoothly. Here, "unsmoothly" means that a movable part such as a rotatable part becomes stuck or seized and is prevented from smoothly moving. The unsmooth operation may be caused by rusts, dusts, oil adhesion, and the like. When grease is dried out or the lock unit 60 operate unsmoothly, the doors 11A and 11B may not move to the fully closed positions even after the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS} by controlling the motor 9.

[0104] As shown in Fig. 6, for example, the rotating members 66A and 66B may move unsmoothly relative to the rotation shafts 81A and 81B. In this case, the rotating members 66A and 66B may not be able to rotate in the directions of the arrows F1 and F2 around the rotation shafts 81A and 81B and is held in place even when subjected to the biasing force of the return springs 74A and 74B. In the example of Fig. 6, the rotating members 66A and 66B that are half-opened are shown by the two dotted lines. In the rotating members 66A and 66B in the half-opened state, the second concave portions 68A and 68B face in the close directions A_{CLS} and B_{CLS}, respectively, and the outer edges of the second walls 66d face in the open direction A_{OPN} and B_{OPN}.

[0105] When the rotating members 66A and 66B are retained half-open as shown in Fig. 6, the doors 11A and 11B may not reach the fully closed positions although the motor 90 is controlled to move the doors 11A and 11B in the close direction A_{CLS} and B_{CLS}. For example, the lock pins 14A and 14B that move in the close directions A_{CLS} and B_{CLS} from the fully opened positions to-

gether with the doors 11A and 11B come into contact with the outer edges of the second wall portions 66d of the rotating members 66A and 66B that are half-opened. Therefore, the lock pins 14A and 14B are not able to fit in the first concave portions 67A and 67B of the rotating members 66A and 66B. Consequently, the doors 11A and 11B stop on the way from the fully opened positions to the fully closed positions and before reaching the fully closed positions.

[0106] Depending on how much the part is stuck or seized (in the case where the part can be loosened), the rotating members 66A and 66B may rotate and move when the doors 11A and 11B move in the close directions A_{CLS} and B_{CLS} even when the rotating members 66A and 66B are held in the half-opened state of Fig. 6. In the example of Fig. 6, the rotating members 66A and 66B in which the lock pins 14A and 14B do not reach the fully closed positions together with the doors 11A and 11B are shown by the solid lines. When the lock pins 14A and 14B do not reach the fully closed positions together with the doors 11A and 11B, the lock pins 14A and 14B that move in the close directions A_{CLS} and B_{CLS} push the outer edges of the second wall portions 66d of the rotating members 66A and 66B that are half-opened and rotate the rotating members 66A and 66B in the directions of arrows E1 and E2 around the rotation shafts 81A and 81B against the biasing force of the return springs 74A and 74B. The lock pins 14A and 14B do not reach the fully closed positions together with the doors 11A and 11B, and contact the outer edges of the second wall portions 66d of the rotating members 66A and 66B (shown by the solid lines in Fig. 6). In the state shown by the solid lines in Fig. 6, the lock pins 14A and 14B are not fitted in the first concave portions 67A and 67B of the rotating members 66A and 66B due to the malfunction of the rotating members 66A and 66B.

[0107] In the example of Fig. 6, both horizontal ends of the link mechanism 61 in the straight-line form (the ends of the links 62b and 62c on the opening direction A_{OPN} and B_{OPN} sides) engage with the rotating members 66A and 66B by being fitted into the second concave portions 68A and 68B of the rotating members 66A and 66B.

<Normal Door Opening Operation>

[0108] A door opening operation in a normal state will be now described with reference to the flowchart of Fig. 8. Here, the normal state means states where the drying out of grease or the unsmooth operation of the lock unit 60 does not occurs and the doors 11A and 11B can be moved properly. An open command is first supplied by a communication terminal (step S101). For example, in step S101, a door open button of the communication terminal is operated and turned on. After step S101, the process proceeds to step S102.

[0109] In step S102, the lock unit 60 is activated. For example, in step S102, in response to the operation of the door open button, the output shaft 90a of the motor 90 is rotated in the other direction. This rotates the rotating members 66A and 66B as described above, and the doors 11A and 11B are unlocked. After step S102, the process proceeds to step S103.

[0110] In step S103, the DLS 52 is turned off. In other words, it is indicated that the doors 11A and 11B are unlocked by the lock unit 60. After step S103, the process proceeds to step S104.

[0111] In step S104, the doors 11Aand 11B are moved in the open directions A_{OPN} and B_{OPN}, respectively. The doors 11A and 11B move to the fully opened positions. After step S104, the process proceeds to step S105.

[0112] In step S105, the DCS 51 is turned off. That is, it is indicated that the doors 11A and 11B are situated at the open positions. After step S105, the process proceeds to step S106.

[0113] In step S106, it is recognized that the doors 11Aand 11B are situated at the fully opened positions. As described above, the door opening operation in the normal state is completed.

<Normal Door Closing Operation>

[0114] The door closing operation in the normal state will be described with reference to the flowchart of Fig. 9. A close command is first supplied by the communication terminal (step S201). For example, in step S201, the door close button of the communication terminal is operated and turned on. After step S201, the process proceeds to step S202.

[0115] In step S202, the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS}, respectively. The doors 11A and 11B move to the fully closed positions. After step S202, the process proceeds to step S203.

[0116] In step S203, the DCS 51 is turned on. That is, it is indicated that the doors 11A and 11B are situated at the fully closed positions. After step S203, the process proceeds to step S204.

[0117] In step S204, the lock unit 60 is activated. For example, in step S204, the output shaft 90a of the motor 90 is rotated in one direction. As described above, the doors 11A and 11B are locked by the lock pins 14A and 14B that engage with the rotating members 66A and 66B. After step S204, the process proceeds to step S205.

[0118] In step S205, the DLS 52 is turned on. In other words, it is indicated that the doors 11A and 11B are locked by the lock unit 60. After step S205, the process proceeds to step S206.

[0119] In step S206, it is recognized that the doors 11A and 11B are situated at the fully closed positions. In step S206, when focusing on the doors alone, it is recognized that the entire closing operation have been completed (locking completed). As described above, the door closing operation in the normal state is completed.

<Door Opening Operation When Rotating Members Are Half-Opened>

[0120] A door opening operation when the rotating members 66A and 66B are half-opened will be now described with reference to the flowchart of Fig. 10. Here, "the rotating members 66A and 66B are half-opened" means that the unlocking operation can be performed although the rotating members 66A and 66B are not fully opened at the time of the opening operation due to deterioration of the lock unit 60 or the like, but a problem may occur when the locking operation is subsequently performed since the rotating members 66A and 66B are not sufficiently opened. The open command is first supplied by the communication terminal (step S301). For example, in step S301, the door open button of the communication terminal is operated and turned on. After step S301, the process proceeds to step S302.

[0121] In step S302, the lock unit 60 is activated. For example, in step S302, in response to the operation of the door open button, the output shaft 90a of the motor 90 is rotated in the other direction. This rotates the rotating members 66A and 66B as described above, and the doors 11A and 11B are unlocked. However, in step S302, the rotating members 66A and 66B are not fully opened and are half opened due to deterioration of the lock unit 60. After step S302, the process proceeds to step S303.

[0122] In step S303, the DLS 52 is turned off. In other words, it is indicated that the doors 11A and 11B are unlocked by the lock unit 60. After step S303, the process proceeds to step S304. Steps S304 to S306 are the same as steps S104 to S106 described above, so description will not be repeated.

<Door Closing Operation When Part Operates Unsmoothly>

[0123] A door closing operation when a part moves unsmoothly or is seized will be described with reference to the flowchart of Fig. 11. The close command is first supplied by the communication terminal (step S401). For example, in step S401, the door close button of the communication terminal is operated and turned on. After step S401, the process proceeds to step S402.

[0124] In step S402, the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS}, respectively. The doors 11A and 11B move toward the fully closed positions. After step S402, the process proceeds to step S403.

[0125] In step S403, the DCS 51 is not activated like it is in the normal state. For example, the rotating members 66A and 66B may be seized in the half-opened state when the lock unit 60 operate unsmoothly or is stuck. In this case, the lock pins 14A and 14B that move in the close directions A_{CLS} and B_{CLS} from the fully opened positions together with the doors 11A and 11B come into contact with the outer edges of the second wall portions 66d of the rotating members 66A and 66B that are half-opened, as described above. Therefore, the lock pins 14A and 14B are not able to fit in the first concave portions 67A and 67B of the rotating members 66A and 66B. Consequently, the doors 11A and 11B stop on the way from the fully opened positions to the fully closed positions and before reaching the fully closed positions. After step S403, the process proceeds to step S404.

[0126] In step S404, the lock unit 60 is activated. For example, in step S404, the output shaft 90a of the motor 90 is rotated in one direction. This causes the link mechanism 61 to engage with the rotating members 66A and 66B as described above. After step S404, the process proceeds to step S405.

[0127] In step S405, the DLS 52 is turned on. As described above, in the unsmooth door closing operation, the lock pins 14A and 14B come into contact with the outer edges of the second wall portions 66d of the rotating members 66A and 66B, so that the doors 11A and 11B are stopped before reaching the fully closed positions. When the movements of the doors 11A and 11B are stopped and the output shaft 90a of the motor 90 further rotates, the carrier 23 becomes rotatable. Once the carrier 23 rotates by a predetermined amount, the position of the permanent magnet fixed to the carrier 23 changes, and the DLS 52 is turned on. After step S405, the process proceeds to step S406.

[0128] In step S406, it is recognized that the doors 11A and 11B are situated at the fully closed positions. Specifically, the strokes of the doors 11A and 11B are less than a predetermined distance and the DLS 52 is turned on, thereby it is considered that the fully closed state of the doors is detected. As described above, the door closing operation in the unsmooth operation state is completed.

<Door Control>

[0129] A door control according to the embodiment will be described with reference to the flowchart of Fig. 12. The flow of Fig. 12 is periodically and repeatedly executed during the closing operation of the doors. The door catch determination unit 113 determines whether anything is caught by the doors based on an operation signal during the closing operation (step S501). For example, in step S501, it is determined whether the door catch has occurred by determining whether the above-mentioned door speed or motor current exceeds a predetermined threshold value. When it is determined that the door catch has occurred (step S501: YES), the process proceeds to step S502.

[0130] In step S502, it is determined whether the lock unit 60 operates unsmoothly or is seized. For example, in step S502, it is determined whether the rotating members 66A and 66B operate unsmoothly or are seized by determining whether the predetermined condition is satisfied. When it is determined that the rotating members 66A and 66B operate smoothly or are not seized (step S502: NO), the process proceeds to step S503.

[0131] In step S503, a normal door catch control is performed. Here, the normal door catch means door catch that is not caused by the unsmooth operation of the lock unit 60 (for example, an obstacle such as a person or an object gets caught by the doors 11A and 11B when the doors 11A and 11B are closed). In such a normal door catch, the DCS is OFF and DLS is OFF, thus when door catch is detected and the DLS is OFF, the normal door catch control is performed.

[0132] For example, in the normal door catch control, the doors 11A and 11B are pressed in the close directions (the closing operation is performed) for a predetermined time, then the doors 11A and 11B are stopped for a predetermined time (motor brake), and the motor is made free for a predetermined time. While the motor is made free, the doors 11A and 11B can be opened manually. Next, the closing operation of the doors 11A and 11B is performed again for a predetermined time and detection of an obstacle is performed again. Such a door catch control is repeated.

[0133] When it is determined that the rotating members 66A and 66B operate unsmoothly or are seized (step S502: YES), the process proceeds to step S504. In step S504, the information regarding the unsmooth operation (for example, the DCS is OFF and the DLS is ON) is recorded and informed. For example, the unsmooth operation information is stored in the storage unit 115 of the control unit 110. For example, the unsmooth operation information is supplied to the train central device or an external device by the alarm unit 57 (for example, the chime 57a, the indicator light 57b). After step S504, the process proceeds to step S505.

[0134] In step S505, the opening operation is performed up to the unlock position where the lock is released. For example, in step S505, the motor 90 is driven so as to move the lock unit 60 that is situated at the lock position to the unlock position. For example, the end position of the opening operation in step S505 may be calculated from the rotation angle of the motor 90 or the like, and a value different from that of the normal door catch control may be set for the end position. The end position of the opening operation may be calculated by rotating the motor 90 in the open directions A_{OPN} and B_{OPN} for a predetermined time. After step S505, the process proceeds to step S506.

[0135] In step S506, it is determined whether the unsmooth operation or seizure of the lock unit 60 is resolved. For example, in step S506, it is determined whether the above-mentioned predetermined condition is satisfied (for example, whether the DCS is OFF and the DLS is not ON), thereby determining whether the unsmooth operation or seizure of the lock unit 60 has been resolved. When it is determined that the unsmooth operation or seizure of the lock unit 60 has not been resolved (step S506: NO), the process proceeds to step S507.

[0136] In step S507, failure is informed and the closing operation of the doors 11A and 11B is stopped. For example, the failure information is supplied to the train central device or an external device by the alarm unit 57 (for example, the chime 57a, the indicator light 57b).

[0137] When it is determined that the unsmooth operation or seizure of the lock unit 60 has been resolved (step S506: YES), the process proceeds to step S508. In step S508, the reclosing operation is performed. For example, in step S508, the doors 11A and 11B are moved again toward the fully closed position. After step S508, the process proceeds to step S509.

[0138] In step S509, it is determined whether the door catch has occurred. For example, in step S509, it is determined whether the door catch has occurred by determining whether the above-mentioned door speed or motor current exceeds the predetermined threshold value. When it is determined that the door catch has occurred (step S509: YES), the process proceeds to step S502.

[0139] When it is determined that the door catch has not occurred (step S509: No), the process proceeds to step S510. In step S510, it is detected that the doors 11A and 11B are fully closed. In step S510, the DCS 51 is turned ON. After step S510, the process proceeds to step S511.

[0140] In step S511, it is determined whether the number of times the unsmooth operation is detected consecutively is more than a predetermined number of times (e.g., one or more times). When it is determined that the number of times the unsmooth operation has been detected consecutively is less than the predetermined number of times (step S511: NO), the process proceeds to step S512.

[0141] In step S512, it is determined whether the elapsed time since the last unsmooth operation was detected is less than a predetermined time (e.g., less than 24 hours). When it is determined that the number of times that the unsmooth operation has been detected consecutively is greater than the predetermined number of times (step S511: YES) or when it is determined that the time elapsed since the last unsmooth operation was detected is less than the predetermined time (step S512: YES), then the process proceeds to step S513.

[0142] In step S513, it is informed that a failure is likely to occur (failure sign). For example, the failure sign may be supplied to the train central device or an external device by the alarm unit 57 (for example, the chime 57a, the indicator light 57b).

[0143] The condition for giving the failure sign is not limited to including both S511 and S512. For example, the condition for giving the failure sign may include either S511 or S512. For example, after step S510, the process may not proceed to step S511, but may proceed to step S512. For example, after step S511: NO, the process may return to step S501 without proceeding to step S512.

<Advantageous Effects>

[0144] As described above, the door opening-closing device 2 according to the embodiment includes: the drive unit 19 for driving the doors 11A and 11B that open and

close the doorway 8; the lock pins 14A and 14B that are moved together with the doors 11A and 11B by a driving force of the drive unit 19; the lock unit 60 movable between the lock position where the lock unit 60 engages with the lock pins 14A and 14B at the fully closed positions of the doors 11A and 11B and the unlock position where the lock unit 60 is disengaged from the lock pins 14A and 14B; the DCS 51 that obtains the position signal indicating the positions of the doors 11A and 11B; the DLS 52 that obtains the lock signal indicating that the lock unit 60 is situated at the lock position; and the determination unit 111 that determines whether a predetermined condition is satisfied, the predetermined condition being that the position signal indicates that the doors 11A and 11B are not at the fully closed positions and the lock signal indicates that the lock unit 60 is at the lock position.

[0145] In the normal state, the position signal indicates that the doors 11A and 11B are situated at the fully closed positions after the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS}, and the lock signal indicates that the lock unit 60 is at the lock position. However, when grease is dried out or the lock unit 60 operate unsmoothly, the doors 11A and 11B may not reach to the fully closed positions even when the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS}. With the above configuration, by determining whether the predetermined condition (it is indicated that the doors 11A and 11B are not situated at the fully closed position and the lock unit 60 is situated at the lock position) is satisfied, it is possible to determine whether the doors 11A and 11B are unable to move. In this way, it is possible to detect the state in which the doors do not move due to lack of grease, unsmooth operation or stuck of the lock 60 or the like.

[0146] According to the embodiment, when the doors 11A and 11B are stopped after the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS}, the lock unit 60 receives the driving force from the drive unit 19 and moves from the unlock position to the lock position. The determination unit 111 determines whether the predetermined condition is satisfied when the doors 11A and 11B are stopped, to determine whether the lock unit 60 has moved to the lock position although the lock unit 60 is not engaged with the lock pins 14A and 14B. When the lock unit 60 is moved from the unlock position to the lock position by receiving the driving force from the driving unit 19, there are two cases: one is where the lock unit 60 engages with the lock pins 14A and 14B at the fully closed positions of the doors 11A and 11B and moves to the lock position; and the other is where the lock unit 60 moves to the lock position without engaging with the lock pins 14A and 14B. According to the embodiment, by determining whether the predetermined condition is satisfied when the doors 11A and 11B are stopped, it is possible to determine whether the lock unit 60 has moved to the lock position even through the lock unit 60 is not engaged with the lock pins 14A and 14B. Accordingly it is possible to distinguish the two cases: one is where the lock unit 60 engages with the lock pins 14A and 14B at the fully closed positions of the doors 11A and 11B and moves to the lock position; and the other is where the lock unit 60 moves to the lock position without engaging with the lock pins 14A and 14B.

[0147] The lock unit 60 in embodiment includes the rotation shafts 81A and 81B that extend in the vertical direction, the rotating members 66A and 66B that rotate and move around the rotation shaft 81A and 81B between the unlock position and the lock position. The drive unit 19 includes the rack-and-pinion mechanism 10 having the racks 7A and 7B to which the doors 11A and 11B are attached respectively and the pinion 9 that engages with the racks 7A and 7B. The rotation shafts 81A and 81B are situated under the racks 7A and 7B in the vertical direction. The determination unit 111 determines whether the rotating members 66A and 66B are stuck or seized by determining whether the predetermined condition is satisfied. When the rotation shafts 81A and 81B are disposed under the racks 7A and 7B in the vertical direction, dust and wear debris collected on the racks 7A and 7B may fall on the rotation shafts 81A and 81B and such dust and wear debris tend to accumulate around the rotation shafts 81A and 81B. The dust or wear debris accumulated on the rotation shafts 81A and 81B may cause the unsmooth operation of the rotating members 66A and 66B or cause the rotating members 66A and 66B to be seized. In the described embodiment, by determining whether the predetermined condition is satisfied, it is possible to determine whether the rotating members 66A and 66B operate unsmoothly or are seized, and thus it is possible to know that the unsmooth operation or seizure of the lock unit 60 is caused by the unsmooth operation or seizure of the rotating members 66A and 66B. As discussed above, it is actually beneficial to know whether the rotating members 66A and 66B operate unsmoothly or are seized when the unsmooth operation of the lock unit 60 is checked.

[0148] The drive unit 19 in the embodiment includes the motor 90 and the planetary gear mechanism 20 to which the driving force of the motor 90 is inputted. The planetary gear mechanism 20 includes the internal gear 22 that outputs a driving force to the pinion 9, and the carrier 23 that outputs a driving force for moving the lock unit 60 between the unlock position and the lock position when the doors 11A and 11B are stopped. The lock unit 60 includes the lock slider 33 that is moved by the driving force of the carrier 23, and the link mechanism 61 that pushes the rotating members 66A and 66B to rotate the rotating members 66A and 66B in accordance with the movement of the lock slider 33. With such a configuration in which the drive unit 19 includes the motor 90 and the planetary gear mechanism 20 and the lock unit 60 includes the lock slider 33 and the link mechanism 61, it is possible to know that the unsmooth operation or seizure of the lock unit 60 is caused by the unsmooth operation or seizure of the rotating members 66A and 66B.

[0149] The door control device 100 according to the

embodiment includes: the control unit 11 controlling the motor 90 such that the drive unit 19 is powered to move the doors 11A and 11B open or close when the running resistance of the doors 11A and 11B is less than a predetermined running resistance, and the lock unit 60 is powered to lock the doors 11A and 11B at the fully closed positions when the running resistance of the doors 11A and 11B is equal to or higher than the predetermined running resistance. the DCS 51 that obtains the position signal indicating the positions of the doors 11A and 11B; the DLS 52 that obtains a lock signal indicating the lock unit 60 is situated at the lock position where the lock unit 60 locks the doors 11A and 11B; and the determination unit 111 that determines whether a predetermined condition is satisfied when the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS} by controlling the motor 90, the predetermined condition being that the position signal indicates that the doors 11A and 11B are not situated at the fully closed positions and the lock signal indicates that the lock unit 60 is situated at the lock position.

[0150] In the normal state, after the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS} by controlling the motor 90, the position signal indicates that the doors 11A and 11B are situated at the fully closed positions and the lock signal indicates that the lock unit 60 is at the lock position. However, when grease is dried out or the lock unit 60 operate unsmoothly, the doors 11A and 11B may not move to the fully closed positions even after the doors 11A and 11B are moved in the close directions A_{CLS} and B_{CLS} by controlling the motor 90. With the above configuration, by determining whether the predetermined condition (it is indicated that the doors 11A and 11B are not situated at the fully closed position and the lock unit 60 is situated at the lock position) is satisfied, it is possible to determine whether the doors 11A and 11B are unable to move. In this way, it is possible to detect the state in which the doors do not move due to lack of grease, unsmooth operation or stuck of the lock 60 or the like.

[0151] The door control device 100 in the embodiment includes the door catch determination unit 113 that determines, based on an operation signal of the drive unit 19, whether door catch has occurred at the doorway 8 where the doors 11A and 11B are closed and opened. For example, when it is determined that the door catch has occurred, the determination unit 111 determines whether the predetermined condition is satisfied. There are two possible cases for the doors 11A and 11B that do not move to the fully closed positions even by controlling the motor 90, one is the case where the doors 11A and 11B are stopped due to lack of grease or unsmooth operation or stuck of the lock unit 60, the other is the case where the doors 11A and 11B are stopped by something got caught between the doors 11A and 11B. In the embodiment, determination whether the predetermined condition is satisfied is performed when it is determined the door catch has occurred, thereby it is possible to know whether the doors 11A and 11B are stopped after detection of the door catch. Therefore, it is possible to distinguish between the stop of the doors 11A and 11B caused by the lack of grease or unsmooth operation of the lock unit 60 and the stop of the doors 11A and 11B caused by door catch.

[0152] When the door catch occurs, the control unit 110 in the embodiment controls the motor 90 in different modes depending on whether the predetermined condition is satisfied or not. In this configuration, when the door catch occurs, the moving mode of the doors 11A and 11B can be made different depending on whether the predetermined condition is satisfied or not. For example, when the door catch occurs, the motor 90 may be controlled with at least one selected from the group consisting of a different rotational speed of the motor 90, a different rotational direction of the motor 90, and a different amount of rotation of the motor 90, depending on whether the predetermined condition is satisfied or not. Thus, when the door catch occurs, at least one selected from the group consisting of the moving speed of the doors 11A and 11B, the moving direction of the doors 11A and 11B, and the moving amount of the doors 11A and 11B is made different between when the predetermined condition is satisfied and when the predetermined condition is not satisfied.

[0153] In the embodiment, the control unit 110 drives the motor 90 so as to move the lock unit 60 located at the lock position to the unlock position when it is determined that the predetermined condition is satisfied. According to this configuration, when it is determined that the predetermined condition is satisfied, a resolving operation may be performed on the doors 11A and 11B that become unmovable due to the lack of grease or unsmooth operation of the lock unit 60 by reversely driving the motor to move the lock unit 90 to the unlock position. At the time of the resolving operation for the unmovable doors 11A and 11B, for example, the closing operation of the doors 11A and 11B may be performed after the opening operation of the doors 11A and 11B is performed in order to prevent passengers from getting on the vehicle as the doors 11A and 11B open.

[0154] The door control device 100 in the embodiment includes the estimation unit 114 that estimates deterioration of the lock unit 60 based on the number of times the predetermined condition is satisfied or the frequency of occurrence of the event that satisfies the predetermined condition. In this configuration, it is possible to estimate deterioration of the lock unit 60 based on the number of times the predetermined condition is satisfied or the frequency of occurrence of the event that satisfies the predetermined condition.

[0155] The estimation unit 114 in the embodiment estimates the deterioration of the lock unit 60 based on the weather, humidity, air temperature, and environmental information of at least one of traveling points of the vehicle whose doorway 8 is opened or closed by the doors 11A and 11B. With this configuration, the reliability of the de-

terioration estimation for the lock unit 60 can be improved as compared with the case of estimating the deterioration of the lock unit 60 based only on the occurrence frequency of the event satisfying the predetermined condition.

[0156] The door control device 100 in the embodiment includes the alarm unit 57 that informs an external device of information regarding the determination result when it is determined that the predetermined condition is satisfied. With this configuration, it is possible to recognize that the predetermined condition is satisfied by informing an external device of the information regarding the determination result.

[0157] In one embodiment, when the number of times the predetermined condition is satisfied or the frequency of occurrence of the event satisfying the predetermined condition is equal to or greater than a predetermined value, the alarm unit 57 informs an external unit or device of the information regarding the determination result. With this configuration, it is possible to improve the information reliability of the determination result as compared with the case where it is determined sporadically that the predetermine condition is satisfied.

<Modification Examples>

[0158] The technical scope of the present invention is not limited to the embodiments described above but is susceptible of various modification within the purport of the present invention.

[0159] In the above-described embodiment, the lock pin has been described as an example of the engaging portion that moves together with the door by receiving the driving force from the drive unit, but the invention is not limited to this. For example, the engaging portion may be any member other than the lock pin. For example, the engaging portion may not include the roller rotatable about the lock pin as the center of rotation. Alternatively, the engaging portion may be a convex portion protruding upward from the door. For example, the engaging portion may be changed according to required specifications.

[0160] In the above embodiment, the position signal indicates that the door is not situated at the fully closed position when the DCS is OFF. However, the invention is not limited to this. For example, the position signal may indicate that the door is not in the fully closed position when the stroke of the door is greater than or equal to a predetermined length. Based on what the position signal indicates that the door is not at the fully closed position may be changed according to the required specifications.

[0161] In the above embodiment, the lock unit is moved from the unlock position to the lock position by receiving the driving force from the drive unit when the doors are moved in the close directions and then stopped. However, the invention is not limited to this. For example, the lock unit may be moved from the unlock position to the lock position by receiving a driving force from another drive unit different from the drive unit. For example, the drive unit is not limited to a single motor, but may include a plurality of motors. For example, after the doors are moved to the fully closed positions by the output of a first motor, the doors may be locked by operating the lock unit by the output of a second motor different from the first motor. For example, how the lock unit moves from the unlock position to the lock position can be changed according to required specifications.

[0162] In the above embodiment, the determination unit determines whether the predetermined condition is satisfied when the doors are stopped, but the invention is not limited to this. For example, the determination unit may determine whether the predetermined condition is satisfied before the doors are stopped. For example, how (the timing at which) the determination unit determines whether the specific condition is satisfied can be changed according to required specifications.

[0163] The lock unit 60 in the embodiment includes the rotation shafts 81A and 81B that extend in the vertical direction, the rotating members 66A and 66B that rotate around the rotation shaft 81A and 81B and move between the unlock position and the lock position. However the invention is not limited to this. For example, the rotation shafts may extend in a direction intersecting the vertical direction. For example, the lock unit may include a movable member that moves between the unlock position and the lock position instead of or in addition to the rotating members that rotate around the rotation shafts and between the unlock position and the lock position. For example, the lock unit can be configured in various manners in accordance with required specifications.

[0164] In the above embodiment, the drive unit includes the rack-and-pinion mechanism that has the racks to which the doors are attached and the pinion that engages with the racks. However, the invention is not limited to this. For example, the drive unit may have a belt mechanism or a ball screw mechanism, instead of or in addition to the rack-and-pinion mechanism In the above embodiment, the doors are driven using the rack and pinion system. Specifically, the motor rotates the pinion and the doors attached to the racks are moved open or close. Alternatively, the doors may be driven by a so-called belt driven system. Specifically, the door is connected to a belt spanning from a drive pulley to a driven pulley that are separated from each other, and the door is moved by moving the belt to be opened and closed. As another alternative example, the door may be driven using the screw system. Specifically, a motor rotates a screw shaft corresponding to a bolt, so that a door attached to a ball nut corresponding to a nut is opened or closed. For example, the door driving system may be changed in accordance with required specifications. For example, the drive unit can be configured in various manners in accordance with the drive method of the door or required specifications.

[0165] In the above embodiment, the rotation shafts are disposed below the racks in the vertical direction, but the invention is not limited to this. For example, the rotation shafts may be situated above the racks in the vertical

direction. For example, the rotation shafts may be situated at positions where they overlap the corresponding racks viewed from the horizontal direction. For example, the arrangement of the rotation shafts can be changed according to required specifications.

[0166] In the above embodiment, the determination unit determines whether the rotating members operate unsmoothly or are seized by determining whether the predetermined condition is satisfied. However, the invention is not limited to this. For example, the determination unit may determine whether any part of the lock unit other than the rotating members operates unsmoothly or is seized by determining whether the predetermined condition is satisfied. For example, how to determine the unsmooth operation can be modified in accordance with required specifications.

[0167] In the above embodiment, the drive unit includes the motor (an example of the actuator) and the planetary gear mechanism to which the driving force of the motor is inputted, but the invention is not limited to this. For example, the drive unit is not limited to the motor and may include a solenoid. For example, the actuator serving as the drive unit can be configured in various manners in accordance with required specifications. For example, the drive unit is not limited to the planetary gear mechanism, and may include other power transmission mechanisms such as a belt mechanism and a ball screw mechanism. For example, the drive unit can be configured in various manners in accordance with required specifications.

[0168] In the above embodiment, the planetary gear mechanism includes the internal gear (first output portion) that outputs a driving force to the pinion, and the carrier (second output portion) that outputs a driving force for moving the lock unit between the unlock position and the lock position. For example, it is not limited that the planetary gear mechanism couples the sun gear to the output shaft of the motor, couples the internal gear to the pinion, and couples the carrier to the traction member. Alternatively the planetary gear mechanism may couple the sun gear to the pinion and couple the internal gear to the output shaft of the motor. For example, the first and second output portions can be configured in various manners in accordance with the configuration of the planetary gear mechanism and the required specifications.

[0169] In the above embodiment, the lock unit includes the lock slider that is moved by the driving force from the carrier, and the link mechanism that pushes the rotating members and to rotate them in accordance with the movement of the lock slider. However, the invention is not limited to this. For example, the lock unit may not include the lock slider. For example, the link mechanism may push the rotating members to rotate in accordance with the rotation of the carrier. For example, the link mechanism may not include three links. For example, the link mechanism may have two or four or more links. For example, the configuration of the link mechanism may be changed according to the door configuration and required specifications. For example, the lock unit can be configured in various manners in accordance with required specifications.

[0170] The above embodiments are described with reference to the example in which the door opening-closing device includes the pair of doors separately slidable to open and close the entrance/exit of the railway vehicle. However, the configuration is not limited to this. For example, the door opening-closing device may be provided on vehicles other than railway vehicles. For example, the door opening-closing device may include a single leaf sliding door.

[0171] The above embodiments are based on the example where the door opening-closing device is provided on the doors of the railway vehicle (vehicle). However, the invention is not limited to this. For example, the door opening-closing device may be installed on any transporter other than a vehicle (e.g., aircraft or ship), or pm equipment or facilities that are fixed in a fixed position. For example, installation configuration of the door opening-closing device can be modified in accordance with required specifications.

[0172] In the above embodiment, the door control device includes the door catch determination unit that determines, based on the operation signal of the drive unit, whether door catch has occurred at the doorway where the doors are closed and opened. However, the invention is not limited to this. For example, the door control device may not include the door catch determination device. For example, the configuration of the door control device can be modified in any manner in accordance with required specifications.

[0173] In the above embodiment, when it is determined that door catch has occurred, the determination unit determines whether the predetermined condition is satisfied. However, the invention is not limited to this. For example, the determination unit may determine whether the predetermined condition is satisfied when it is determined that door catch is not occurring. Alternatively, the determination unit may determine whether the predetermined condition is satisfied irrespective of the occurrence of the door catch. For example, how the determination unit perform the determination may be configured in various manners in accordance with required specifications.

[0174] In the above embodiment, when the door catch occurs, the control unit controls the motor in a different mode between when the predetermined condition is satisfied and when the predetermined condition is not satisfied. However the invention is not limited to this. Alternatively, when the door catch occurs, the control unit may control the motor in the same manner between when the predetermined condition is satisfied and when the predetermined condition is not satisfied. For example, when the door catch occurs, the control unit may control the motor with the same rotational speed of the motor, the same rotational direction, and the same amount of rotation of the motor between when the predetermined condition is satisfied and when the predetermined condition

is not satisfied. For example, the control of the motor at the time of door catch can be modified in accordance with required specifications.

[0175] In the above embodiment, the control unit drives the motor so as to move the lock unit situated at the lock position to the unlock position when it is determined that the predetermined condition is satisfied. However, the invention is not limited to this. For example, the control unit may not drive the motor so as to move the lock unit situated at the lock position to the unlock position when it is determined that the predetermined condition is satisfied. For example, when it is determined that the predetermined condition is satisfied, in addition to or instead of performing the resolving operation on the stopped doors due to the lack of grease or unsmooth operation of the lock unit by reversely driving the motor to move the lock unit to the unlock position, the state in which the doors are stopped may be informed as a failure. For example, the control performed when the predetermined condition is satisfied may be modified in any manners in accordance with required specifications.

[0176] In the above embodiment, the determination unit determines that the lock unit is broken when it is determined that the number of times the predetermined condition is satisfied reaches a predetermined number of times or more. However, the invention is not limited to this. For example, the control unit may determine that a failure has occurred even when it is not consecutively determined more than one time that the predetermined condition is satisfied. Instead determining that a failure occurs in the lock unit when the predetermined condition is satisfied one or more times, but the determination unit may determine that a failure occurs in the lock unit when the predetermined condition is satisfied two or more times. For example, how the determination unit determines that a failure occurs in the lock unit can be modified in various manners in accordance with required specifications.

[0177] In the above embodiment, the door control device includes the estimation unit that estimates deterioration of the lock unit based on the number of times the predetermined condition is satisfied or the frequency of occurrence of the event that satisfies the predetermined condition. However the invention is not limited to this. For example, the door control device may not include the estimation unit. For example, the configuration of the door control device can be modified in any manner in accordance with required specifications.

[0178] In the above embodiment, the estimation unit estimates the deterioration of the lock unit based on the weather, humidity, air temperature, and environmental information of at least one of traveling points of the vehicle whose doorway is opened or closed by the doors. However, the invention is not limited to this. For example, the estimation unit may estimate the deterioration of the lock unit based on information other than the environmental information. For example, the estimation unit can be configured in various manners in accordance with required specifications.

[0179] In the above embodiment, the door control device includes the alarm unit that informs an external device of information regarding the determination result when it is determined that the predetermined condition is satisfied. However, the invention is not limited to this. For example, the door control device may not include the alarm unit. For example, the configuration of the door control device can be modified in any manner in accordance with required specifications.

[0180] In the above embodiment, when the number of times the predetermined condition is satisfied or the frequency of occurrence of the event satisfying the predetermined condition is equal to or greater than a predetermined value, the alarm unit informs an external unit or device of the information regarding the determination result. However, the invention is not limited to this. For example, the alarm unit may inform the determination result when it is intermittently determined that the predetermined condition is satisfied. For example, when or how the alarm unit informs the external device may be modified in various manners in accordance with required specifications.

[0181] The invention may be applied to a door control method that controls a door using at least some aspects of the door opening-closing device and door control device described in the embodiments above. The door control method may include: a step of controlling an actuator such that the drive unit is powered to move the door open or close when the running resistance of the door is less than a predetermined running resistance, and the lock unit is powered to lock the door at the fully closed position when the running resistance of the door is equal to or greater than the predetermined running resistance; a step of obtaining a position signal that indicates the position of the door; a step of obtaining a lock signal indicating the lock unit is situated at the lock position where the lock unit locks the door; and a step of determining whether a predetermined condition is satisfied when the door is moved in the close direction by controlling the actuator, the predetermined condition being that the position signal indicates that the door is not situated at the fully closed position and the lock signal indicates that the lock unit is situated at the lock position.

[0182] At least some parts of the door opening-closing device and the door control device described in the above embodiments may be implemented using hardware or software. If the software is used, at least some functions of the door opening-closing device and the door control device are implemented by a program, and the program may be stored on a storage medium such as a flexible disc and a CD-ROM and executed when read by a computer. The storage medium is not limited to detachable ones such as magnetic and optical discs, and may be stationary storage media such as hard disk devices and memory devices. A program implementing at least some functions of the door opening-closing device and the door control device, the program causing a computer to cause

the drive unit to be powered to move the door open or close when the running resistance of the door is less than a predetermined running resistance, and the lock unit to be powered to lock the door at the fully closed position when the running resistance of the door is equal to or greater than the predetermined running resistance, the program further causing the computer to perform:
a step of obtaining a position signal that indicates the position of the door; a step of obtaining a lock signal indicating the lock unit is situated at the lock position where the lock unit locks the door; and a step of determining whether a predetermined condition is satisfied when the door is moved in a close direction, the predetermined condition being that the position signal indicates that the door is not situated at the fully closed position and the lock signal indicates that the lock unit is situated at the lock position.

[0183] For example, at least some of the functions of the door opening-closing device and the door control device may be implemented by a program, and the program may be distributed through communication lines (including wired or wireless communications) such as the Internet. For example, the program may be encrypted, modulated or compressed to be distributed through communication lines such as the Internet or in the state of being stored on storage media.

[0184] The elements of the embodiments described above may be replaced with known elements within the purport of the present invention. Further, the modifications described above may be combined. In the embodiments disclosed herein, a member formed of multiple components may be integrated into a single component, or conversely, a member formed of a single component may be divided into multiple components. Irrespective of whether or not the components are integrated, they are acceptable as long as they are configured to attain the object of the invention. According to the foregoing embodiments disclosed herein, a plurality of functions are distributively provided. Some or all of the functions may be integrated. Any one of the functions may be partly or entirely segmented into a plurality of functions, which are distributively provided. Irrespective of whether or not the functions are integrated or distributed, they are acceptable as long as they are configured to solve the problems.

LIST OF REFERENCE NUMBERS

[0185] 2 ... door opening-closing device, 7A, 7B ... rack, 8 ... doorway, 9 ... pinion, 10 ... rack and pinion mechanism, 11A, 11B ... door, 14A, 14B ... lock pin (engaging portion), 19 ... drive unit, 20 ... planetary gear mechanism, 22 ... internal gear (first output portion), 23 ... carrier (second output portion), 33 ... lock slider, 51 ... DCS (position signal acquisition unit), 52 ... DLS (lock signal acquisition unit), 57 ... alarm unit, 60 ... lock unit, 61 ... link mechanism, 66A, 66B ... rotating member, 81A, 81B ... rotation shaft, 90 ... motor (actuator), 110 ... control unit (actuator control unit), 111 ... determination unit, 113 ... door catch determination unit, 114 ... estimation unit, A_{CLS}, B_{CLS} ... close direction

Claims

1. A door opening-closing device (2), comprising:

a drive unit (19) for driving a door (11A, 11B) that opens and closes a doorway(8);
an engaging portion (14A, 14B) moving together with the door (11A, 11B) by receiving a driving force of the drive unit (19);
a lock unit (60) movable between a lock position where the lock unit (60) engages with the engaging portion (14A, 14B) with the door (11A, 11B) situated at a fully closed position and an unlock position where the lock unit (60) is disengaged from the engaging portion (14A, 14B);
a position signal acquisition unit (51) obtaining a position signal that indicates the position of the door (11A, 11B);
a lock signal acquisition unit (52) obtaining a lock signal indicating that the lock unit (60) is situated at the lock position; and
a determination unit (111) determining whether a predetermined condition is satisfied, the predetermined condition being that the position signal indicates that the door (11A, 11B) is unsituated at the fully closed position and the lock signal indicates that the lock unit (60) is situated at the lock position.

2. The door opening-closing device (2) of claim 1, wherein when the door (11A, 11B) is stopped after the door (11A, 11B) is moved to a close direction, the lock unit (60) is moved from the unlock position to the lock position by receiving a driving force from the drive unit (19), and
wherein the determination unit (111) determines whether the predetermined condition is satisfied when the door (11A, 11B) is stopped to determine whether the lock unit (60) has moved to the lock position even though the lock unit (60) is not engaged with the engaging portion (14A, 14B).

3. The door opening-closing device (2) of claim 1 or 2, wherein

the lock unit (60) includes a rotation shaft (81A, 81B) that extends in a vertical direction, and a rotating member (66A, 66B) that rotates and moves around the rotation shaft (81A, 81B) between the unlock position and the lock position,
wherein the drive unit (19) includes a rack-and-pinion mechanism (10) that includes a rack (7A, 7B) to which the door (11A, 11B) is attached and a pinion 9 that engages with the rack (7A, 7B),

wherein the rotation shaft (81A, 81B) is situated under the rack (7A, 7B) in the vertical direction, and
wherein the determination unit (111) determines whether the rotating member (66A, 66B) operates unsmoothly by determining whether the predetermined condition is satisfied.

4. The door opening-closing device (2) of claim 3, wherein

the drive unit (19) includes:

an actuator (90); and
a planetary gear mechanism (20) to which a driving force of the actuator (90) is inputted,

wherein the planetary gear mechanism (20) includes:

a first output unit (22) outputting a driving force to the pinion (9); and
a second output unit (23) outputting a driving force with which the lock unit (60) is moved between the unlock position and the lock position when the door (11A, 11B) is stopped,

wherein the lock unit (60) further includes:

a lock slider (33) being moved by receiving the driving force from the second output unit (23); and
a link mechanism (61) pushing the rotating member (66A, 66B) to rotate the rotating member (66A, 66B) in accordance with movement of the lock slider (33).

5. A door control device (100), comprising:

an actuator control unit (110) controlling an actuator (90) such that the drive unit (19) is powered to move the door (11A, 11B) open or close when a running resistance of the door (11A, 11B) is less than a predetermined running resistance and the lock unit (60) is powered to lock the door (11A, 11B) at the fully closed position when the running resistance of the door (11A, 11B) is equal to or greater than the predetermined running resistance;
a position signal acquisition unit (51) obtaining a position signal that indicates the position of the door (11A, 11B);
a lock signal acquisition unit (52) obtaining a lock signal indicating that the lock unit (60) is situated at the lock position; and
a determination unit (111) determining whether a predetermined condition is satisfied when the door (11A, 11B) is moved in a close direction by controlling the actuator (90), the predetermined condition being that the position signal indicates that the door (11A, 11B) is unsituated at the fully closed position and the lock signal indicates that the lock unit (60) is situated at the lock position.

6. The door control device (100) of claim 5, further comprising:

a door catch determination unit (113) determining, based on an operation signal of the drive unit (19), whether door catch has occurred at the doorway (8) opened and closed by the door (11A, 11B),
wherein, when it is determined that the door catch has occurred, the determination unit (111) determines whether the predetermined condition is satisfied.

7. The door control device (100) of claim 6, wherein when the door catch occurs, the actuator control unit (110) controls the actuator (90) in a different mode between when the predetermined condition is satisfied and when the predetermined condition is not satisfied.

8. The door control device (100) of any one of claims 5 to 7, further comprising the actuator control unit (110) drives the actuator (90) so as to move the lock unit (60) situated at the lock position to the unlock position when it is determined that the predetermined condition is satisfied.

9. The door control device (100) of any one of claims 5 to 8, further comprising an estimation unit (114) estimating deterioration of the lock unit (60) based on the number of times the predetermined condition is satisfied or frequency of occurrence of an event that satisfies the predetermined condition.

10. The door control device (100) of claim 9, wherein the estimation unit (114) estimates the deterioration of the lock unit (60) based on weather, humidity, air temperature, and environmental information of at least one of traveling points of a vehicle whose doorway (8) is opened or closed by the door (11A, 11B).

11. The door control device (100) of any one of claims 5 to 10, further comprising an alarm unit (57) informing an external device of information regarding a determination result, when it is determined that the predetermined condition is satisfied.

12. The door control device (100) of claim 11, wherein when the number of times the predetermined condition is satisfied or frequency of occurrence of an

event that satisfies the predetermined condition is equal to or greater than a predetermined value, the alarm unit (57) informs the external device of the information regarding the determination result.

13. A method of controlling a door (11A, 11B), comprising:

a step of controlling an actuator (90) such that a drive unit (19) is powered to move the door (11A, 11B) open or close when a running resistance of the door (11A, 11B) is less than a predetermined running resistance and the lock unit (60) is powered to lock the door (11A, 11B) at the fully closed position when the running resistance of the door (11A, 11B) is equal to or greater than the predetermined running resistance;
a step of obtaining a position signal that indicates the position of the door (11A, 11B);
a step of obtaining a lock signal indicating the lock unit is situated at the lock position where the lock unit locks the door (11A, 11B); and
a step of determining whether a predetermined condition is satisfied when the door (11A, 11B) is moved in a close direction by controlling the actuator (90),
the predetermined condition being that the position signal indicates that the door (11A, 11B) is unsituated at the fully closed position and the lock signal indicates that the lock unit (60) is situated at the lock position.

14. A program causing a computer to cause a drive unit (19) to be powered to open or close a door (11A, 11B) when a running resistance of the door (11A, 11B) is less than a predetermined running resistance and a lock unit (60) to be powered to lock the door (11A, 11B) at a fully closed position when the running resistance of the door (11A, 11B) is equal to or greater than the predetermined running resistance,
the program further causing the computer to perform:

a step of obtaining a position signal that indicates the position of the door (11A, 11B);
a step of obtaining a lock signal indicating the lock unit is situated at the lock position where the lock unit locks the door (11A, 11B); and
a step of determining whether a predetermined condition is satisfied when the door (11A, 11B) is moved in a close direction by controlling the actuator, the predetermined condition being that the position signal indicates that the door (11A, 11B) is unsituated at the fully closed position and the lock signal indicates that the lock unit (60) is situated at the lock position.

15. A computer-readable storage medium storing a computer program that, when executed by a computer, realizes the method of claim 13.

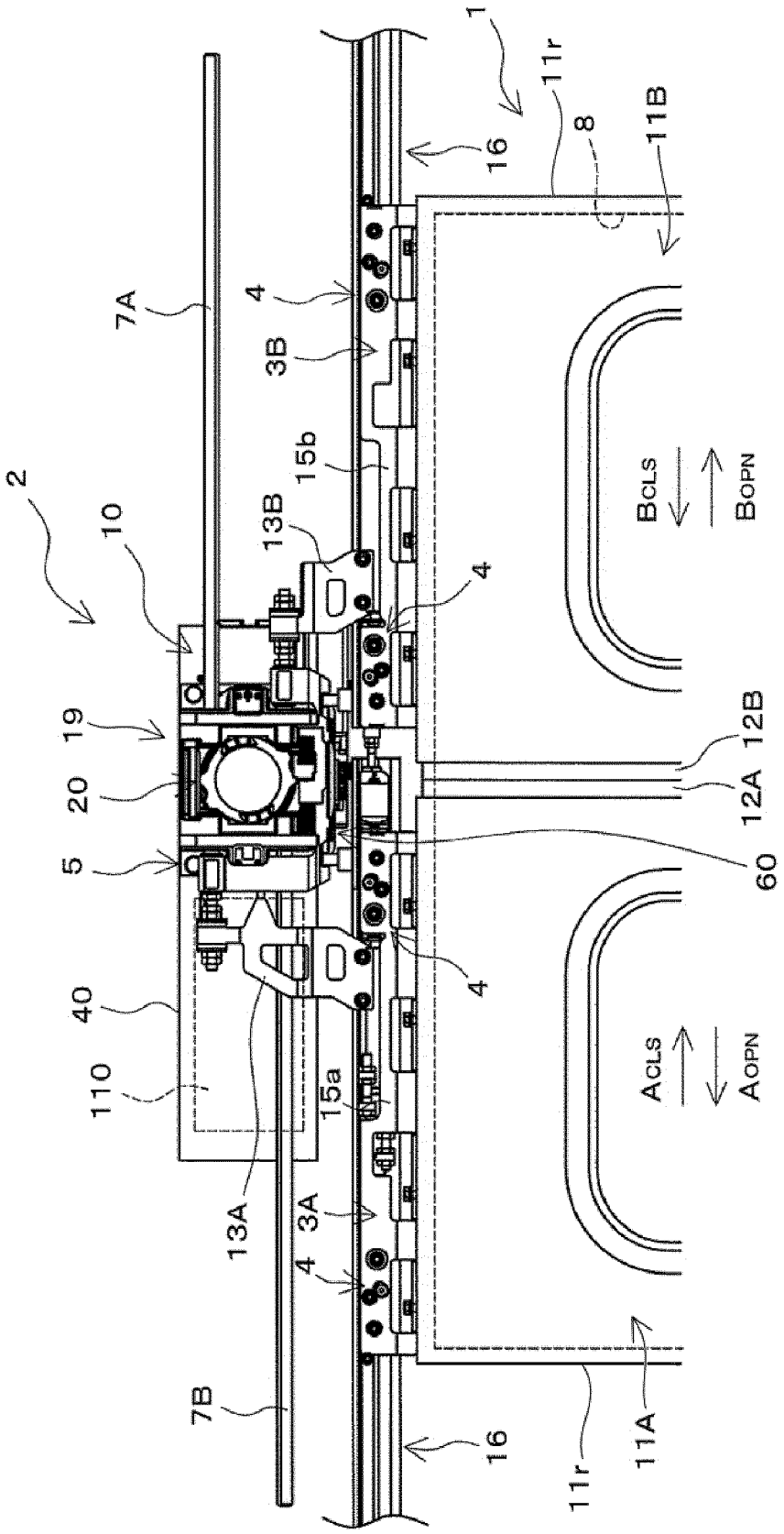
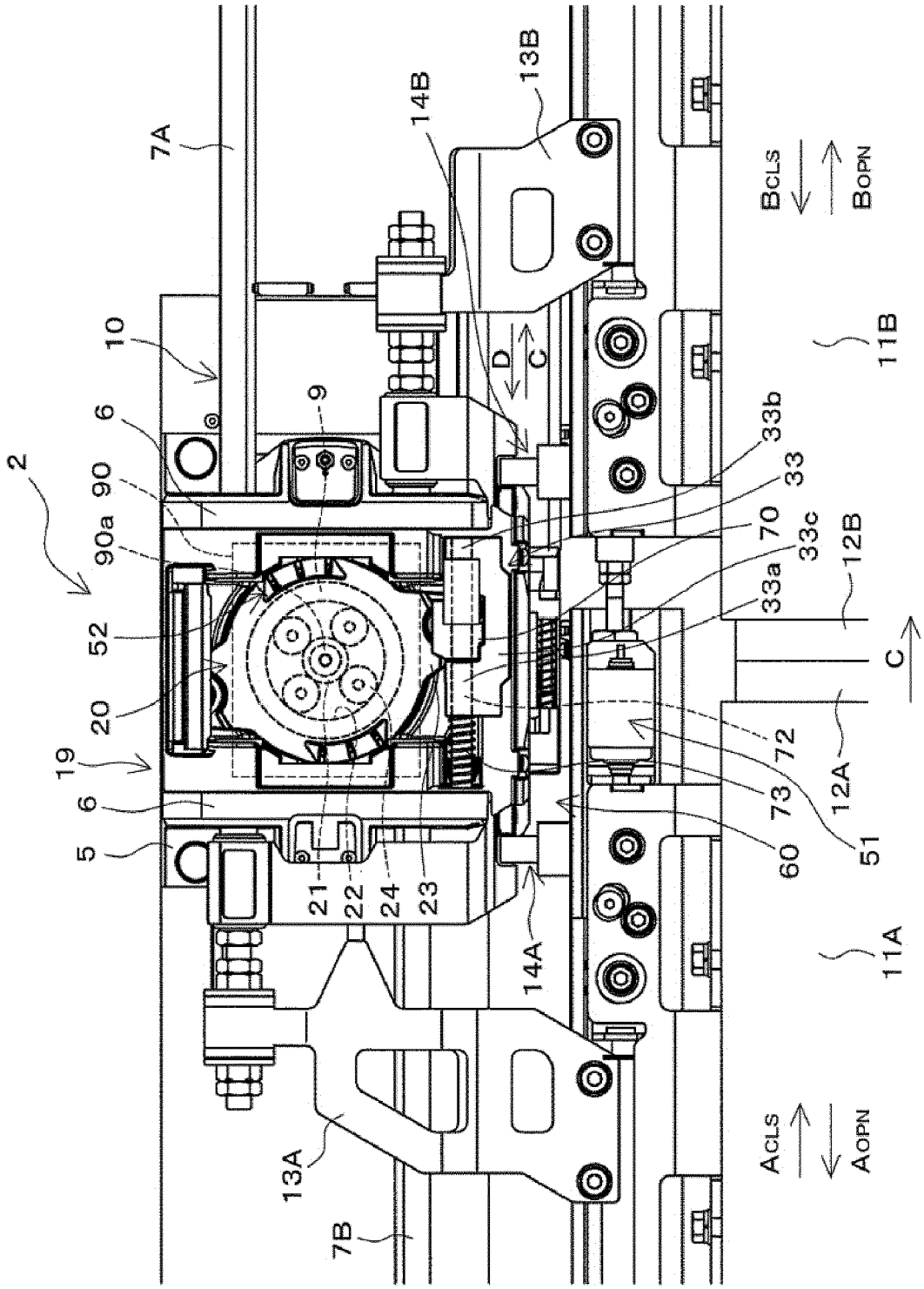

1
11r
8
11B
16
7A
4
3B
15b
13B
2
10
4
BCLS
BOPN
19
20
12B
12A
5
60
4
40
110
15a
ACLS
AOPN
13A
3A
4
7B
16
11r
11A

Fig. 1


2
5
6
19
20
52
90a
90
6
10
7A
13A
7B
14B
13B
9
21
22
24
23
14A
D
C
33b
33
70
33c
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12B
11A
11B
BCLS
BOPN
ACLS
AOPN

Fig. 2

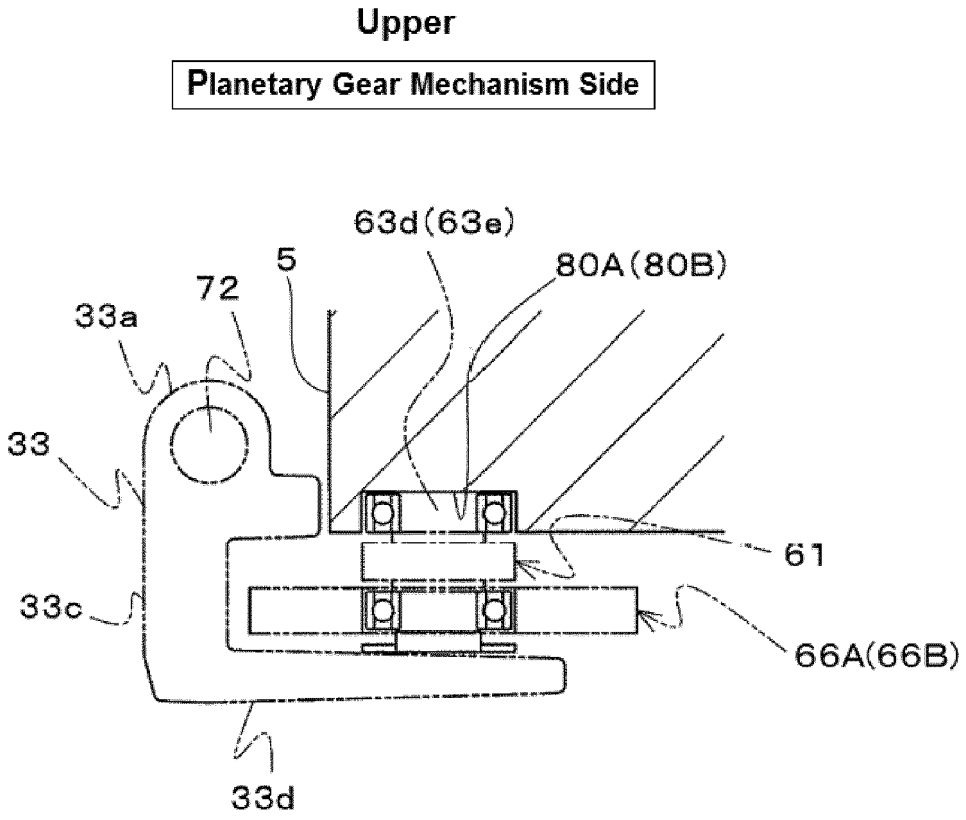

Upper
Planetary Gear Mechanism Side
63d(63e)
5
80A(80B)
72
33a
33
61
33c
66A(66B)
33d
Door Side
Lower

Fig. 3

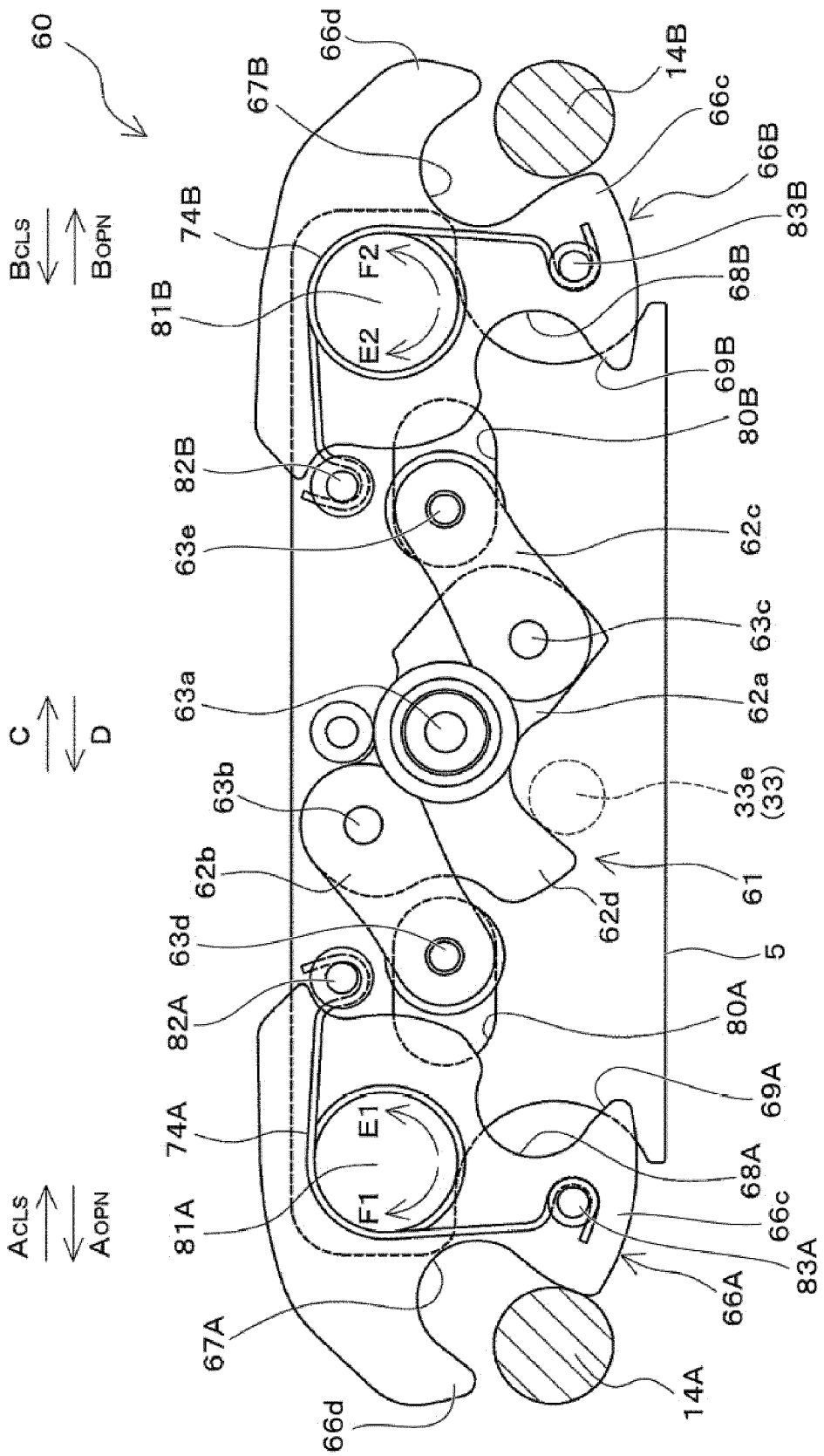
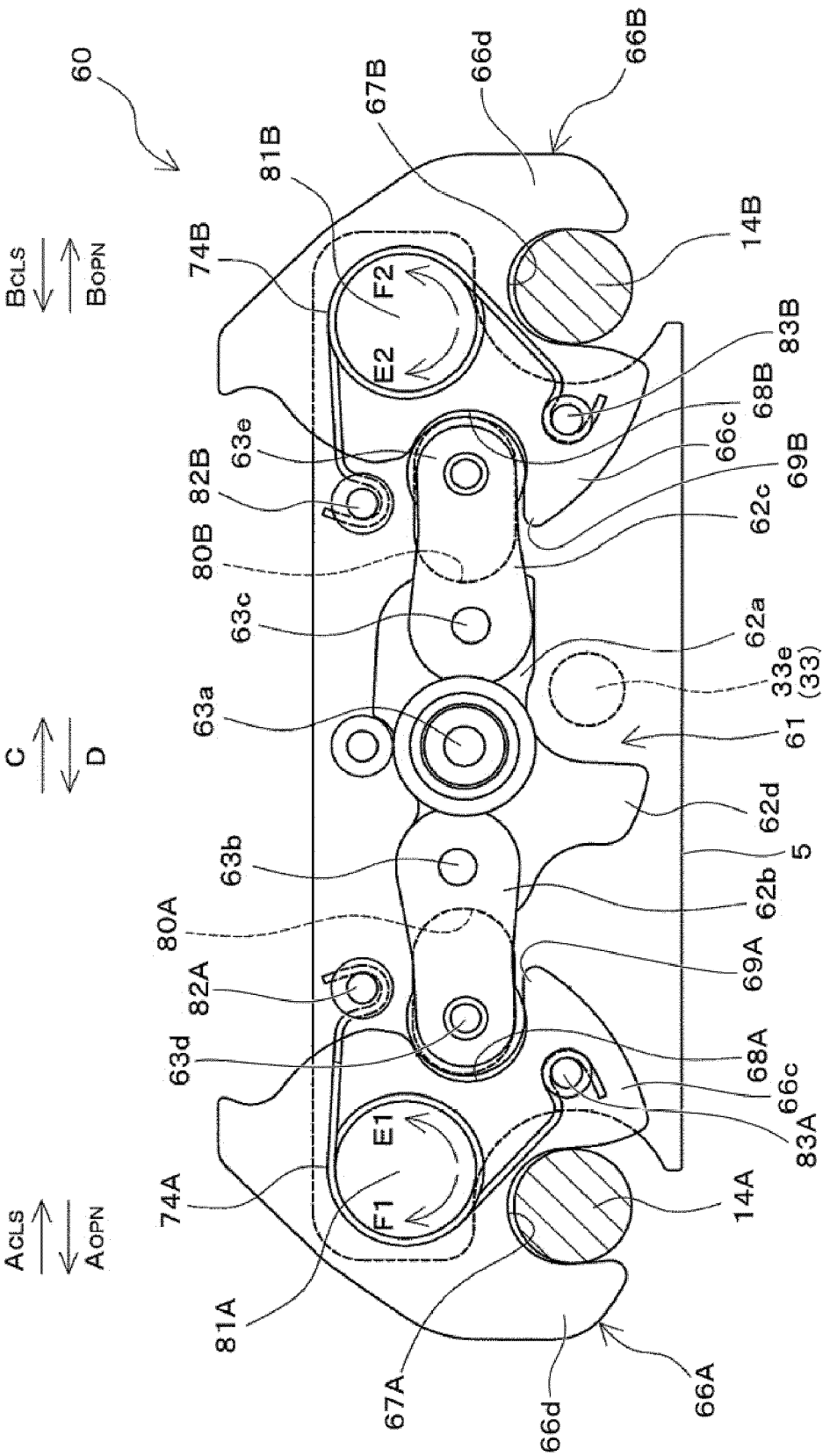

60
BCLS
BOPN
C
D
ACLS
AOPN
66d
67B
14B
66c
66B
83B
74B
F2
E2
81B
68B
69B
80B
82B
63e
62c
63c
63a
62a
33e
(33)
63b
62b
62d
61
63d
5
82A
80A
74A
E1
F1
69A
68A
81A
66c
83A
66A
67A
14A
66d

Fig. 4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BCLS
BOPN
C
D
ACLS
AOPN
74B
81B
67B
66d
66B
14B
F2
E2
83B
68B
66c
69B
62c
63e
82B
80B
63c
62a
33e
(33)
61
63a
62d
5
63b
62b
80A
69A
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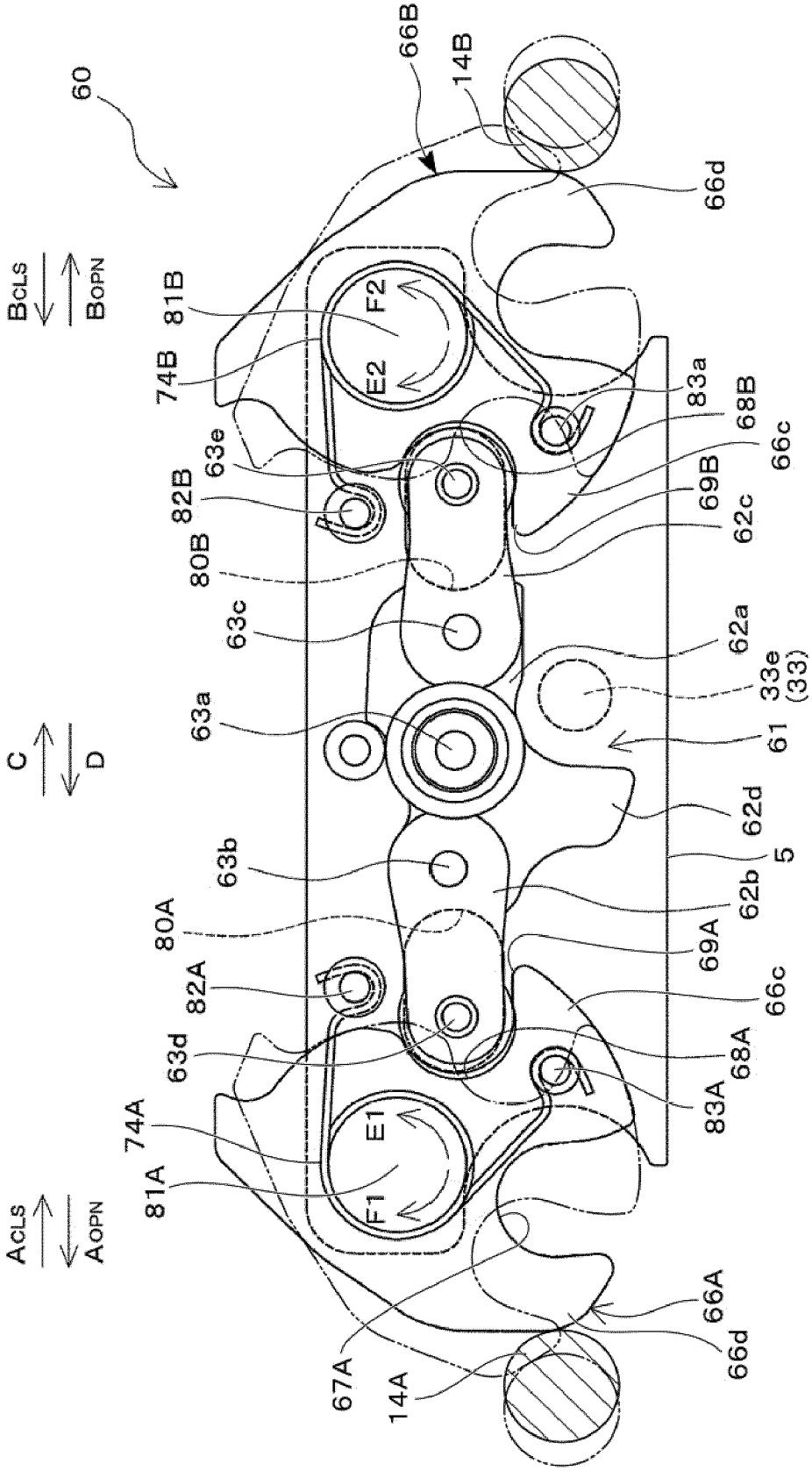
F1
74A
14A
81A
67A
66d
66A

Fig. 5


60
66B
14B
66d
BCLS
BOPN
81B
F2
E2
74B
83a
68B
63e
66c
82B
69B
62c
80B
63c
62a
33e
(33)
63a
61
C
D
62d
5
63b
62b
80A
69A
82A
66c
63d
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74A
E1
81A
F1
ACLS
AOPN
66A
66d
67A
14A

Fig. 6

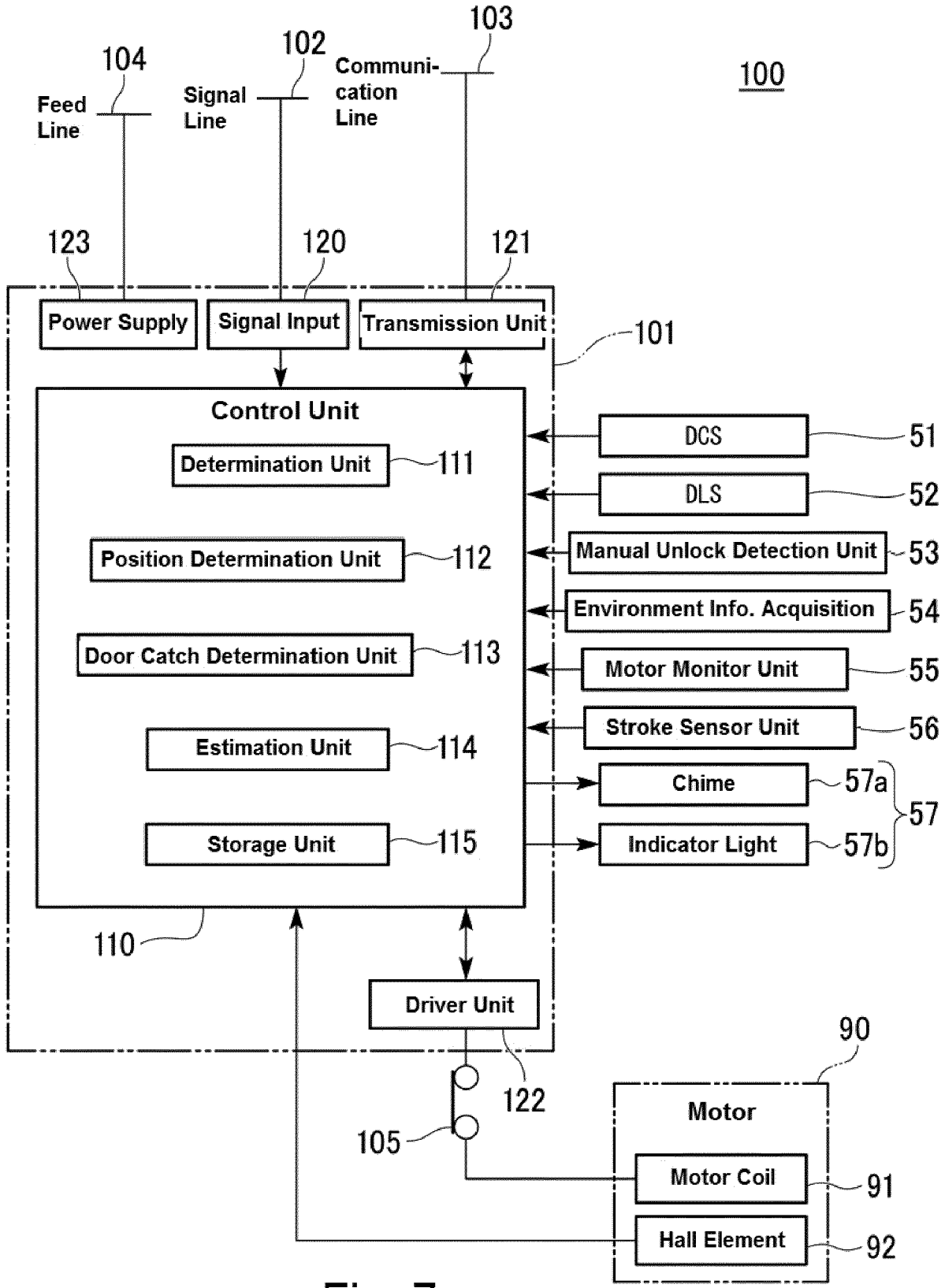
100
103
102
104
Communi-
cation
Line
Signal
Line
Feed
Line
123
120
121
Power Supply
Signal Input
Transmission Unit
101
Control Unit
Determination Unit
111
Position Determination Unit
112
Door Catch Determination Unit
113
Estimation Unit
114
Storage Unit
115
110
DCS
51
DLS
52
Manual Unlock Detection Unit
53
Environment Info. Acquisition
54
Motor Monitor Unit
55
Stroke Sensor Unit
56
Chime
57a
Indicator Light
57b
57
Driver Unit
122
105
90
Motor
Motor Coil
91
Hall Element
92

Fig. 7

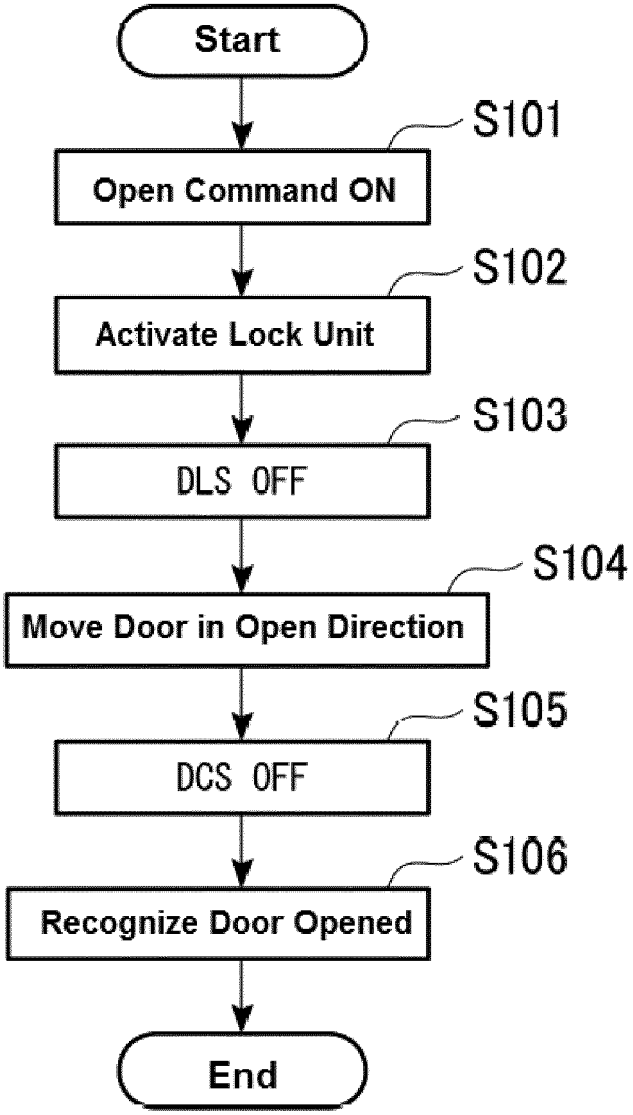
Start
S101
Open Command ON
S102
Activate Lock Unit
S103
DLS OFF
S104
Move Door in Open Direction
S105
DCS OFF
S106
Recognize Door Opened
End

Fig. 8

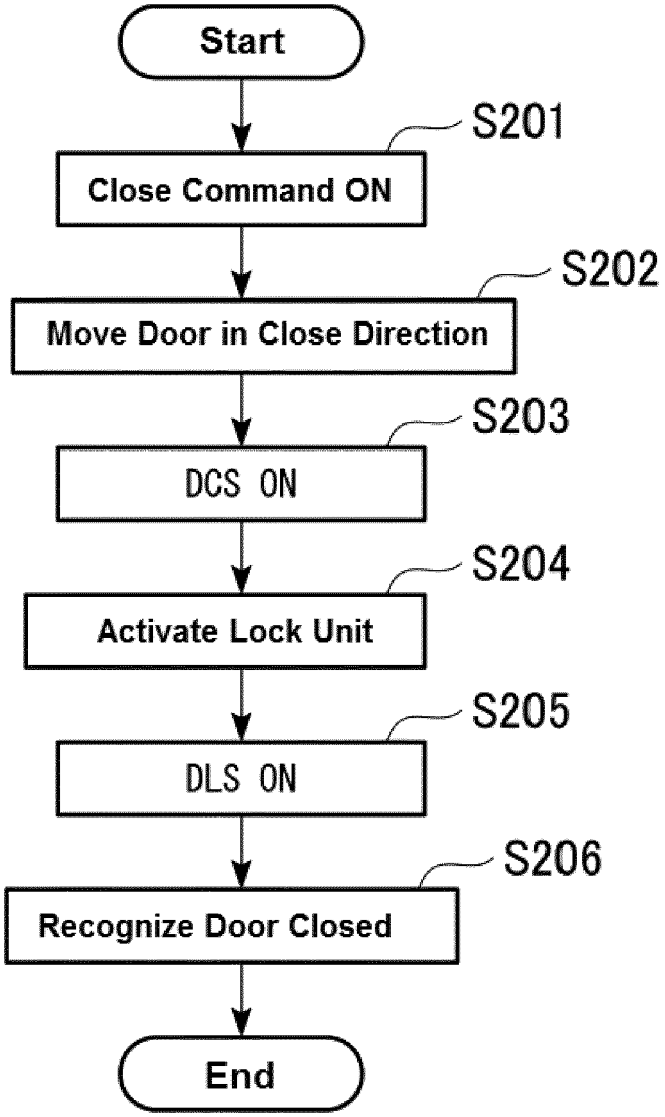
Start
S201
Close Command ON
S202
Move Door in Close Direction
S203
DCS ON
S204
Activate Lock Unit
S205
DLS ON
S206
Recognize Door Closed
End

Fig. 9

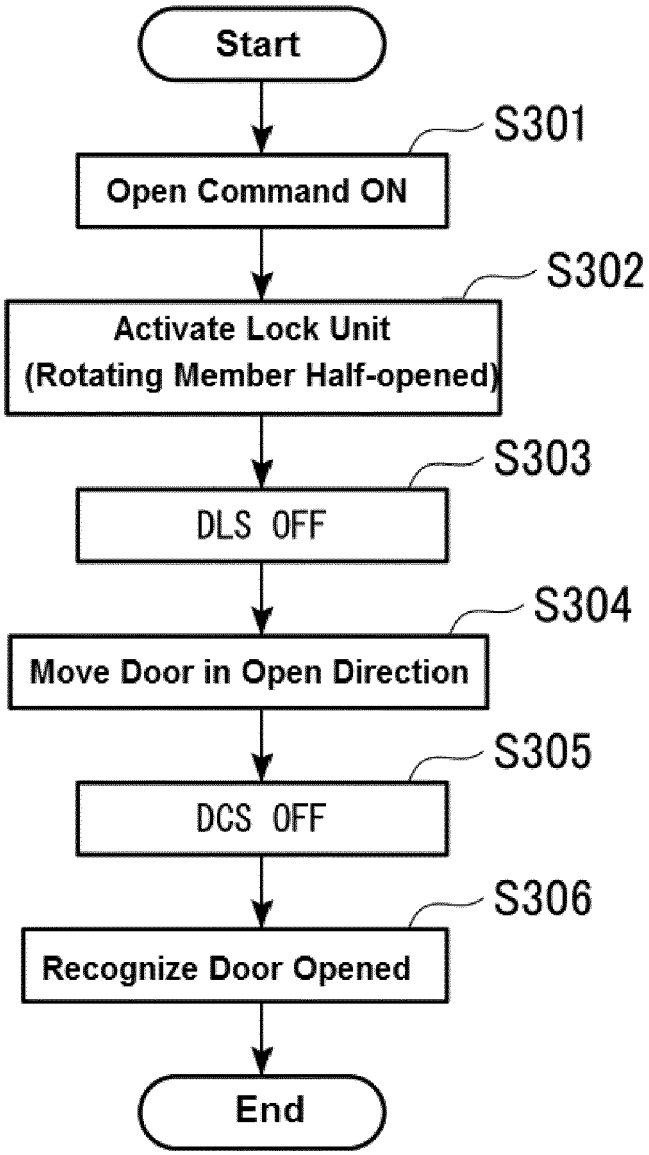
Start
S301
Open Command ON
S302
Activate Lock Unit
(Rotating Member Half-opened)
S303
DLS OFF
S304
Move Door in Open Direction
S305
DCS OFF
S306
Recognize Door Opened
End

Fig. 10

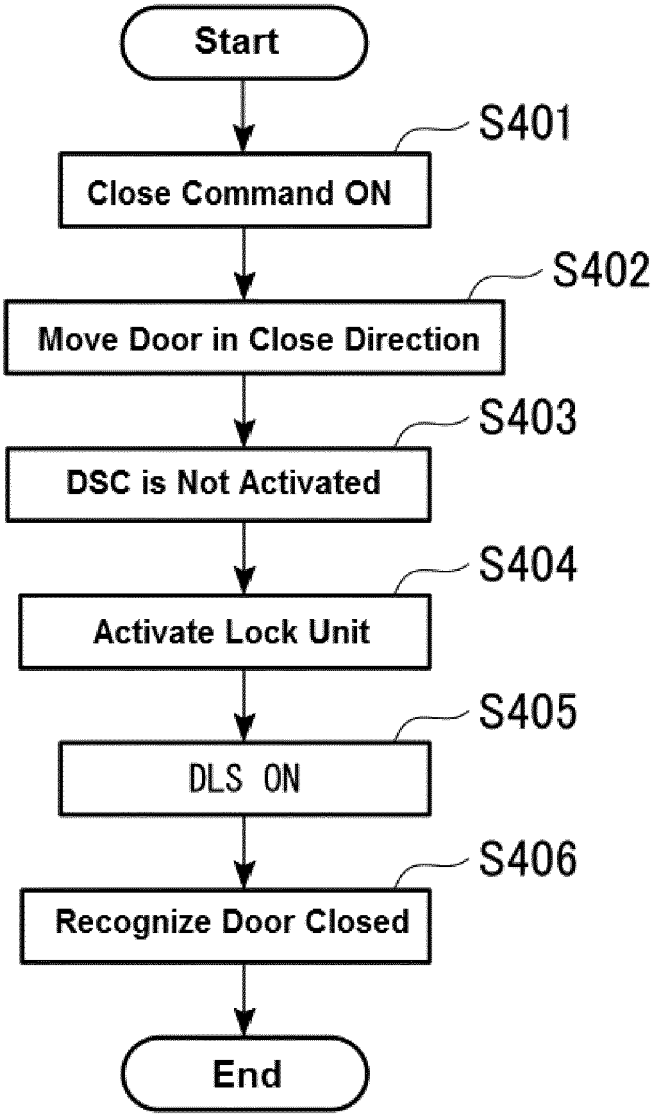
Start
S401
Close Command ON
S402
Move Door in Close Direction
S403
DSC is Not Activated
S404
Activate Lock Unit
S405
DLS ON
S406
Recognize Door Closed
End

Fig. 11

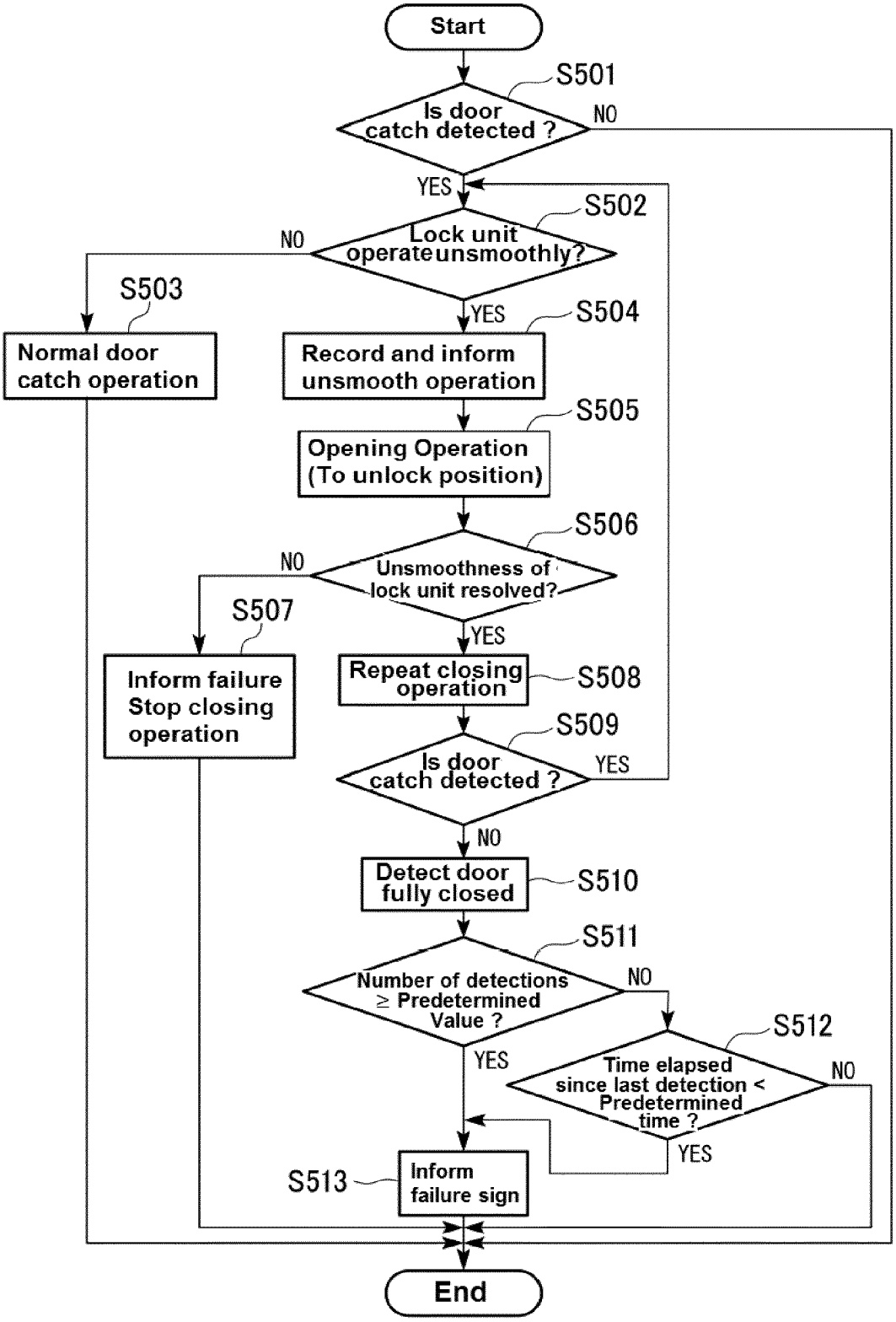
Start
S501
Is door catch detected ?
NO
YES
S502
Lock unit operate unsmoothly?
NO
YES
S503
Normal door catch operation
S504
Record and inform unsmooth operation
S505
Opening Operation (To unlock position)
S506
Unsmoothness of lock unit resolved?
NO
YES
S507
Inform failure Stop closing operation
Repeat closing operation
S508
S509
Is door catch detected ?
YES
NO
Detect door fully closed
S510
S511
Number of detections ≥ Predetermined Value ?
NO
YES
S512
Time elapsed since last detection < Predetermined time ?
NO
YES
S513
Inform failure sign
End

Fig. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 8757

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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E05F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	9 November 2022	Rémondot, Xavier

CATEGORY OF CITED DOCUMENTS

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