(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 317 643 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.02.2024 Bulletin 2024/06

(21) Application number: **23187739.0**

(22) Date of filing: **26.07.2023**

(51) International Patent Classification (IPC):
E05F 15/632 *(2015.01)* ***E05F 15/635*** *(2015.01)*

(52) Cooperative Patent Classification (CPC):
E05F 15/632; E05F 15/635; E05Y 2201/22; E05Y 2201/72; E05Y 2201/722; E05Y 2400/44; E05Y 2400/502; E05Y 2400/554; E05Y 2900/51

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

(30) Priority: **01.08.2022 JP 2022122940**

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(54) **ABNORMALITY IDENTIFICATION DEVICE, ABNORMALITY IDENTIFICATION METHOD, AND COMPUTER-READABLE STORAGE MEDIUM**

(57) An abnormality identification device (1) according to one aspect of the invention includes: a vibration obtaining unit (40) obtaining vibration information that indicates a vibration generated during opening and closing movements of a door leaf (3R, 3L) of a door device (2) for opening and closing a doorway of a railway vehicle; a determination unit (42) determining whether there is an abnormality of the door device (2) by comparing the vibration indicated by the obtained vibration information with a predetermined vibration reference value; a movement obtaining unit (44) obtaining movement information that indicates an elapsed time or a displacement of the door leaf (3R, 3L) of the door device (2) from start of operation of the door device (2) to a specific point in time at which abnormality is determined by the determination unit (42); and an identification unit (46) identifying a component related to an operation of the door device (2) at the specific point in time among a plurality of components of the door device (2) using the movement information.

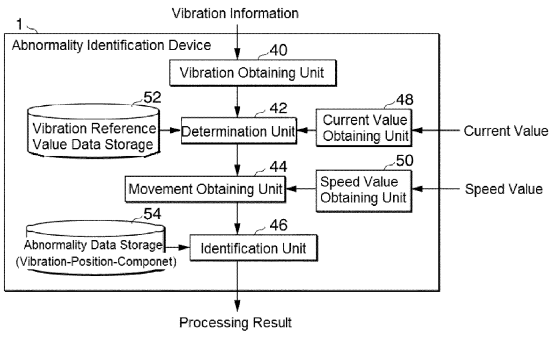

Fig. 4

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Description

TECHNICAL FIELD

[0001] The present invention relates to an abnormality identification device, an abnormality identification method, and a computer-readable storage medium.

BACKGROUND

[0002] A door controller for monitoring door operation using sensor signals has been known as described, for example, in Patent Literature 1. The door controller of Patent Literature 1 converts a time-domain signal provided by a triaxial accelerometer into a frequency-domain signal by Fourier transformation, analyzes the amplitude of the signal at each frequency, and identifies the cause of a door failure.

RELEVANT REFERENCES

LIST OF RELEVANT PATENT LITERATURE

[0003] Patent Literature 1: Specification of U.S. Patent No. 11028630

SUMMARY

[0004] However, the door controller of Patent Literature 1 needs to convert the time-domain sensor signal to the frequency-domain signal in order to identify the cause of the failure, which results in a high processing load.

[0005] In view of the above, one object of the present disclosure is to provide an abnormality identification device, an abnormality identification method, and a computer-readable storage medium that can reduce the load of processing for identifying the cause of a failure.

[0006] An abnormality identification device according to one aspect of the invention includes: a vibration obtaining unit obtaining vibration information that indicates a vibration generated during opening and closing movements of a door leaf of a door device for opening and closing a doorway of a railway vehicle; a determination unit determining whether there is an abnormality of the door device by comparing the vibration indicated by the obtained vibration information with a predetermined vibration reference value; a movement obtaining unit obtaining movement information that indicates an elapsed time or a displacement of the door leaf of the door device from start of operation of the door device to a specific point in time at which abnormality is determined by the determination; and an identification unit identifying a component related to an operation of the door device at the specific point in time among a plurality of components of the door device using the movement information.

[0007] An abnormality identification method according to another aspect of the invention includes: obtaining vibration information that indicates a vibration generated during opening and closing movements of a door leaf of a door device that opens or closes a doorway of a railway vehicle, and movement information that indicates an elapsed time or a displacement of the door leaf from start of operation of the door device; determining whether there is an abnormality of the door device by comparing the vibration indicated by the vibration information with a predetermined vibration reference value; and identifying, from among the plurality of the components of the door device, a component related to an operation of the door device at a specific point in time when it is determined that there is the abnormality, the component being identified using an elapsed time or a displacement of the door leaf from the start of operation of the door device to the specific point in time.

[0008] A computer-readable storage medium according to yet another aspect of the invention stores a program for causing a computer of a door device that controls opening and closing of a door leaf that opens and closes a doorway of a railway vehicle to: output an open or close command to the door device; obtain vibration information that indicates a vibration generated during opening and closing movements of the door leaf and movement information that indicates an elapsed time or a displacement of the door leaf from start of operation of the door device; determine whether there is an abnormality of the door device by comparing the vibration indicated by the vibration information with a predetermined vibration reference value; and identify, from among the plurality of the components of the door device 2, a component related to an operation of the door device 2 at a specific point in time when it is determined that there is the abnormality, the component being identified using an elapsed time or a displacement of the door leaf from the start of operation of the door device 2 to the specific point in time.

ADVANTAGEOUS EFFECTS

[0009] The above drive transmission device and construction machine can secure sufficient mechanical strength while their sizes can be reduced

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is an external view of an electric door device (railway vehicle door device, automatic door device) with a built-in abnormality identification device according to a first embodiment of the present invention.

Fig. 2 specifically illustrates a structure around a motor of the electric door device.

Fig. 3 is a block diagram schematically showing a configuration of a control system of the electric door device.

Fig. 4 is a block diagram showing an example of a

functional configuration of an abnormality identification device in the electric door device.

Fig. 5 is a flowchart showing exemplary steps of a process performed in the door opening-closing control unit in the electric door device.

Fig. 6 is a diagram showing the position (stroke) of a door, vibration, sound pressure, and current value relating to the electric door device with reference to a time axis while the door moves from a fully closed position to a fully opened position.

Fig. 7 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value relating to the electric door device with reference to the time axis when a malfunction of a lock unit occurs.

Fig. 8 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value relating to the electric door device with reference to the time axis when a malfunction of the lock unit occurs.

Fig. 9 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value relating to the electric door device with reference to the time axis when a malfunction of a guide rail occurs.

Fig. 10 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value relating to the electric door device with reference to the time axis when a malfunction of a motor occurs.

Fig. 11 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value relating to the electric door device with reference to the time axis when a malfunction of a motor occurs.

Fig. 12 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value relating to the electric door device with reference to the time axis when a malfunction of a door roller occurs.

Fig. 13 is a flowchart showing exemplary steps of a process performed in a determination unit provided in the electric door device.

Fig. 14 schematically illustrates an example of a pneumatic door device equipped with an abnormality identification device according to a second embodiment of the invention, illustrated is the door device in the closed state.

Fig. 15 schematically illustrates the pneumatic door device in the open state.

Fig. 16 is a sectional view of a cylinder portion of the pneumatic door device, viewed in section including the central axis line.

Fig. 17 is a block diagram schematically showing a configuration of a control system provided in the pneumatic door device.

Fig. 18 is a block diagram showing an example of a functional configuration of an abnormality identification device provided in the pneumatic door device.

Fig. 19 illustrates an example of the position (stroke) [mm] of door leaves air pressure [Pa] supplied to the cylinder portion, and door roller vibration information relating to the pneumatic door device with reference to the time axis.

Fig. 20 illustrates an example of the position (stroke) [mm] of the door leaves, air pressure [Pa] supplied to the cylinder portion, and door roller vibration information relating to the pneumatic door device with reference to the time axis when a malfunction of the door roller occurs.

Fig. 21 illustrates an example of the position (stroke) [mm] of the door leaves, air pressure [Pa] supplied to the cylinder portion, and vibration information of a door separating mechanism relating to the pneumatic door device with reference to the time axis.

Fig. 22 illustrates an example of the position (stroke) [mm] of the door leaves, air pressure [Pa] supplied to the cylinder portion, and the door roller vibration information relating to the pneumatic door device with reference to the time axis when a malfunction of the door separating mechanism occurs.

Fig. 23 illustrates an example of the position (stroke) [mm] of the door leaves, air pressure [Pa] supplied to the cylinder portion, and door roller vibration information relating to the pneumatic door device with reference to the time axis.

Fig. 24 illustrates an example of the position (stroke) [mm] of the door leaves, air pressure [Pa] supplied to the cylinder portion, and the door roller vibration information relating to the pneumatic door device with reference to the time axis when a malfunction of the cylinder occurs.

Fig. 25 illustrates an example of the position (stroke) [mm] of the door leaves, air pressure [Pa] supplied to the cylinder portion, and vibration information of the changeover valve portion (a first solenoid valve and/or second solenoid valve) relating to the pneumatic door device with reference to the time axis.

Fig. 26 illustrates an example of the position (stroke) [mm] of the door leaves, air pressure [Pa] supplied to the cylinder portion, and vibration information of the changeover valve portion relating to the pneumatic door device with reference to the time axis when a malfunction of the changeover valve portion occurs.

Fig. 27 illustrates an example of the position (stroke) [mm] of the door leaves, air pressure [Pa] supplied to the cylinder portion, and exhaust silencer vibration information relating to the pneumatic door device with reference to the time axis.

Fig. 28 illustrates an example of the position (stroke) [mm] of the door leaves, air pressure [Pa] supplied to the cylinder portion, and exhaust silencer vibration information relating to the pneumatic door device with reference to the time axis when a malfunction of the exhaust silencer occurs.

Fig. 29 illustrates an abnormality identification device according to a third embodiment of the inven-

tion, and shows one example of a case in which the door device is tilted.

Fig. 30 is a perspective view of another example of the case in which the door device is tilted.

Fig. 31 is a longitudinal sectional view of the door leaf of the door device when it is not tilted.

Fig. 32 is a longitudinal sectional view of the door leaf of the door device when an external force is applied to the door leaf by passengers.

Fig. 33 is a longitudinal sectional view of the door leaf when the vehicle body equipped with the door device is tilted.

Fig. 34 is a block diagram showing an example of a functional configuration of an abnormality identification device provided in the door device.

Fig. 35 is a flowchart showing exemplary steps of a process performed in the door opening-closing control unit that includes the abnormality identification device and is provided in the electric door device.

DESCRIPTION OF THE EMBODIMENTS

[0011] Embodiments of the present disclosure will now be described with reference to the appended drawings.

First Embodiment

[0012] Fig. 1 is an external view of an electric door device 2 (railway vehicle door device, automatic door device) with a built-in abnormality identification device according to the first embodiment. The electric door device 2 is installed, for example, in railway vehicles. In Fig. 1, for example, the X direction is a left-right direction, the Y direction is an upper-lower direction, and the X and Y directions are orthogonal to each other.

[0013] The electric door device 2 includes a pair of door leaves 3R and 3L constituting a sliding door. Above the door leaves 3R and 3L (in +Y direction), a guide rail 4, a door hanging device 5R supporting the right door leaf 3R and a door hanging device 5L supporting the left door leaf 3L are provided. The door hanging device 5R and door leaf 3R are integrally movable along the guide rail 4. Likewise, the door hanging device 5L and door leaf 3L are integrally movable along the guide rail 4. The leading edge of the door leaves 3R and 3L has a rubber 7 attached thereto, which is made of a soft synthetic rubber material.

[0014] In the door hanging devices 5R and 5L, a plurality of rollers 6 are provided, as shown by the dotted lines in Fig. 1. The rollers 6 roll while remaining in contact with the upper or lower surface of the guide rail 4.

[0015] Above the guide rail 4, a right rack gear 8R and a left rack gear 8L are provided and extend in the direction in which the guide rail 4 extends. The right rack gear 8R is coupled with a right connecting bracket 9R. As the right rack gear 8R moves in the left-right (X) direction, the movement causes the right connecting bracket 9R to move in the left-right direction. Similarly, the left rack gear 8L is coupled with a left connecting bracket 9L. As the left rack gear 8L moves in the left-right direction, the movement causes the left connecting bracket 9L to move in the left-right direction. The right connecting bracket 9R is coupled with the door hanging device 5R. As the right connecting bracket 9R moves in the left-right direction, the door hanging device 5R and door leaf 3R integrally move in the left-right direction. Similarly, the left connecting bracket 9L is coupled with the door hanging device 5L. As the left connecting bracket 9L moves in the left-right direction, the door hanging device 5L and door leaf 3L integrally move in the left-right direction.

[0016] The right and left rack gears 8R and 8L mesh with a pinion gear 10, so that they are configured to convert the rotation of the pinion gear 10 into linear movement. The pinion gear 10 is rotated when acted upon by a driving force from a motor 11.

[0017] Lock pins 22R and 22L are fixed above the door hanging devices 5R and 5L. The lock pins 22R and 22L extend vertically upward. The lock pins 22R and 22L can move together with the door leaves 3R and 3L. When the door leaves 3L and 3R of the electric door device 2 are at the fully closed position, the lock pins 22R and 22L are restrained by the lock unit 20. This prevents the electric door device 2 from moving in the left-right direction.

[0018] The lock unit 20 is arranged between the door leaves 3R, 3L and the pinion gear 10 in the vertical direction. The lock unit 20 functions as a lock mechanism that restricts the door leaves 3R and 3A from moving in the door open direction when the electric door device 2 is situated at the fully closed position. The lock unit 20 is movable between a lock position where the lock unit 20 engages with the lock pins 22R and 22L to lock the door at the fully closed position of the electric door device 2 and an unlock position where the lock unit 20 is disengaged with the lock pins 22R and 22L. The lock unit 20 has a pair of rotating members (not shown) for engaging with the lock pins 22R and 22L, respectively. Each of the rotating members in the lock unit 20 is biased by an elastic force of a return spring (not shown). When the lock unit 20 is moved to the lock position by the drive of the motor 11, the lock pins 22R and 22L are engaged with the rotating members by being pushed into the rotating members. When the lock unit 20 is moved to the unlocked position by the drive of the motor 11, the lock pins 22R and 22L are released from the rotating members and the lock pins 22R and 22L are disengaged with the rotating members.

[0019] The electric door device 2 further includes a vibration sensor unit 30. The vibration sensor unit 30 detects vibration in the electric door device 2, generates vibration information indicating vibration, and supplies the vibration information to the controller 15. Although the vibration sensor unit 30 is disposed near the controller 15 in this example, it is not limited to this arrangement. The vibration sensor unit 30 may be disposed at any position where vibration of the electric door device 2 can be detected.

[0020] Fig. 2 more specifically shows the constituent parts in the vicinity of the motor 11. The electric door device 2 further includes a sun gear 13 attached around a rotational shaft 12, a plurality of planetary gears 14 surround and mesh with the sun gear 13, and the pinion gear 10 serves as an outer gear that is positioned outside the planetary gears 14 and meshes with the planetary gears 14.

[0021] When the motor 11 rotates, the rotational force of the motor 11 is transmitted to the rack gears 8R and 8L via the pinion gear 10. As the rack gears 8R and 8L move in the left-right direction as a result of the rotation of the motor 11, the door leaves 3R and 3L move in the left-right direction along the guide rails 4 via the right and left connecting brackets 9R and 9L. One or both of the door leaves 3R and 3L may be hereinafter referred to simply as a door.

[0022] The door (door leaves 3R and 3L) is movable in the left-right direction in the drawing. The movement of the door in the left-right direction opens or closes the doorway of the railway vehicle. In other words, the railway vehicle doorway is closed by the door moving in the closing direction (the direction in which the leading edges of the door leaves touch each other). As for the movement of the door in the closing direction (closing movement), the door is configured to stop after the rubbers 7 on the leading edges of the door leaves contact each other and the rubbers 7 contract to a certain degree a certain extent while touching each other. The railway vehicle doorway is opened by the door moving in the opening direction (the direction in which the leading edges of the door leaves separate from each other). As for the movement of the door in the opening direction (opening operation), the door is stopped after the entire door leaves including the rubber 7 are stored in respective door cases (not shown) formed in the vehicle body.

[0023] In the above description, the electric door device 2 may be opened or closed using the rack and pinion system, but the present disclosure is not necessarily limited to such. Any other systems (for example, belt, screw and linear motor systems) may be employed.

[0024] Fig. 3 is a block diagram schematically showing a configuration of a control system of the electric door device 2. The control system of the electric door device 2 includes, for example, the controller 15, a power supply unit 16, a motor monitor unit 17, and the vibration sensor unit 30, as shown in Fig. 3.

[0025] The power supply unit 16 includes a power unit for converting an alternating-current voltage fed from an overhead line into a direct-current voltage. The controller 15 includes a door opening-closing control unit 18, a command unit 19, and a transmission unit 29. The command unit 19 outputs, to the door opening-closing control unit 18, an opening or closing signal (command signal) for opening or closing the door. The door opening-closing control unit 18 controls the opening and closing of the door based on drive commands. The command unit 19 may also output information (e.g., it may be a drive command) that allows the abnormality identification device 1 to know what kind of drive command is being output to a PWM control unit 22.

[0026] The transmission unit 29 transmits information to the outside (e.g., an unshown management device or a mobile terminal of a maintenance worker). For example, the transmission unit 29 transmits (reports) information indicating a component identified by the abnormality identification device 1 to the outside. The transmission unit 29 may output an alert indicating that an abnormality has been identified by the abnormality identification device 1.

[0027] The door opening-closing control unit 18 includes, for example, a power-supply voltage detection unit 21, the PWM control unit 22, a motor driving unit 23, a Hall signal detection unit 24, a speed detection unit 25, and the abnormality identification device 1.

[0028] The power-supply voltage detection unit 21 is configured to detect the level of the DC voltage output from the power supply unit 16. The PWM control unit 22 is configured to generate a PWM signal for driving the motor 11 based on the level of the DC voltage detected by the power-supply voltage detection unit 21 and the drive command from the command unit 19. More specifically, the PWM control unit 22 generates the PWM signal for controlling a duty ratio of a voltage to be fed to the motor 11, based on a reference voltage commanded pattern indicated by the drive command and the voltage level of the DC signal detected by the power-supply voltage detection unit 21.

[0029] The motor driving unit 23 drives the motor 11. The motor driving unit 23 is configured to turn on or off transistors configured to drive the motor 11, based on the PWM signal. For example, when the motor 11 is a three-phase motor, the motor driving unit 23 generates gate signals for turning on or off the U-phase, V-phase and W-phase transistors.

[0030] A Hall element 26 is provided in the vicinity of the rotational shaft 12 of the motor 11. The Hall element 26 detects the number of rotations of the motor 11. In the vicinity of the motor 11, the motor monitoring unit 17 is provided. The motor monitoring unit 17 includes, in addition to the above-mentioned Hall element 26, a motor current detector 27 for detecting the motor current (value of the current running through the motor 11). The motor current detector 27 provides information indicating the motor current to the abnormality identification device 1.

[0031] The Hall signal detection unit 24 is configured to detect the number of rotations of the motor 11 based on the detection signal from the Hall element 26. The motor driving unit 23 can refer to the number of rotations of the motor 11 detected by the Hall signal detector 24 to feedback control the timing of turning on or off the transistors for driving the motor 11. The speed detection unit 25 detects the moving speed of the door from the signal detected by the hall signal detection unit 24. The speed detection unit 25 supplies information indicating the detected moving speed to the abnormality identifica-

tion device 1.

[0032] The vibration sensor unit 30 generates vibration information indicating the vibration generated in the electric door device 2 that opens and closes the doorway of the railway vehicle when the electric door device 2 moves to be opened or closed the doorway. The vibration sensor unit 30 supplies the generated vibration information to the abnormality identification device 1. The vibration sensor unit 30 may be disposed at any position provided that it can detect vibration in the electric door device 2. In addition to the sensor that detects vibration, the vibration sensor unit 30 may further include a sound pressure sensor that detects sound pressure as the vibration generated in the opening and closing movements of the door of the electric door device 2. The vibration sensor unit 30 may detect both the vibration generated in the electric door device 2 in the opening and closing movements of the electric door device 2 and the sound pressure generated in the opening and closing movements of the door of the electric door device 2.

[0033] The abnormality identification device 1 obtains vibration information indicating vibration of the electric door device 2 generated in the opening and closing movements of the door of the electric door device 2 that opens and closes the doorway of the railway vehicle, and determines whether an abnormality of the electric door device 2 occurs by comparing the vibration indicated by the obtained vibration information with a vibration reference value. The abnormality identification device 1 then obtains movement information indicating the elapsed time from the start of opening or closing movement of the electric door device 2 to a specific point in time at which the abnormality is determined or movement information indicating the opening or closing amount of the door of the electric door device 2. The abnormality identification device 1 identifies a component related to an operation of the electric door device 2 at the specific point in time among the plurality of components of the electric door device 2 using the movement information.

[0034] Fig. 4 is a block diagram showing an example of a functional configuration of the abnormality identification device 1. The abnormality identification device 1 includes, for example, a vibration obtaining unit 40, a determination unit 42, a movement obtaining unit 44, an identification unit 46, a current value obtaining unit 48, a speed value obtaining unit 50, a vibration reference value data storage 52, and an abnormality data storage 54. The functions of each component, such as the vibration obtaining unit 40, the determination unit 42, the movement obtaining unit 44, the identification unit 46, the current value obtaining unit 48, and the speed value obtaining unit 50, are realized by, for example, executing a program stored in the program memory by a computer such as a CPU (Central Processing Unit) installed in the door opening-closing control unit 18. The vibration reference value data storage 52 and the abnormality data storage 54 are implemented by various storage devices such as RAM (Random Access Memory), ROM (Read Only Memory), SSD (Solid State Drive), hard disk, etc.

[0035] The vibration obtaining unit 40 obtains the vibration information indicating the vibration generated in the opening and closing movements of the door of the electric door device 2. The determination unit 42 determines whether there is an abnormality of the electric door device 2 by comparing the vibration indicated by the vibration information obtained by the vibration obtaining unit 40 with a predetermined vibration reference value. The vibration reference value is indicated by vibration reference value data stored in the vibration reference value data storage 52. The vibration reference value data storage 52 stores the vibration reference value data indicating the vibration reference values.

[0036] The current value obtaining unit 48 obtains a current value from the motor current detector 27. The determination unit 42 may determine an abnormality of the electric door device 2 by comparing the current value obtained from the motor current detector 27 with a current reference value stored in the vibration reference value data storage 52.

[0037] The speed value obtaining unit 50 obtains a speed value from the speed detection unit 25. The movement obtaining unit 44 detects the position of the door that is moving to be opened based on the speed value from the speed value obtaining unit 50. The movement obtaining unit 44 obtains movement information indicating the elapsed time from the start of opening or closing movement of the electric door device 2 to a specific point in time at which the abnormality is determined by the determination unit 42 or indicating the opening or closing amount of the door of the electric door device 2.

[0038] The identification unit 46 identifies a component related to the operation of the electric door device 2 at the specific point in time among the plurality of components of the electric door device 2 using the movement information. The plurality of components of the electric door device 2 include the parts of the electric door device 2 described above, such as, but not limited to, the guide rail 4, the door rollers 6, the motor 11, and the lock unit 20. The identification unit 46 stores, in the abnormality data storage unit 54, abnormality data in which, for example, the vibration information, the specific point in time or the position of the door, and the identified components are associated with each other. The identification unit 46 may transmit the abnormality data as a processing result to an external device such as the unshown management device or mobile terminal of the maintenance worker.

[0039] Fig. 5 is a flowchart showing exemplary steps of a process performed in the door opening-closing control unit 18. The door opening-closing control unit 18 inputs the open or close command from the command unit 19 (step S100). The door opening-closing control unit 18 causes the motor 11 to be driven by the motor driving unit 23 to start the open or close operation of the electric door device 2 (step S102). The abnormality identification device 1 obtains the vibration information from the vibration sensor unit 30 and the position (movement informa-

tion) of the door detected based on the speed value detected by the speed detection unit 25 (step S104). The determination unit 42 of the abnormality identification device 1 determines whether there is an abnormality of the electric door device 2 by comparing the vibration indicated by the vibration information and the vibration reference value (step S106). When the determination unit 42 determines there is no abnormality of the electric door device 2 (step S106: NO), the process of the flowchart ends. When the determination unit 42 determines that there is an abnormality of the electric door device 2 (step S106: YES), the identification unit 46 identifies the component of the electric door device 2 using the movement information as of the specific time when the abnormality is determined (step S108). The identification unit 46 then records the abnormality data in the abnormality data storage 54 (step S110).

[0040] Fig. 6 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value with reference to a time axis while the door moves from a fully closed position (PC) to a fully opened position (P3). The horizontal axis in Fig. 6 represents the time and the vertical axis represents the door position. Position P0 is the fully closed position. Position P3 is the fully opened position. For convenience of explanation, Fig. 6 shows the graphs of the door position, vibration information, sound pressure information, and current value, but the vertical axis represents the position information of the door and does not represent the scales for the vibration information, sound pressure information, and current value. The same applies to Figs. 7 to 12.

[0041] The range from position P0 to position P1 and time t0 to t1 is an acceleration period in which the door is gradually accelerated to reach a constant speed in the opening movement. The range from position P1 to position P2 and time t1 to t2 is a high speed period in which the door moves at the constant high speed in the opening movement. The range from position P2 to position P3 and time t2 to t3 is a deceleration period in which the door is gradually decelerated to eventually stop in the opening movement. The range from time t3 to t4 is the period in which the door is stopped and fully opened. The range from position P3 to position P2 and time t4 to t5 is an acceleration period in which the door is gradually accelerated to reach a constant speed in the closing movement. The range from position P2 to position P1 and from time t5 to t6 is a high speed period in which the door moves at the constant high speed in the closing movement. The range from position P1 to position P0 and time t6 to t7 is a deceleration period in which the door is gradually decelerated to eventually stop in the closing movement. The acceleration, high speed, and deceleration periods are based on the open and close commands. When there is no abnormality of the electric door device 2, the vibration, sound pressure, and current value change for change according to the door position and the time as shown in Fig. 6. In Figs. 6 to 12, the change of the door position with time in the opening movement and the change of the door position with time in the closing movement are symmetrical to each other. However, the embodiment is not limited to this. The change of the door position over time in the opening movement may be asymmetrical to the change of the door position with time in the closing movement. For example, the door position at which the high speed period starts in the opening movement and the door position at which the high speed period ends in the closing movement may be different from each other. The door position at which the deceleration period starts in the opening movement and the door position at which the acceleration period ends in the closing movement may be different from each other.

[0042] Fig. 7 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value with reference to the time axis when a malfunction of the lock unit 20 occurs. The malfunction of the lock unit 20 may be caused by, for example, an increase in the load on the movement of a movable part, such as a rotating part, which prevents a smooth movement of the part and results in malfunction. For example, malfunction can be caused by rust or dust or oil on the lock unit 20. When the door leaves 3R and 3L start to open after the lock pins 22R and 22L are released from the lock unit 20, the vibration is supposed to (normally) increase (see Fig. 6), but as indicated by arrow A in Fig. 7, the vibration decreases when a malfunction of the lock unit 20 occurs. Thus, the abnormality identification device 1 uses the vibration obtaining unit 40 to obtain the vibration information indicating the vibration of the electric door device 2 when the motor 11 is driven. When the displacement of the door or the elapsed time indicated by the movement information obtained during the opening movement of the door (acceleration period) is less than or equal to the elapsed time or the displacement from the unlocking of the lock unit 20 to the start of the opening movement of the door leaves 3R and 3L, the identification unit 46 identifies the lock unit 20 as the component related to the operation of the electric door device 2. The elapsed time or the displacement of the door that is less than or equal to the elapsed time or the displacement from the unlocking of the lock unit 20 to the start of the opening movement of the door leaves 3R and 3L is, for example, the elapsed time or the displacement that is included in the acceleration period.

[0043] When a malfunction of the lock unit 20 occurs, the sound pressure increases due to friction between the lock unit 20 and the lock pins 22R and 22L, as indicated by the arrow B in Fig. 7. Thus, in the abnormality identification device 1, the vibration obtaining unit 40 obtains the vibration information indicating the sound pressure of the electric door device 2 when the motor 11 is driven. When the displacement of the door or the elapsed time indicated by the movement information obtained during the opening movement of the door is less than or equal to the elapsed time or the displacement from the unlocking of the lock unit 20 to the start of the opening movement of the door leaves 3R and 3L, the identification unit 46

identifies the lock unit 20 as the component related to the operation of the electric door device 2.

[0044] Fig. 8 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value with reference to the time axis when a malfunction of the lock unit 20 occurs. When the door leaves 3R and 3L reach the lock position in the deceleration period, the lock pins 22R and 22L normally engage with the lock unit 20, so abnormal vibration will not occur (see Fig. 6). However when a malfunction of the lock unit 20 occurs, abnormal vibration occurs at the locked position as indicated by arrow C in Fig. 8. Thus, the abnormality identification device 1 uses the vibration obtaining unit 40 to obtain the vibration information indicating the vibration of the electric door device 2 when the motor 11 is driven. When the displacement of the door or the elapsed time indicated by the movement information obtained during the closing movement of the door is greater than or equal to the elapsed time or the displacement from the start of the closing movement of the door leaves 3R and 3L to the end of the closing movement to stop at the fully closed position, the identification unit 46 identifies the lock unit 20 as the component related to the operation of the electric door device 2. The elapsed time or the displacement of the door that is greater than or equal to the elapsed time or the displacement from the start of the closing movement of the door leaves 3R and 3L to the end of the closing movement to stop at the fully closed position is, for example, the elapsed time or the displacement that is included in the deceleration period.

[0045] When a malfunction of the lock unit 20 occurs, the sound pressure increases due to friction between the lock unit 20 and the lock pins 22R and 22L, as indicated by the arrow D in Fig. 8. Thus, the abnormality identification device 1 uses the vibration obtaining unit 40 to obtain the vibration information indicating the sound pressure of the electric door device 2 when the motor 11 is driven. When the displacement of the door or the elapsed time indicated by the movement information obtained during the closing movement of the door is greater than or equal to the elapsed time or the displacement from the start of the closing movement of the door leaves 3R and 3L to the end of the closing movement to stop at the fully closed position, the identification unit 46 identifies the lock unit 20 as the component related to the operation of the electric door device 2.

[0046] Fig. 9 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value with reference to the time axis when a malfunction of the guide rail 4 occurs. When the door leaves 3R and 3L are moved in the high speed period, the vibration is normally small (see Fig. 6). However, when there is an abnormality of the guide rail 4, the vibration temporarily increases at the defective portion of the guide rail 4 as indicated by the arrows E and E' in Fig. 9. Thus, the abnormality identification device 1 determines the point in time when the vibration temporarily increases at the defective portion of the guide rail 4 as the specific point in time. The abnormality identification device 1 identifies the guide rail 4 as the component related to the operation of the electric door device 2 when the door position calculated from the movement information as of the specific time point in the period (high speed period) during which the door leaves 3R and 3L move to be opened at a constant speed coincides with the door position calculated from the movement information as of the specific time in the period (high speed period) during which the door leaves 3R and 3L move to close at a constant speed.

[0047] When the door leaves 3R and 3L are moved at the high speed, the sound pressure is normally low (see Fig. 6). However when there is an abnormality of the guide rail 4, the sound pressure temporarily increases as shown by the arrows F and F' in Fig. 9. Thus, the abnormality identification device 1 can determine the point in time when the sound pressure temporarily increases at the defective portion of the guide rail 4 as the specific point in time. When the door position calculated from the movement information as of the specific point in the period when the door leaves 3R and 3L move to be opened at a constant speed (high speed range) coincides with the door position calculated from the movement information as of the specific point in the period when the door leaves 3R and 3L move to be closed at a constant speed (high speed range), the abnormality identification device 1 can identify the guide rail 4 as the component related to the operation of the electric door device 2.

[0048] Fig. 10 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value with reference to the time axis when an abnormality of the motor 11 occurs. When there is an abnormality of the motor 11, the current value supplied to the motor 11 increases in all the periods as indicated by the arrow G in Fig. 10, compared to the current value shown in Fig. 6. When there is an abnormality of the motor 11, the abnormality is not determined by comparing the vibration information shown in Fig. 6 with that shown in Fig. 10. Thus, by comparing the current value supplied from the motor current detector 27 with the current reference value, the determination unit 42 determines whether there is an abnormality of the electric door device 2. When no abnormality is determined from the vibration information but an abnormality is determined from the current value, the identification unit 46 identifies the motor 11 as the component related to the operation of the electric door device 2. The current reference value is, for example, the current value shown in Fig. 6. Specifically, the current reference value is set to the current amplitude value in the high speed period in Fig. 6 where there is no abnormality of the motor 11, and the determination unit 42 can determine whether there is an abnormality by comparing the current amplitude value supplied from the motor current detector 27 in the high speed period with the current amplitude value in the high speed period of Fig. 6. By comparing the current value supplied from the motor current detector 27 with the current ref-

erence value, the determination unit 42 determines the abnormality of the electric door device 2, and if the abnormality is not determined from the vibration information but is determined from the current value, the identification unit 46 may identify the rubbing of the door leaves 3R and 3L against the vehicle body as the cause of the abnormality.

[0049] Fig. 11 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value with reference to the time axis when an abnormality of the motor 11 occurs. When there is an abnormality of the motor 11, the sound pressure increases in all the periods as shown by the arrow H in Fig. 11 compared to the sound pressure shown in Fig. 6. Thus, the determination unit 42 determines the abnormality of the electric door device 2 by comparing the sound pressure supplied from the vibration sensor unit 30 with the sound pressure reference value. When no abnormality is determined from the vibration information but an abnormality is determined from the sound pressure, the identification unit 46 identifies the motor 11 as the component related to the operation of the electric door device 2. The sound pressure reference value may be set, for example, to the sound pressure in the high speed period of Fig. 6. The determination unit 42 can determine the presence or absence of an abnormality by comparing the sound pressure in the high speed period provided by the vibration sensor unit 30 with the sound pressure reference value. The determination unit 42 may determine the presence or absence of an abnormality based on at least one of the result of comparing the sound pressure acquired in the high speed period in the door opening movement with the sound pressure reference value or the results of comparing the sound pressure acquired in the high speed period in the door closing movement with the sound pressure reference value. The determination unit 42 may determine the abnormality of the electric door device 2 by comparing the sound pressure provided by the vibration sensor unit 30 with the sound pressure reference value. When it is determined from the sound pressure that there is the abnormality, the identification unit 46 may identify rubbing between the door leaves 3R and 3L and the vehicle body as the cause of the abnormality.

[0050] Fig. 12 is a diagram showing the position (stroke) of the door, vibration, sound pressure, and current value with reference to the time axis when an abnormality of the door roller(s) 6 occurs. When there is an abnormality of the door roller 6, abnormal vibration occurs at regular intervals in all the periods, as indicated by the arrow I in Fig. 12, compared with the current value shown in Fig. 6. Thus, the determination unit 42 determines whether there is an abnormality of the electric door device 2 by comparing the change in the sound pressure provided from the vibration sensor unit 30 with the sound pressure reference value. When it is determined from the sound pressure that there is the abnormality, the identification unit 46 identifies the door roller 6 as the component related to the operation of the electric door device 2. The sound pressure reference value may be set, for example, to the change in the sound pressure in the high speed period of Fig. 6. The determination unit 42 can determine the presence or absence of an abnormality by comparing the change in the sound pressure in the high speed period provided by the vibration sensor unit 30 with the sound pressure reference value.

[0051] Fig. 13 is a flowchart showing exemplary steps of a process performed in the identification unit 46. The identification unit 46 starts the process of the flowchart after the determination unit 42 determines that there is an abnormality in step S106 described above. The identification unit 46 determines whether the specific point in time when the determination unit 42 determined that there is an abnormality is within the acceleration period in the opening movement (step S120) based on the elapsed time up to the specific point in time or the movement information indicating the opening or closing amount of the electric door device 2. When the specific point in time is within the acceleration period in the opening movement (step S120: YES), the identification unit 46 identifies the lock unit 20 (step S122). The identification unit 46 determines whether the specific point in time is within the deceleration period in the closing movement based on the movement information (step S124). When the specific point in time is within the deceleration period in the opening movement (step S124: YES), the identification unit 46 identifies the lock unit 20 (step S126).

[0052] The identification unit 46 determines whether the specific point in time is within the high speed period in the opening or closing movement based on the movement information (step S128). When the specific point in time is within the high speed period in the opening or closing movement (step S128: YES), the identification unit 46 determines whether the door position calculated from the movement information at the specific point in time in the opening movement coincides with the door position calculated from the movement information at the specific point in time in the closing movement (step S130). When the door positions coincide with each other (step S130: YES), the identification unit 46 identifies the guide rail 4 (step S126).

[0053] When it is determined that there is no abnormality in the vibration information and it is determined that there is an abnormality in the current value or the sound pressure in the all the periods in which the electric door device 2 operates (step S134: YES), the identification unit 46 identifies the motor 11 (step S136). When it is determined that an abnormal vibration occurs at regular intervals in all the periods in which the electric door device 2 operates (step S138: YES), the identification unit 46 identifies the door roller 6 (step S140).

[0054] As described above, the abnormality identification device 1 of the first embodiment includes: the vibration obtaining unit 40 that obtains the vibration information indicating a vibration generated during the opening and closing movements of the door of the electric door device 2 (door device) for opening and closing the door-

way of the railway vehicle; the determination unit 42 that determines whether there is an abnormality of the electric door device 2 by comparing the vibration indicated by the obtained vibration information with a predetermined vibration reference value; the movement obtaining unit 44 that obtains the movement information indicating the elapsed time from the start of operation of the electric door device 2 to a specific point in time at which the abnormality is determined by the determination unit 42 or indicating the opening or closing amount of the door of the electric door device 2; and the identification unit 46 that identifies a component related to the operation of the electric door device 2 at the specific point in time among the plurality of components of the electric door device 2 using the movement information. The abnormality identification device 1 of the first embodiment can provide an abnormality identification method. The method includes: obtaining the vibration information indicating vibration generated during the opening and closing movements of the electric door device 2 that opens or closes the doorway of the railway vehicle, and the movement information indicating the elapsed time from the start of operation of the electric door device 2 or indicating the opening or closing amount of the door of the electric door device 2 (for example, step S104); determining whether there is an abnormality of the electric door device 2 by comparing the vibration indicated by the vibration information and the predetermined vibration reference value (for example, step S106); and identifying, from among the plurality of the components of the electric door device 2, a component of the electric door device 2 related to an operation of the electric door device 2 at the specific point in time by using the elapsed time from the start of operation of the electric door device 2 to the specific point in time at which it is determined that there is the abnormality or the opening or closing amount of the door of the electric door device 2 (for example, step S108). The abnormality identification device 1 of the first embodiment can provide a program. The program causes a computer (for example, the door opening-closing control unit 18) of the electric door device 2 that controls opening and closing of the door for the doorway of the railway vehicle to: output the open or close command to the electric door device 2 (for example, step S100); obtain the vibration information indicating vibration generated during the opening and closing movements of the electric door device 2 and the movement information indicating the elapsed time from the start of operation of the electric door device 2 or indicating the opening or closing amount of the door of the electric door device 2 (for example, step S102); determine whether there is an abnormality of the electric door device 2 by comparing the vibration indicated by the vibration information and the predetermined vibration reference value (for example, step S106); and identify, from among the plurality of the components of the electric door device 2, a component of the electric door device 2 related to an operation of the electric door device 2 at the specific point in time by using the elapsed time from the start of operation of the electric door device 2 to the specific point in time at which it is determined that there is the abnormality or the opening or closing amount of the door of the electric door device 2 (for example, step S108). Therefore, with the abnormality identification device 1, it is possible to identify which of the plurality of components of the electric door device 2 is the cause of the abnormality of the electric door device 2 without requiring a process to convert the time-domain vibration into the frequency domain. As a result, the abnormality identification device 1 can reduce the load of the processing to identify the cause of the failure.

[0055] In the abnormality identification device 1 of the first embodiment, the plurality of components include the motor 11 that powers the door leaves 3R and 3L to move to be opened or closed, and the lock unit 20 that receives power from the motor 11 and lock the door leaves 3R and 3L after the door leaves 3R and 3L reach the fully closed position after the closing movement. The vibration obtaining unit 40 may obtain the vibration information indicating vibration of the electric door device 2 when the motor 11 is driven. When the displacement of the door or the elapsed time indicated by the movement information obtained during the closing movement is greater than or equal to the elapsed time or the displacement from the start of the closing movement of the door leaves 3R and 3L to the end of the closing movement to stop at the fully closed position, the identification unit 46 may identify the lock unit 20 as the component related to the operation of the electric door device 2. With this abnormality identification device 1, it is possible to reduce the load of the processing to identify the lock unit 20 as the cause of the failure.

[0056] In the abnormality identification device 1 of the first embodiment, the plurality of components include the motor 11 that powers the door leaves 3R and 3L to move to be opened or closed, and the lock unit 20 that receives power from the motor 11 and unlocks the door leaves 3R and 3L before the door leaves 3R and 3L start to move to be opened. The vibration obtaining unit 40 may obtain the vibration information indicating vibration of the electric door device 2 when the motor 11 is driven. When the displacement of the door or the elapsed time indicated by the movement information obtained during the opening movement of the door is less than or equal to the elapsed time or the displacement from the unlocking of the lock unit 20 to the start of the opening movement of the door leaves 3R and 3L, the identification unit 46 may identify the lock unit 20 as the component related to the operation of the electric door device 2. With this abnormality identification device 1, it is possible to reduce the load of the processing to identify the lock unit 20 as the cause of the failure.

[0057] In the abnormality identification device 1 of the first embodiment, the plurality of components include the door roller attached to each of the door leaves 3R and 3L, and the guide rail 4 that the door roller contacts and

rolls on. When the door position calculated from the movement information as of the specific point in the period when the door leaves 3R and 3L move to be opened at a constant speed coincides with the door position calculated from the movement information as of the specific point in the period when the door leaves 3R and 3L move to close at a constant speed, the abnormality identification unit 46 may identify the guide rail 4 as the component related to the operation of the electric door device 2. With this abnormality identification device 1, it is possible to reduce the load of the processing to identify the guide rail 4 as the cause of the failure.

[0058] In the abnormality identification device 1 of the first embodiment, the electric door device 2 includes the motor 11 that generates a driving force to move the door leaves 3R and 3L to be opened or closed as one of the components. The abnormality identification device 1 includes the current value obtaining unit 48 that obtains the current value information indicating the current value supplied to the motor 11. The determination unit 42 further determines whether there is an abnormality of the electric door device 2 by comparing the current value indicated by the obtained current value information with the current reference value. When no abnormality is determined from the vibration information but an abnormality is determined from the current value information, the identification unit 46 identifies the motor 11 as the component related to the operation of the electric door device 2. With this abnormality identification device 1, it is possible to reduce the load of the processing to identify the motor 11 as the cause of the failure.

[0059] In the abnormality identification device 1 of the first embodiment, the electric door device 2 includes the motor 11 that generates a driving force to move the door leaves 3R and 3L to be opened and closed. The abnormality identification device 1 includes the sound pressure obtaining unit (vibration obtaining unit 40) that obtains sound pressure information indicating the sound pressure generated during the opening and closing movements of the electric door device 2. When no abnormality is determined from the vibration information and the sound pressure exceeds the sound pressure reference value in the period from the start to the end of the opening or closing movement, the identification unit 46 identifies the motor 11 as the component related to the operation of the electric door device 2. With this abnormality identification device 1, it is possible to reduce the load of the processing to identify the motor 11 as the cause of the failure.

Second Embodiment

[0060] The second embodiment of the invention will be hereinafter described. The door device of the second embodiment is a pneumatic door device 2A, and an abnormality identification device 1A in this second embodiment is provided in the pneumatic door device 2A. For purposes of clarity and brevity, like elements and components are labeled with same or similar designations and numbering as discussed in the first embodiment and description of such elements will be hereunder omitted. The description of the second embodiment will focus on the points that differ from the first embodiment described above.

[0061] Fig. 14 schematically shows an example of the pneumatic door device 2A in the closed state. Fig. 15 schematically shows an example of the pneumatic door device 2A in the opened state. Fig. 16 is a sectional view of a cylinder portion viewed in section including the central axis line. The pneumatic door device 2A includes, for example, a connecting fitting 102, an upper rack 104, a connecting fitting 106, a lower rack 108, a cylinder portion 110, a cushion cylinder 112, a piston 114, a piston shaft 115, a closing cushion throttle 116, an opening cushion throttle 118, a closing speed throttle 120, and check valves 122, 124. The connecting fitting 102 is connected to the door hanging device 5 via a door leaf connecting plate 5a (door hanger). The upper rack 104 and piston shaft 115 are connected to the connecting fitting 102. The connecting fitting 106 is connected to the door hanging device 5 via the door leaf connecting plate 5a. The lower rack 108 is connected to the connecting fitting 106. In the cylinder portion 110, the piston 114 moves in a pressure chamber formed in the cushion cylinder 112 in the left-right direction (X direction). The piston 114 is connected to the piston shaft 115 and is disposed inside the cushion cylinder 112. The piston shaft 115 is connected to the upper rack 104 via the coupling fitting 102.

[0062] The pneumatic door device 2A further includes, for example, a door separating mechanism 130, a pinion 132, a door switch 134, and a switch push rod 136. Driving force from the upper rack 104 and the lower rack 108 is transmitted to the pinion 132.

[0063] The pneumatic door device 2A further includes, for example, a strainer 140, a changeover valve unit 150, and a manual push button 160. The changeover valve unit (changeover valve) 150 includes, for example, a first solenoid valve 152 and a second solenoid valve 154. The strainer 140 and the second solenoid valve 154 are connected via an air passage 142a. The second solenoid valve 154 and the cylinder portion 110 are connected via an air passage 142b. The cylinder portion 110 and the first solenoid valve 152 are connected via an air passage 142c. The first solenoid valve 152 and an exhaust silencer 144 are connected via an air passage 142d.

[0064] When air is supplied from the air passage 142b to the cylinder portion 110 as shown in Fig. 14, the piston 114 is moved to the right, the upper rack 104 also moves to the right, which rotates the pinion 132 to the right. The rotation of the pinion 132 to the right moves the lower rack 108 to the left. In this way, the pneumatic door device 2A drives the door leaves 3R and 3L in the closing direction. When the piston 114 is moved to the left by air supplied to the cylinder portion 110 from the air passage 142c as shown in Fig. 15, the upper rack 104 also moves to the left, which rotates the pinion 132 to the left. The

rotation of the pinion 132 to the left moves the lower rack 108 to the right. In this way, the pneumatic door device 2A drives the door leaves 3R and 3L in the opening direction.

[0065] The closed state of the pneumatic door device 2A shown in Fig. 14 will be now described. In the closed state of the pneumatic door device 2A, the first solenoid valve 152 and the second solenoid valve 154 are demagnetized. In the demagnetized state, pressure air from an air source (not shown) flows through the strainer 140, air passage 142a, second solenoid valve 154, air passage 142b, and air passage 142f in this order, and then the air is supplied to a left pressure chamber in the cylinder section 110 through the check valve 124, open cushion throttle 118, and open speed throttle 121. A right pressure chamber is communicated with the atmosphere through the air passage 142e, air passage 142c, first solenoid valve 152, air passage 142d, and exhaust silencer 144. Thus, the piston 114 is pressed to the right side and moves the door leaf 3R to the closed position via the connecting fitting 102 connected to the end of the piston shaft 115. Since the upper rack 104 is connected by the connecting fitting 102, the movement of the piston 114 is transmitted to the lower rack 108 via the pinion 132, which also moves the door leaf 3L to the closed position via the connecting fitting 106.

[0066] The opened state of the pneumatic door device 2A shown in Fig. 15 will be now described. When the open command is supplied, the first solenoid valve 152 and the second solenoid valve 154 are excited. When the first solenoid valve 152 and the second solenoid valve 154 are excited, the pressure air passes through the strainer 140, air passage 142a, first solenoid valve 152, air passage 142c, and air passage 142e, and then through the check valve 122, closing cushion throttle 116, and closing speed throttle 120, and the pressure air is supplied to the right pressure chamber of the cylinder portion 110. The pressure air in the left pressure chamber is discharged to the atmosphere from the opening cushion throttle 118 and opening speed throttle 121 through the air passage 142f, air passage 142b, second solenoid valve 154, air passage 142d, and exhaust silencer 144. As a result, the piston 114 begins to move to the left, and the door leaf 3L is moved to the left to be opened by the movement of piston shaft 115 and upper rack 104. At the same time, the lower rack 108 moves to the right by the pinion 132, and the door leaf 3R directly connected to the lower rack 108 is moved to the right to be opened. The pneumatic door device 2A can adjust the opening speed of door leaves 3R and 3L by adjusting the amount of air discharged from the cylinder portion 110 by controlling the opening speed throttle 121.

[0067] Fig. 16 illustrates the cushioning action. When the piston 114 moves and a left end of the cushion cylinder 112 hits a left end of the cylinder portion 110, the pressure chamber in the cushion cylinder 112 is blocked from communicating with the open speed throttle 121, leaving only the opening cushion throttle 118 as the exhaust passage. Thus, the amount of pressure air discharged from the left pressure chamber of the cylinder unit 110 is reduced, the pressure in the cushion cylinder 112 temporarily increases due to the moving inertia force of the door leaves 3R and 3L, thus causing a cushioning action, after which the door leaves 3R and 3L are moved to the left and right respectively with a reduced speed to complete the opening operation. The opening speed of the door leaves 3R and 3L after the cushioning action can be adjusted by the opening cushion throttle 118.

[0068] The close command is generated when the door leaves 3R and 3L that are opened are operated to be closed. The pneumatic door device 2A causes the first solenoid valve 152 and the second solenoid valve 154 to be demagnetized in response to the close command. When the first solenoid valve 152 and the second solenoid valve 154 are demagnetized, the pressure air passes through the strainer 140, air passage 142a, second solenoid valve 154, air passage 142b, and air passage 142f, and then through the check valve 124, opening cushion throttle 118, and opening speed throttle 121, and the pressure air is supplied to the left pressure chamber of the cylinder portion 110. At the same time that pressure air is supplied to the left pressure chamber of the cylinder portion 110, the pressure air in the right pressure chamber is discharged to the atmosphere. This causes the piston 114 to move to the right and the door leaves 3R and 3L to move in the closing direction. When the piston 114 moves and a right end of the cushion cylinder 112 hits a right end of the cylinder portion 110, the cushioning action occurs, after which the door leaves 3R and 3L are moved in the left and right directions respectively at a reduced speed, completing the closing operation. The pneumatic door device 2A can adjust the opening speed of door leaves 3R and 3L by adjusting the amount of air discharged from the cylinder portion 110 by controlling the closing speed throttle 120.

[0069] At the time of inspection, adjustment, or power failure of the pneumatic door device 2A, the door leaves 3R and 3L can be opened and closed in response to operation of the manual push button 160. When the manual push button 160 is pressed to open the door leaves 3R and 3L, plungers of the first solenoid valve 152 and the second solenoid valve 154 are pushed and the same state occurs as when the first solenoid valve 152 and the second solenoid valve 154 are excited, which opens the door leaves 3R and 3L. While the manual push button 160 is kept pressed, the door leaves 3R and 3L remain at the opened position. When the manual push button 160 is released, the door leaves 3R and 3L are closed because the manual push button 160 is returned by a return spring.

[0070] Fig. 17 is a block diagram schematically showing a configuration of a control system of the pneumatic door device 2A. The control system of the pneumatic door device 2A includes, for example, a controller 15A, a power supply 16A, a changeover valve 150, and a vibration sensor 30A, as shown in Fig. 17.

[0071] The power supply unit 16A includes a power unit for converting an alternating-current voltage fed from an overhead line into a direct-current voltage. The controller 15 includes a door opening-closing control unit 18A, a command unit 19A, and a transmission unit 29A. The command unit 19A outputs, to the door opening-closing control unit 18A, an opening or closing signal (command signal) for opening or closing the door. The door opening-closing control unit 18A controls the opening and closing of the door based on the open and close commands.

[0072] The transmission unit 29A transmits information to the outside (e.g., an unshown management device or a mobile terminal of a maintenance worker). For example, the transmission unit 29A transmits (reports) information indicating a component identified by the abnormality identification device 1Ato the outside. The transmission unit 29A may output an alert indicating that an abnormality has been identified by the abnormality identification device 1A.

[0073] The door opening-closing control unit 18A includes, for example, a solenoid valve control unit 150A and the abnormality identification device 1A. The solenoid valve control unit 150A controls the power supply voltage supplied to the first solenoid valve 152 and the first solenoid valve 152 of the solenoid valve control section 150A from the power supply unit 16A. The solenoid valve control unit 150A thereby excites and de-magnetizes the first solenoid valve 152 and the second solenoid valve 154.

[0074] The vibration sensor unit 30A generates vibration information indicating the vibration generated in the pneumatic door device 2A that opens and closes the doorway of the railway vehicle during the opening and closing movement of the pneumatic door device 2A. The vibration sensor unit 30A is installed, for example, but not exclusively, in the vicinity of the door separating mechanism 130. The vibration sensor unit 30A supplies the generated vibration information to the abnormality identification device 1A. The vibration sensor unit 30A may be disposed at any position provided that it can detect vibration in the pneumatic door device 2A. In addition to the sensor that detects vibration, the vibration sensor unit 30A may further include a sound pressure sensor that detects sound pressure as the vibration generated in the pneumatic door device 2A during the opening and closing operation of the door of the pneumatic door device 2A. The vibration sensor unit 30A may detect both the vibration generated in the pneumatic door device 2A during the opening and closing operation of the pneumatic door device 2A and the sound pressure generated during the opening and closing movements of the door of the pneumatic door device 2A.

[0075] The abnormality identification device 1A obtains vibration information indicating vibration of the pneumatic door device 2A generated in the opening and closing movements of the door of the pneumatic door device 2A, and determines whether an abnormality of the pneumatic door device 2A occurs by comparing the vibration indicated by the obtained vibration information with a predetermined vibration reference value. The abnormality identification device 1A then obtains movement information indicating the elapsed time from the start of operation of the pneumatic door device 2A to a specific point in time at which the abnormality is determined or movement information indicating the opening or closing amount of the door of the pneumatic door device 2A. The abnormality identification device 1A identifies a component related to an operation of the pneumatic door device 2A at the specific point in time among the plurality of components of the pneumatic door device 2A using the movement information.

[0076] Fig. 18 is a block diagram showing an example of a functional configuration of the abnormality identification device 1A. The abnormality identification device 1A includes, for example, a vibration obtaining unit 40A, a timing detection unit 40B, a determination unit 42A, a movement obtaining unit 44A, an identification unit 46A, a vibration reference value data storage 52A, and an abnormality data storage 54A. The functions of each component, such as the vibration obtaining unit 40A, the timing detection unit 40B, the determination unit 42A, the movement obtaining unit 44A, and the identification unit 46A are realized by, for example, executing a program stored in the program memory by a computer such as a CPU (Central Processing Unit) installed in the door opening-closing control unit 18A. The vibration reference value data storage 52A and the abnormality data storage 54A are implemented by various storage devices such as RAM, ROM, SSD, hard disk, etc.

[0077] The vibration obtaining unit 40 obtains the vibration information indicating the vibration generated during the opening and closing movements of the door of the pneumatic door device 2A. The timing detection unit 40B detects the movement timing of the door leaves 3R and 3L in response to the detection of the open or close command outputted from the command unit 19A. The determination unit 42A determines whether there is an abnormality of the pneumatic door device 2A by comparing the vibration indicated by the vibration information obtained by the vibration obtaining unit 40A with a predetermined vibration reference value. The vibration reference value is indicated by vibration reference value data stored in the vibration reference value data storage 52A. The vibration reference value data storage 52A stores the vibration reference value data indicating the vibration reference values.

[0078] The movement obtaining unit 44A obtains movement information indicating the elapsed time from the start of movement of the pneumatic door device 2A to a specific point in time at which the abnormality is determined by the determination unit 42A or indicating the opening or closing amount of the door of the pneumatic door device 2A. The movement obtaining unit 44A obtains the elapsed time by calculating from the time of the movement of the door leaves 3R and 3L detected by the

timing detection unit 40B. The movement obtaining unit 44A may calculate the door position from the elapsed time and the speed of the door leaves 3R and 3L corresponding to the elapsed time.

[0079] The identification unit 46A identifies a component related to the operation of the pneumatic door device 2A at the specific time among the plurality of components of the pneumatic door device 2A using the movement information. The plurality of components of the pneumatic door device 2A include the parts of the pneumatic door device 2A described above, such as, but not limited to, the door rollers 6, the door separating mechanism 130, the cylinder portion 110, the changeover valve 150, and the exhaust silencer 144. The identification unit 46A stores, in the abnormality data storage unit 54A, abnormality data in which, for example, the vibration information, the specific point in time or the position of the door, and the identified components are associated with each other. The identification unit 46A may transmit the abnormality data as a processing result to an external device such as the management device (not shown) or mobile terminal of the maintenance worker.

[0080] The door opening-closing control unit 18A of the pneumatic door device 2A performs a process according to the flowchart of Fig. 5 described in the first embodiment above. The door opening-closing control unit 18A first inputs the open or close command from the command unit 19A (step S100). The door opening-closing control unit 18A then causes the door leaves 3R and 3L to start an opening or closing movement by supplying or exhausting air to the cylinder portion 110 (step S102). The abnormality identification device 1A collects the vibration information acquired from the vibration sensor unit 30A and the elapsed time (movement information) from the time of the input of the open or close command. The determination unit 42A of the abnormality identification device 1A determines whether there is an abnormality of the pneumatic door device 2A by comparing the vibration indicated by the vibration information and the vibration reference value (step S106). When the determination unit 42A determines there is no abnormality of the pneumatic door device 2A (step S106: NO), the process of the flowchart ends. When the determination unit 42A determines that there is an abnormality of the pneumatic door device 2A (step S106: YES), the identification unit 46A identifies the component of the pneumatic door device 2A using the movement information as of the specific time when the abnormality is determined (step S108). The identification unit 46A then records the abnormality data in the abnormality data storage 54A (step S110).

[0081] Fig. 19 illustrates an example of the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and the vibration information of the door roller 6 with reference to the time axis. Fig. 20 illustrates an example of the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and the vibration information of the door roller 6 with reference to the time axis when there is an abnormality of the door roller 6. In Figs. 19 and 20, the horizontal axis represents the elapsed time, and the vertical axis represents the door position and the magnitude of vibration. Here, P0 is the fully closed position and P10 is the fully opened position of the door. The pneumatic door device 2A opens the door from time t0 to time t10, stops opening and closing the door from time t10 to time t11, and closes the door from time t11 to time t12. The air pressure supplied to the cylinder portion 110 is a constant value (level A) from the fully closed to fully opened state of the door. For convenience of explanation, Figs. 19 and 20 show the supplied air pressure (level A) and vibration information (level B) of the cylinder portion 110 on the vertical axis on the right side of the drawing. The vertical axis on the right side of the drawing represents the vibration information and does not represent which is greater or lesser between the supply air pressure (level A) and the vibration information (level B). The same applies to Figs. 21 to 28.

[0082] When there is no abnormality of the door roller 6, as shown in Fig. 19, the vibration detected during the movement of the door roller 6 fluctuates around the level B. When there is an abnormality of the door roller 6, the vibration occurring during the movement of the door roller 6 fluctuates around the level B as shown in Fig. 20, and the amplitude of the vibration is increased compared to that of Fig. 19. The determination unit 42A determines that there is an abnormality when the vibration amplitude normally fluctuating around the level B exceeds the amplitude (vibration reference value) shown when there is no abnormality of the door roller 6. When the determination unit 42A determines whether there is an abnormality in the vibration amplitude normally fluctuating around the level B in the elapsed times (t0 to t10, t11 to t12) during which the opening and closing operations of the door are performed, the identification unit 46A can identify the door roller 6 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined.

[0083] Fig. 21 illustrates an example of the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and the vibration information of the door separating mechanism 130 with reference to the time axis. Fig. 22 illustrates an example of the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and the vibration information of the door roller 130 with reference to the time axis when there is an abnormality of the door separating mechanism 130. When there is no abnormality of the door separating mechanism 130, the vibration detected during the movement of the door separating mechanism 130 fluctuates around level C as shown in Fig. 21. When there is an abnormality of the door separating mechanism 130, the vibration occurring during the operation of the door separating mechanism 130 fluctuates around the level C as shown in Fig. 22, and the amplitude of the vibration is increased compared

to that of Fig. 21. The determination unit 42A determines that there is an abnormality when the vibration amplitude normally fluctuating around the level C exceeds the amplitude (vibration reference value) shown when there is no abnormality of the door separating mechanism 130. When the determination unit 42A determines whether there is an abnormality in the vibration amplitude normally fluctuating around the level C in the elapsed times (t0 to t10, t11 to t12) during which the opening and closing operations of the door are performed, the identification unit 46A can identify the door separating mechanism 130 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined.

[0084] Fig. 23 illustrates an example of the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and the vibration information of the cylinder portion 110 with reference to the time axis. Fig. 24 illustrates an example of the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and the vibration information of the cylinder portion 110 with reference to the time axis when there is an abnormality of the cylinder portion 110. When there is no abnormality of the cylinder portion 110, the vibration detected during the operation of the cylinder portion 110 fluctuates around level D as shown in Fig. 23. When there is an abnormality of the cylinder portion 110, the vibration occurring during the operation of the cylinder portion 110 fluctuates around the level D as shown in Fig. 24, but the amplitude of the vibration is increased compared to that of Fig. 23. The determination unit 42A determines that there is an abnormality when the vibration amplitude normally fluctuating around the level D exceeds the amplitude (vibration reference value) shown when there is no abnormality of the cylinder portion 110. When the determination unit 42A determines whether there is an abnormality in the vibration amplitude normally fluctuating around the level D in the elapsed times (t0 to t10, t11 to t12) during which the opening and closing operations of the door are performed, the identification unit 46A can identify the cylinder portion 110 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined.

[0085] Fig. 25 illustrates an example of information on the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and vibration of a changeover valve portion 150 (the first solenoid valve 152 and/or the second solenoid valve 154) with reference to the time axis. Fig. 26 illustrates an example of the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and the vibration information of the changeover valve portion 150 with reference to the time axis when there is an abnormality of the changeover valve portion 150. When there is no abnormality of the changeover valve portion 150, the vibration detected during the operation of the changeover valve portion 150 fluctuates around level E as shown in Fig. 25. When there is an abnormality of the changeover valve portion 150, the vibration occurring during the operation of the changeover valve portion 150 fluctuates around the level E as shown in Fig. 26, but the amplitude of the vibration is increased compared to that of Fig. 25. The determination unit 42A determines that there is an abnormality when the vibration amplitude normally fluctuating around the level E exceeds the amplitude (vibration reference value) shown when there is no abnormality of the changeover valve portion 150. When the determination unit 42A determines whether there is an abnormality in the vibration amplitude normally fluctuating around the level E in the elapsed times (t0 to t10, t11 to t12) during which the opening and closing operations of the door are performed, the identification unit 46A can identify the changeover valve portion 150 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined.

[0086] Fig. 27 illustrates an example of the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and the vibration information of the exhaust silencer 144 with reference to the time axis. Fig. 28 illustrates an example of the position (stroke) [mm] of the door leaves 3R and 3L, air pressure [Pa] supplied to the cylinder portion 110, and the vibration information of the door exhaust silencer 144 with reference to the time axis when there is an abnormality of the exhaust silencer 144. When there is no abnormality of the exhaust silencer 144, the vibration detected during the operation of the exhaust silencer 144 fluctuates around the level F as shown in Fig. 27. When there is an abnormality of the exhaust silencer 144, the vibration occurring during the operation of the exhaust silencer 144 fluctuates around the level F as shown in Fig. 28, and the amplitude of the vibration is increased compared to that of Fig. 27. The determination unit 42A determines that there is an abnormality when the vibration amplitude normally fluctuating around the level F exceeds the amplitude (vibration reference value) shown when there is no abnormality of the exhaust silencer 144. When the determination unit 42A determines whether there is an abnormality in the vibration amplitude normally fluctuating around the level F in the elapsed times (t0 to t10, t11 to t12) during which the opening and closing operations of the door are performed, the identification unit 46A can identify the exhaust silencer 144 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined.

[0087] As described above, in the abnormality identification device 1A of the second embodiment, the pneumatic door device 2A includes, as the plurality of components, the cylinder portion 110 in which the piston 114 is provided to move in the pressure chamber, the valve (changeover valve portion 150, the first solenoid valve 152, the second solenoid valve 154) that supplies or exhausts air to the pressure chamber to move the piston 114, and a transmission unit (the door separating mech-

anism 130, the upper rack 104, the lower rack 108) that transmits the moving force of the piston 114 to the pneumatic door device 2A. The identification unit 46A can specify, using the movement information, the components related to the operation of the pneumatic door device 2A at the time when the determination unit 42A determines that there is an abnormality. Thus, with the abnormality identification device 1A, it is possible to identify which of the plurality of components of the pneumatic door device 2A is the cause of the abnormality of the pneumatic door device 2A without requiring a process to convert the time-domain vibration into the frequency domain. As a result, the abnormality identification device 1A can reduce the load of the processing to identify the cause of the failure.

[0088] The pneumatic door device 2A includes the door roller 6 as the plurality of components, and in the abnormality identification device 1A, the identification unit 46A can identify the door roller 6 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined, using the movement information (for example, elapsed times t0 to t10, t11 to t12) as described with reference to Figs. 19 and 20.

[0089] The pneumatic door device 2A includes the door separating mechanism 130 as the plurality of components, and in the abnormality identification device 1A, the identification unit 46A can identify the door separating mechanism 130 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined, using the movement information (for example, elapsed times t0 to t10, t11 to t12) as described with reference to Figs. 21 and 22.

[0090] The pneumatic door device 2A includes the cylinder portion 110 as the plurality of components, and in the abnormality identification device 1A, the identification unit 46A can identify the door roller 110 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined, using the movement information (for example, elapsed times t0 to t10, t11 to t12) as described with reference to Figs. 23 and 24.

[0091] The pneumatic door device 2A includes the first electromagnetic valve 152 and the second electromagnetic valve 154 as the plurality of components, and in the abnormality identification device 1A, the identification unit 46A can identify the first electromagnetic valve 152 and the second electromagnetic valve 154 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined, using the movement information (for example, elapsed times t0 to t10, t11 to t12) as described with reference to Figs. 25 and 26.

[0092] The pneumatic door device 2A includes the exhaust silencer 144 as the plurality of components, and in the abnormality identification device 1A, the identification unit 46A can identify the exhaust silencer 144 as the component related to the operation of the pneumatic door device 2A at the time when the abnormality is determined, using the movement information (for example, elapsed times t0 to t10, t11 to t12) as described with reference to Figs. 27 and 28.

Third Embodiment

[0093] The third embodiment of the invention will be hereinafter described. The abnormality identification device of the third embodiment differs from the above first and second embodiments in that it includes an inclination obtaining unit that obtains inclination information indicating the inclination of the door device. The abnormality identification device compares the inclination indicated by the inclination information with an inclination reference value, and determines that the operation of the door device is not abnormal when both the vibration information and the inclination information indicate an abnormality. The features different from the first and second embodiments will be further described below. For purposes of clarity and brevity, like elements and components are labeled with same or similar designations and numbering as discussed in the first and second embodiments and description of such elements will be hereunder omitted. The description of the second embodiment will focus on the points that differ from the first embodiment described above. Although this third embodiment can be applied to both the electric door device 2 and the pneumatic door device 2A, the third embodiment will be described as the case where it is applied to the electric door device 2.

[0094] Fig. 29 shows an example in which the door of the electric door device 2 is tilted, and Fig. 30 shows another example in which the door of the electric door device 2 is tilted. For example, as shown in Fig. 29, when a person presses or pushes the door leaves 3R and 3L in the thickness direction of in a crowded railway vehicle, the door leaves 3R and 3L of the electric door device 2 are tilted. In addition, as shown in Fig. 30, when the train tilts by stopping on a curved rail, the door leaves 3R and 3L of the electric door device 2 also tilt.

[0095] Fig. 31 is a longitudinal view showing the state in which the door leaves 3R and 3L are not tilted. Fig. 32 is a longitudinal sectional view showing the state of the door leaves 3R and 3L when an external force is applied to the door leaves 3R and 3L by a person. Fig. 33 is a longitudinal sectional view showing the state of door leaves 3R and 3L when the vehicle body is tilted. The door leaves 3R and 3L are hung and supported by the door leaf connecting plate 5a included in the door hanging device 5. On the upper surface of the guide rail 4, provided is a tilt sensor unit 60 that generates tilt information indicating the tilt of the electric door device 2. A door operator 2a that houses the motor 11 and other components is provided above the guide rail 4. The door operator 2a is disposed, for example, inclined with respect to the +Y direction when the door leaves 3R and 3L are not tilted.

[0096] In a state where the door leaves 3R and 3L are

not tilted, the door leaves 3R and 3L are supported along the vertical direction (Y direction) as shown in Fig. 31. In a state where an external force is applied to the door leaves 3R and 3L by a person, the door leaves 3R and 3L are pressed from the -Z side to the +Z side, causing the door leaves to roll toward the +Z side with respect to the door hanging device 5, as shown in Fig. 32. When the vehicle body tilts, the door operator 2A, door hanging device 5, door connecting plate 5A, and guide rail 4 are tilted as shown in Fig. 33. Then, the door leaves 3R and 3L roll to the -Z side with respect to the door hanging device 5 due to their own weight of the door leaves 3R and 3L.

[0097] Fig. 34 is a block diagram showing an example of a functional configuration of an abnormality identification device 1B. The abnormality identification device 1B includes, for example, the vibration obtaining unit 40, a tilt obtaining unit 62, a vehicle location obtaining unit 64, a determination unit 42B, a movement obtaining unit 44B, an identification unit 46B, the current value obtaining unit 48, the speed value obtaining unit 50, a vibration reference value data storage 52B, and the abnormality data storage 54. The functions of each component, such as the vibration obtaining unit 40, the tilt obtaining unit 62, the vehicle location obtaining unit 64, the determination unit 42B, the movement obtaining unit 44B, the identification unit 46B, the current value obtaining unit 48, and the speed value obtaining unit 50, are realized by, for example, executing a program stored in the program memory by a computer such as a CPU (Central Processing Unit) installed in the door opening-closing control unit 18. The vibration reference value data storage 52B and the abnormality data storage 54 are implemented by various storage devices such as RAM, ROM, SSD, hard disk, etc.

[0098] The vibration obtaining unit 40 obtains the vibration information indicating the vibration generated in the opening and closing movements of the door of the electric door device 2. The tilt obtaining unit 62 obtains the tilt information from the tilt sensor unit 60. The vehicle location obtaining unit 64 obtains the vehicle location information. The vehicle location information is information indicating the location of the rail vehicle equipped with the electric door device 2, for example, information for identifying the position of the railway vehicle by latitude and longitude. The vehicle location information is derived, for example, by a GPS (Global Positioning System) device mounted on the railway vehicle.

[0099] The determination unit 42B determines whether there is an abnormality of the electric door device 2 by comparing the vibration indicated by the vibration information obtained by the vibration obtaining unit 40 with a predetermined vibration reference value. The vibration reference value is indicated by vibration reference value data stored in the vibration reference value data storage 52. The vibration reference value data storage 52 stores the vibration reference value data indicating the vibration reference values. The current value obtaining unit 48 obtains a current value from the motor current detector 27. The determination unit 42B may determine an abnormality of the electric door device 2 by comparing the current value obtained from the motor current detector 27 with a current reference value stored in the vibration reference value data storage 52.

[0100] The determination unit 42B further compares the tilt indicated by the tilt information obtained by the tilt obtaining unit 62 with a predetermined tilt reference value, and when both the vibration information and the tilt information indicate that there is abnormality, the determination unit 42B determines that there is no abnormality of the electric door device 2. The tilt reference value is the reference value of tilt indicated by the tilt reference value data stored in the vibration reference value data storage 52B.

[0101] The determination unit 42B may obtain the tilt information corresponding to the vehicle location obtained by the vehicle location obtaining unit 64. The tilt information corresponding to the vehicle location is stored, for example, in the vibration reference value data storage 52B. The determination unit 42B compares the tilt indicated by the tilt information corresponding to the vehicle location with a predetermined tilt reference value, and when both the vibration information and the tilt information indicate that there is abnormality, the determination unit 42B determines that there is no abnormality of the electric door device 2.

[0102] The current value obtaining unit 48 obtains a current value from the motor current detector 27. The speed value obtaining unit 50 obtains a speed value from the speed detection unit 25. The movement obtaining unit 44B detects the position of the door that is moving to be opened based on the speed value from the speed value obtaining unit 50. The movement obtaining unit 44B obtains movement information indicating the elapsed time from the start of opening or closing movement of the electric door device 2 to a specific point in time at which the abnormality is determined by the determination unit 42B or indicating the opening or closing amount of the electric door device 2.

[0103] The identification unit 46B identifies a component related to the operation of the electric door device 2 at the specific point in time among the plurality of components of the electric door device 2 using the movement information. The identification unit 46B stores, in the abnormality data storage unit 54, abnormality data in which, for example, the vibration information, the specific point in time or the position of the door, and the identified components are associated with each other. The identification unit 46B may transmit the abnormality data as a processing result to an external device such as the management device (not shown) or mobile terminal of the maintenance worker.

[0104] Fig. 35 is a flowchart showing exemplary steps of a process performed in the door opening-closing control unit 18 including the abnormality identification device 1B. The door opening-closing control unit 18 inputs the

open or close command from the command unit 19 (step S200). The abnormality identification device 1B obtains the vehicle location information (step S202). The door opening-closing control unit 18 causes the motor 11 to be driven by the motor driving unit 23 to start the open or close operation of the electric door device 2 (step S204). The abnormality identification device 1B collects the tilt information obtained from the tilt sensor unit 60, the tilt information corresponding to the vehicle location information, the vibration information obtained from the vibration sensor unit 30, and the position (movement information) of the door detected based on the speed value detected by the speed detection unit 25 (step S206). The determination unit 42B of the abnormality identification device 1 determines whether there is an abnormality of the electric door device 2 by comparing the vibration indicated by the vibration information and the vibration reference value (step S208). When the determination unit 42B determines there is no abnormality of the electric door device 2 (step S208: NO), the process of the flowchart ends.

[0105] When the determination unit 42B determines that there is an abnormality of the electric door device 2 (step S208: YES), it further determines whether the tilt of the railway vehicle is detected by using the tilt information (step S210). When the tilt indicated by the tilt information obtained from the tilt sensor unit 60 exceeds a predetermined inclination, the determination unit 42B detects the tilt of the railway vehicle. When the determination unit 42B does not detect the tilt of the railway vehicle (step S210: NO), it identifies the component of the electric door device 2 using the movement information as of the specific time when the abnormal is determined by the identification unit 46B (step S212). The identification unit 46B then records the abnormality data in the abnormality data storage 54 (step S214).

[0106] When the determination unit 42B detected the tilt of the railway vehicle (step S210: YES), it determines whether the railway vehicle was tilted by the tilt indicated by the vehicle location information (step S216). When the tilt indicated by the tilt information obtained from the tilt sensor unit 60 matches or corresponds to the tilt based on the vehicle location obtained from the vibration reference value data storage 52B with a predetermined margin of error, the determination unit 42B determines that the tilt was generated due to the vehicle location. When the determination unit 42B determined that the tilt was generated due to the vehicle location (step S216: YES), it determines that there is no abnormality of the electric door device 2 and records the vibration abnormality and the vehicle tilt abnormality (step S218).

[0107] When the determination unit 42B determined that the tilt is not occurring due to the vehicle location (step S216: NO), it determines whether the number of times the tilt of the railway vehicle is detected is above a threshold value (step S220). This determination is performed because, for example, when the door leaves 3R and 3L are pressurized by passengers fully packed in the vehicle, the tilt exceeding the threshold value may be detected. When the number of times the tilt of the railway vehicle is detected exceeds the threshold value (step S220: YES), the determination unit 42B determines that there is no abnormality of the electric door device 2 and records the abnormal vibration and the abnormal tilt due to pressurization (step S222). When the number of times the tilt of the railway vehicle is detected is not more than the threshold value (step S220: NO), the identification unit 46B identifies the component of the electric door device 2 using the movement information as of the specific time when the abnormality is determined (step S212) and records the abnormality data in the abnormality data storage 54 (step S214).

[0108] As a modification example of step S208, the determination unit 42B may exclude, from the vibration indicated by the vibration information, the vibration generated by the tilt indicated by the tilt information obtained from the tilt sensor unit 60, and compare the vibration from which the vibration caused by the tilt indicated by the tilt information with a predetermined vibration reference value to determine whether there is an abnormality of the electric door device 2. For the information indicating the vibration caused by the tilt, vibration information that has been sampled in advance for each tilt angle is stored in the vibration reference value data storage 52B, for example, the determination unit 42B obtains, from the vibration reference value data storage 52B, the vibration information corresponding to the tilt collected in step S206.

[0109] As described above, the abnormality identification device 1B of the third embodiment includes the tilt obtaining unit 62 that obtains the tilt information indicating the tilt of the electric door device 2 or pneumatic door device 2A. The determination unit 42B compares the tilt indicated by the obtained tilt information with the tilt reference value, and when the vibration information and tilt information both indicate that there is an abnormality, the determination unit 42B determines that there is no abnormality of the electric door device 2 or the pneumatic door device 2A. With the abnormality identification device 1B, it is possible to avoid falsely identifying the component of the electric door device 2 or pneumatic door device 2A related to the abnormality even when the vibration caused by the inclination of the electric door device 2 or pneumatic door device 2A occurs.

[0110] The abnormality identification device 1B includes the tilt obtaining unit 62 that obtains the tilt information indicating the tilt of the door leaves 3R and 3L among the plurality of components. The determination unit 42B excludes the vibration generated due to the tilt indicated by the tilt information from the vibration indicated by the vibration information. The determination unit 42B then determines whether there is an abnormality of the electric door device 2 or pneumatic door device 2A by comparing the vibration from which the vibration caused by the tilt indicated by the tilt information with the predetermined vibration reference value. With the abnor-

mality identification device 1B, it is possible to increase the accuracy of determining whether or not an abnormality exists.

[0111] The foregoing is the description of the embodiments of the present invention with reference to the drawings. Specific configurations are not limited to the above embodiments but include design modifications within the purport of the present invention.

[0112] 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.

[0113] The functions of the devices (for example, the abnormality identification device 1A, the abnormality identification device 1B, the electric door device 2, and the pneumatic door device 2A) of the embodiments described above may be implemented in a program stored on a tangible computer-readable storage medium, and the program stored on the storage medium may be loaded onto a computer system and executed for processing. The "computer system" mentioned above may include an operating system (OS) or hardware such as peripheral devices. The "computer-readable storage medium" mentioned above refers to a storage device such as a portable medium like a flexible disc, a magneto-optical disc, a ROM (Read Only Memory), a flash memory or other writable non-volatile memory, and a DVD (Digital Versatile Disc), and a hard disk built-in to the computer system.

[0114] Further, the "computer-readable storage medium" includes storage media that retain the program for some period of time, like a volatile memory (for example, DRAM (Dynamic Random Access Memory)) in an information processing device receiving the program through a network such as the Internet or a communication line such as a telephone line, and a computer system that operates as a client. The computer program mentioned above may be transmitted from a computer system that includes a storage device or the like storing the program to another computer system through a transmission medium or by a transmission wave in a transmission medium. The "transmission medium" for transmitting the program refers to a medium that operates to transmit information, like a network (communication network) such as the Internet or a communication line (communication wire) such as the telephone line. Only a part of the functions described above may be implemented in the above program. Further, the functions described above may be implemented by a combination of the above program and other programs previously stored on the computer system. That is, the above program may be what is called a difference file (a difference program).

LIST OF REFERENCE NUMBERS

[0115]

1, 1A, 1B	abnormality identification device
2	electric door device (railway door device, automatic door device)
2A	pneumatic door device
3R, 3L	door leaf
4	guide rail
5, 5L, 5R	door hanging device
6	door rollers
7	rubber on the edge of door
8R	right rack gear
8L	left rack gear
9L	left connecting bracket
9R	right connecting bracket
10	pinion gear
11	motor
12	rotational axis
13	sun gear
14	planetary gears
15, 15A	controller
16, 16A	power supply unit
17	motor monitor unit
18, 18A	door opening-closing control unit
19, 19A	command unit
20	lock unit
21	power-supply voltage detecting unit
22	PWM control unit
22R, 22L	lock pin
23	motor driving unit
24	Hall signal detection unit
25	speed detection unit
26	Hall element
27	motor current detector
29, 29A	transmission unit
30, 30A	vibration sensor unit
40	vibration obtaining unit
40A	vibration obtaining unit
40B	timing detection unit
42, 42A, 42B	determination unit
44, 44A, 44B	movement obtaining unit
46, 46A, 46B	identification unit
48	current value obtaining unit
50	speed value obtaining unit
52, 52A, 52B	vibration reference value data storage
54, 54A	abnormality data storage
60	tilt sensor unit
62	tilt obtaining unit
64	vehicle location obtaining unit
102	connecting fitting
104	upper lack
108	lower lack
110	cylinder portion
112	cushion cylinder
114	piston
115	piston shaft

122, 124	check valve
130	door separating mechanism
132	pinion
134	door switch
136	switch push rod
140	strainer
142a to 142f	air passage
144	exhaust silencer
150	changeover valve unit (changeover valve)
150A	solenoid valve control unit
152	first electromagnetic valve
154	second electromagnetic valve
160	manual push button

Claims

1. An abnormality identification device (1), comprising:

a vibration obtaining unit (40) obtaining vibration information that indicates a vibration generated during opening and closing movements of a door leaf (3R, 3L) of a door device (2), the door device (2) opening and closing a doorway of a railway vehicle;
a determination unit (42) determining whether there is an abnormality of the door device (2) by comparing the vibration indicated by the obtained vibration information with a predetermined vibration reference value;
a movement obtaining unit (44) obtaining movement information that indicates an elapsed time or a displacement of the door leaf (3R, 3L) of the door device (2) from start of operation of the door device (2) to a specific point in time at which abnormality is determined by the determination unit (42) or indicates; and
an identification unit (46) identifying a component related to an operation of the door device (2) at the specific point in time among a plurality of components of the door device (2), the component being identified using the movement information.

2. The abnormality identification device (1) of claim 1, wherein the plurality of components include a motor (11) powering the door leaf (3R, 3L) to move the door leaf (3R, 3L) to be opened and closed, and a lock unit (20) receiving power from the motor (11) and locking the door leaf (3R, 3L) after the door leaf (3R, 3L) reaches a fully closed position during the closing movement,

wherein the vibration obtaining unit (40) obtains the vibration information indicating the vibration of the door device (2) when the motor (11) is driven, and
wherein when the elapsed time or the displacement indicated by the movement information obtained during the closing movement of the door leaf (3R, 3L) is greater than or equal to an elapsed time or a displacement from start of the closing movement of the door leaf (3R, 3L) to end of the closing movement at the fully closed position, the identification unit (46) identify the lock unit (20) as the component related to the operation of the door device (2).

3. The abnormality identification device (1) of claim 1, wherein the plurality of the components include a motor (11) powering the door leaf (3R, 3L) to move the door leaf (3R, 3L) to be opened and closed, and a lock unit (20) receiving power from the motor (11) and unlocking the door leaf (3R, 3L) before the door leaf (3R, 3L) starts the opening movement,

wherein the vibration obtaining unit (40) obtains the vibration information indicating the vibration of the door device (2) when the motor (11) is driven, and
wherein when the elapsed time or the displacement indicated by the movement information obtained during the opening movement of the door leaf (3R, 3L) is less than or equal to an elapsed time or a displacement from unlocking of the lock unit (20) to start of the opening movement of the door leaf (3R, 3L), the identification unit (46) identifies the lock unit (20) as the component related to the operation of the door device (2).

4. The abnormality identification device (1) of claim 1, wherein the plurality of components include a door roller (6) attached to the door leaf (3R, 3L), and the guide rail (4) that the door roller (6) contacts and rolls on, and
wherein when a door position of the door leaf (3R, 3L) calculated from the movement information as of the specific point in a period when the door leaf (3R, 3L) moves to be opened at a constant speed coincides with a door position of the door leaf (3R, 3L) calculated from the movement information as of the specific point in a period when the door leaf (3R, 3L) moves to be closed at a constant speed, the identification unit (46) identifies the guide rail (4) as the component related to the operation of the door device (2).

5. The abnormality identification device (1) of claim 1, wherein the plurality of components include a motor (11) generating a driving force to move the door leaf (3R, 3L) to be opened and closed,

wherein the abnormality identification device (1) further includes a current value obtaining unit (48) that obtains current value information indi-

cating a value of current supplied to the motor (11),
wherein the determination unit (42) further determines whether there is an abnormality of the door device (2) by comparing the current value indicated by the obtained current value information with a predetermined current reference value,
and
wherein when no abnormality is determined from the vibration information but an abnormality is determined from the current value information, the identification unit (46) identifies the motor (11) as the component related to the operation of the door device (2).

6. The abnormality identification device (1) of claim 1, wherein the door device (2) includes a motor (11) generating a driving force to move the door leaf (3R, 3L) to be opened and closed,

wherein the abnormality identification device (1) further includes a sound pressure obtaining unit (40) that obtains sound pressure information indicating a sound pressure generated during the opening and closing movements of the door device (2), and
wherein when no abnormality is determined from the vibration information and the sound pressure exceeds a sound pressure reference value in a period from start to end of the opening or closing movement, the identification unit (46) identifies the motor (11) as the component related to the operation of the door device (2).

7. The abnormality identification device (1A) of claim 1, wherein the door device (2A) includes, as the plurality of components, a cylinder portion (110) in which a piston (114) is provided to move in a pressure chamber, a valve that supplies air to or exhausts air from the pressure chamber to move the piston (114), and a transmission unit that transmits a moving force of the piston (114) to the door device (2A), and
wherein the identification unit (46A) identifies the component related to an operation of the door device (2A) at a time when the determination unit (42A) determines an abnormality by using the movement information.

8. The abnormality identification device (1B) of claim 1, further comprising a tilt obtaining unit (62) obtaining tilt information that indicates a tilt of the door leaf (3R, 3L),
wherein the determination unit (42B) further compares the tilt indicated by the obtained tilt information with a predetermined tilt reference value, and when both the vibration information and the tilt information indicate that there is abnormality, the determination unit (42B) determines that there is no abnormality of the door device (2).

9. The abnormality identification device (1B) of claim 1, further comprising a tilt obtaining unit (62) obtaining tilt information that indicates a tilt of the door leaf (3R, 3L),
wherein the determination unit (42B) excludes, from the vibration indicated by the vibration information, a vibration generated by the tilt indicated by the tilt information, and compares the vibration from which the vibration generated by the tilt indicated by the tilt information with a predetermined vibration reference value to determine whether there is an abnormality of the door device (2).

10. An abnormality identification method, comprising:

obtaining vibration information that indicates a vibration generated during opening and closing movements of a door leaf (3R, 3L) of a door device (2) that opens or closes a doorway of a railway vehicle, and movement information that indicates an elapsed time or a displacement of the door leaf (3R, 3L) from start of operation of the door device (2);
determining whether there is an abnormality of the door device (2) by comparing the vibration indicated by the vibration information with a predetermined vibration reference value; and
identifying, from among the plurality of the components of the door device (2), a component related to an operation of the door device (2) at a specific point in time when it is determined that there is the abnormality, the component being identified using an elapsed time or a displacement of the door leaf (3R, 3L) from the start of operation of the door device (2) to the specific point in time.

11. A computer-readable storage medium storing a program for causing a computer of a door device (2) that controls opening and closing of a door leaf (3R, 3L) that opens and closes a doorway of a railway vehicle to:

output an open or close command to the door device (2);
obtain vibration information that indicates a vibration generated during opening and closing movements of the door leaf (3R, 3L) and movement information that indicates an elapsed time or a displacement of the door leaf (3R, 3L) from start of operation of the door device (2);
determine whether there is an abnormality of the door device (2) by comparing the vibration indicated by the vibration information with a predetermined vibration reference value; and

identify, from among the plurality of the components of the door device (2), a component related to an operation of the door device (2) at a specific point in time when it is determined that there is the abnormality, the component being identified using an elapsed time or a displacement of the door leaf (3R, 3L) from the start of operation of the door device (2) to the specific point in time.

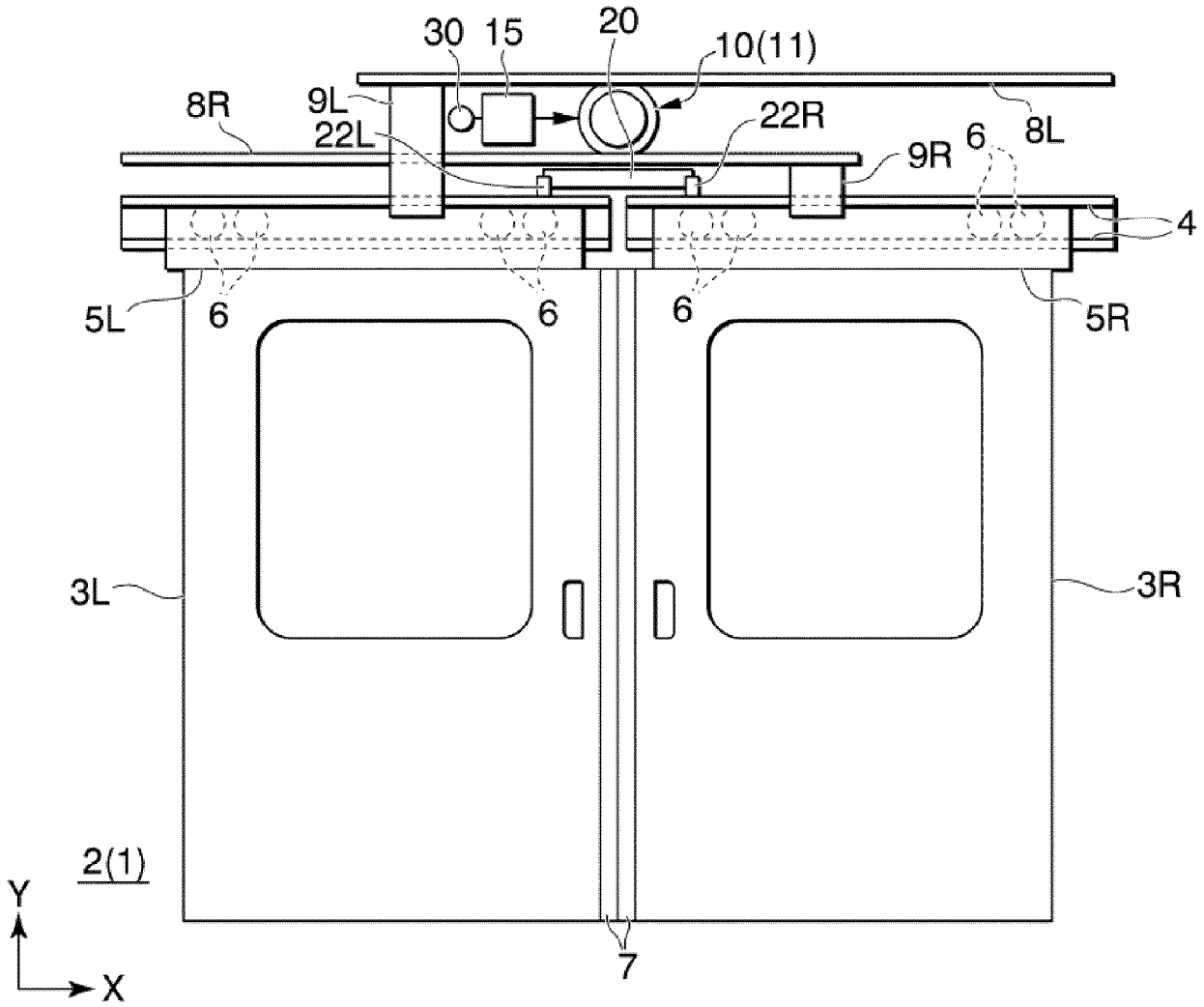

Fig. 1

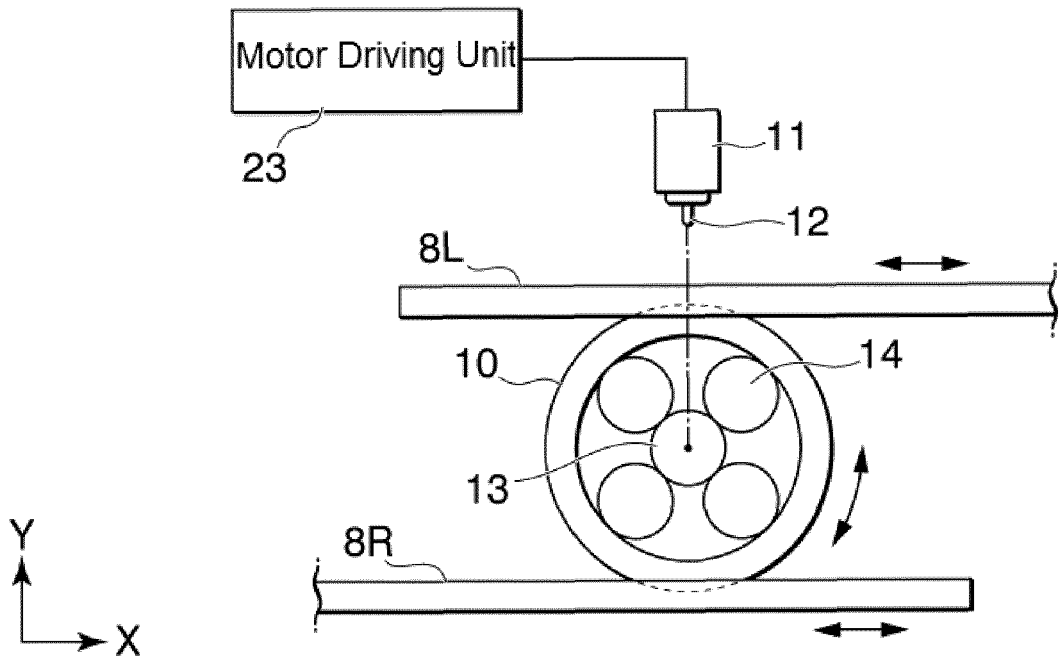

Fig. 2

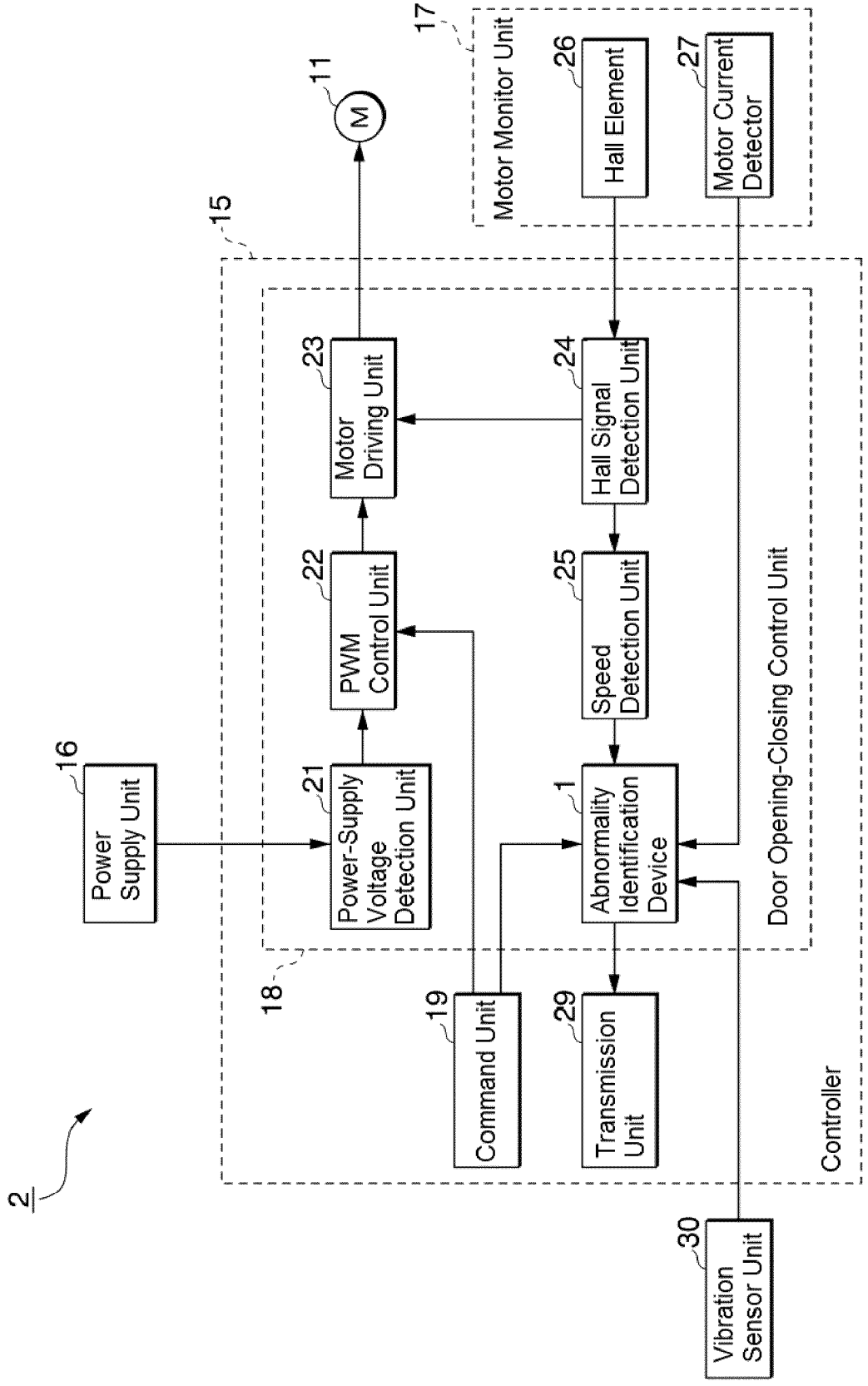
2
Controller
15
Door Opening-Closing Control Unit
18
Motor Monitor Unit
17
11
M
26
Hall Element
27
Motor Current Detector
23
Motor Driving Unit
24
Hall Signal Detection Unit
22
PWM Control Unit
25
Speed Detection Unit
16
Power Supply Unit
21
Power-Supply Voltage Detection Unit
1
Abnormality Identification Device
19
Command Unit
29
Transmission Unit
30
Vibration Sensor Unit

Fig. 3

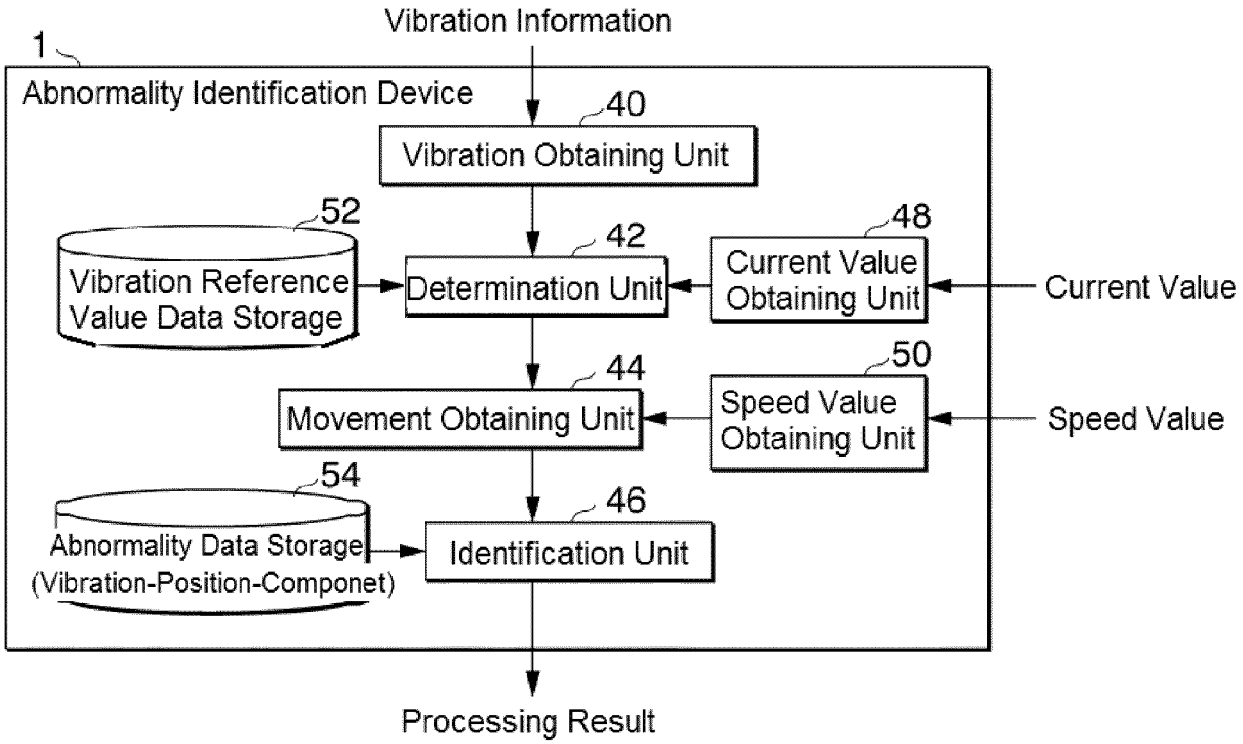
Vibration Information
1
Abnormality Identification Device
40
Vibration Obtaining Unit
52
Vibration Reference Value Data Storage
42
Determination Unit
48
Current Value Obtaining Unit
Current Value
44
Movement Obtaining Unit
50
Speed Value Obtaining Unit
Speed Value
54
Abnormality Data Storage (Vibration-Position-Componet)
46
Identification Unit
Processing Result

Fig. 4

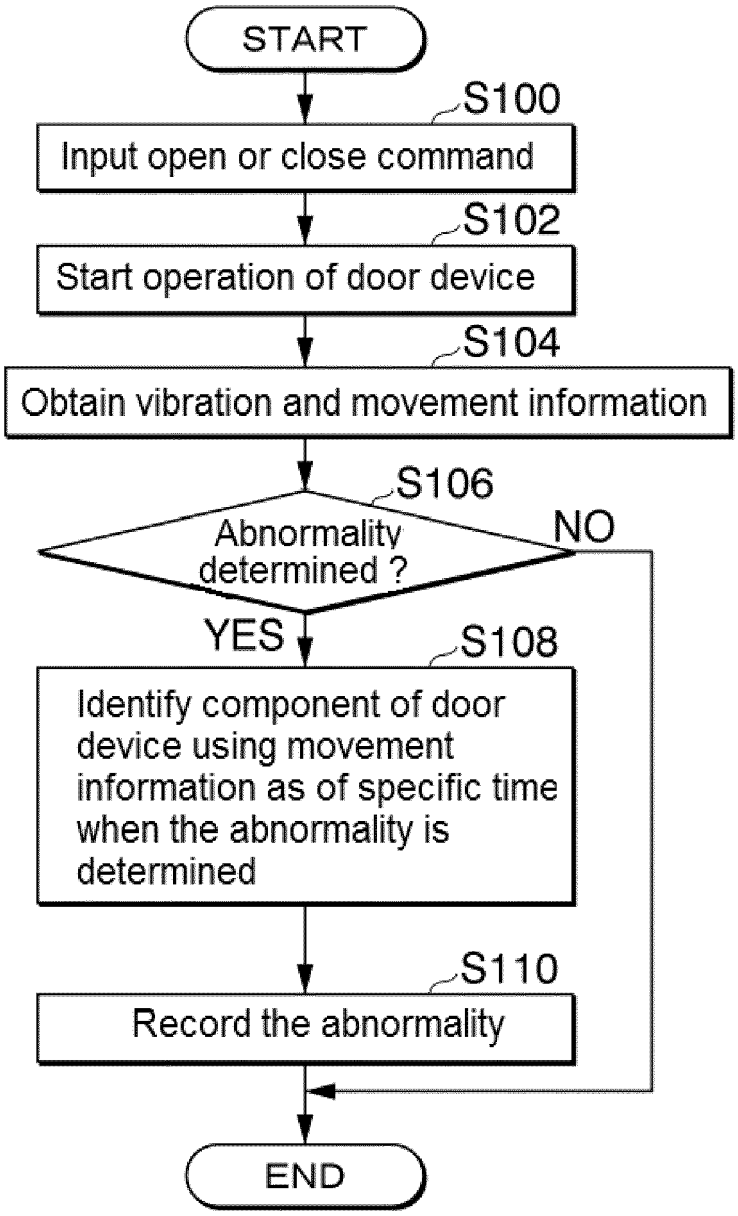
START
S100
Input open or close command
S102
Start operation of door device
S104
Obtain vibration and movement information
S106
Abnormality determined ?
NO
YES
S108
Identify component of door device using movement information as of specific time when the abnormality is determined
S110
Record the abnormality
END

Fig. 5

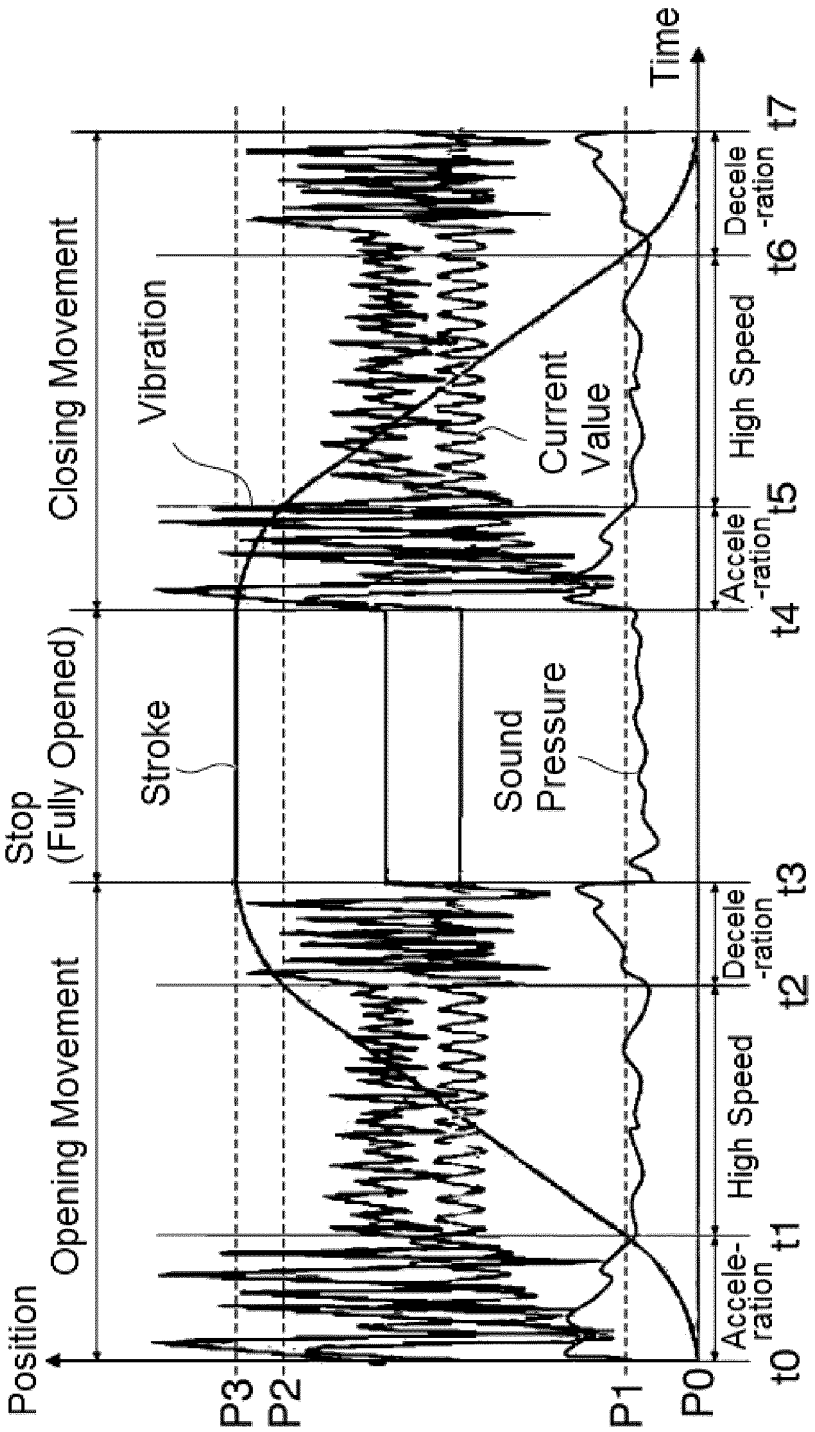
Position
Time
Opening Movement
Stop
(Fully Opened)
Closing Movement
Stroke
Vibration
Sound
Pressure
Current
Value
P3
P2
P1
P0
t0
t1
t2
t3
t4
t5
t6
t7
Accele-
ration
High Speed
Decele
-ration
Accele
-ration
High Speed
Decele
-ration

Fig. 6

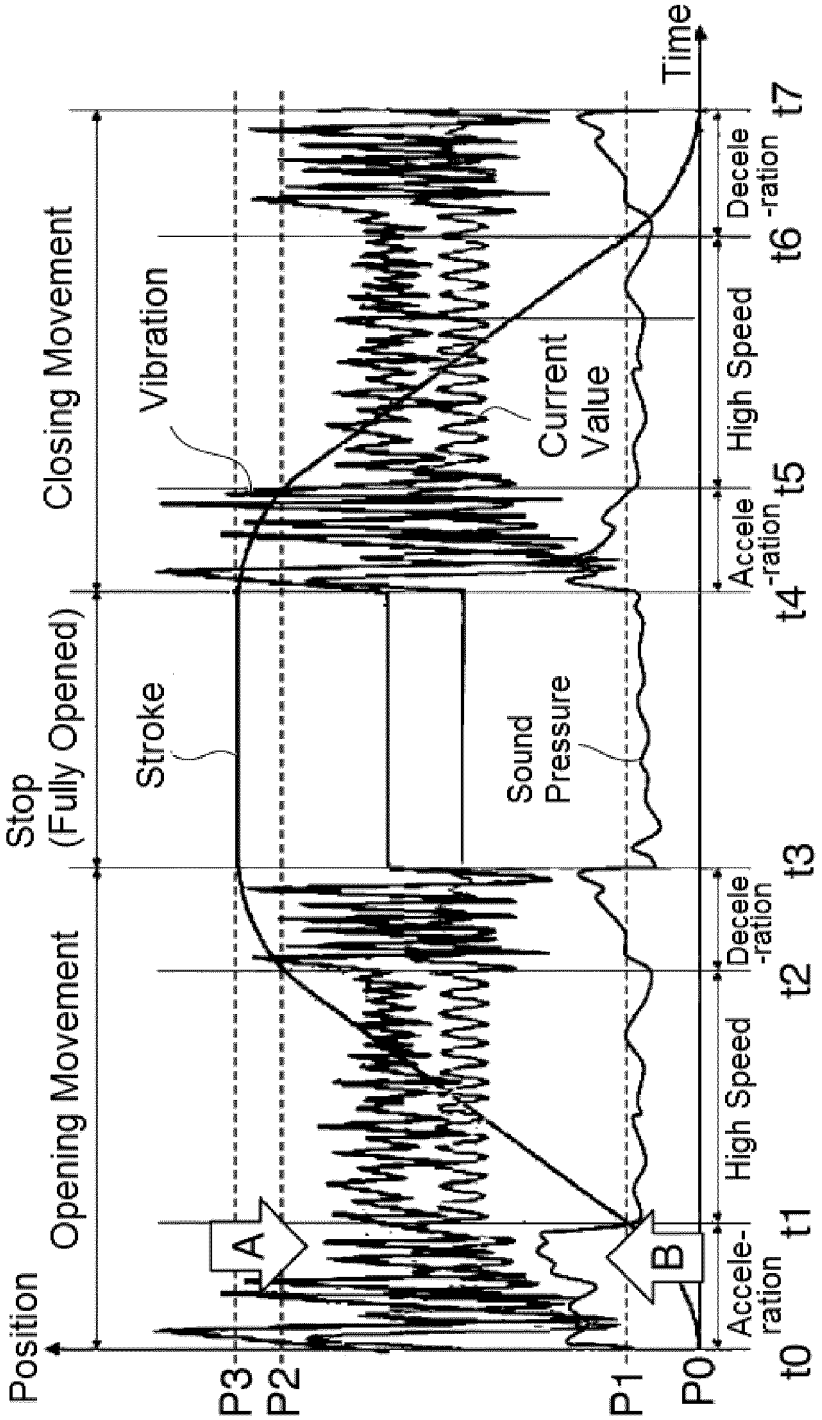
Position
Time
Opening Movement
Stop
(Fully Opened)
Closing Movement
Stroke
Vibration
Current
Value
Sound
Pressure
A
B
P3
P2
P1
P0
t0
t1
t2
t3
t4
t5
t6
t7
Accele-
ration
High Speed
Decele
-ration
Accele
-ration
High Speed
Decele
-ration

Fig. 7

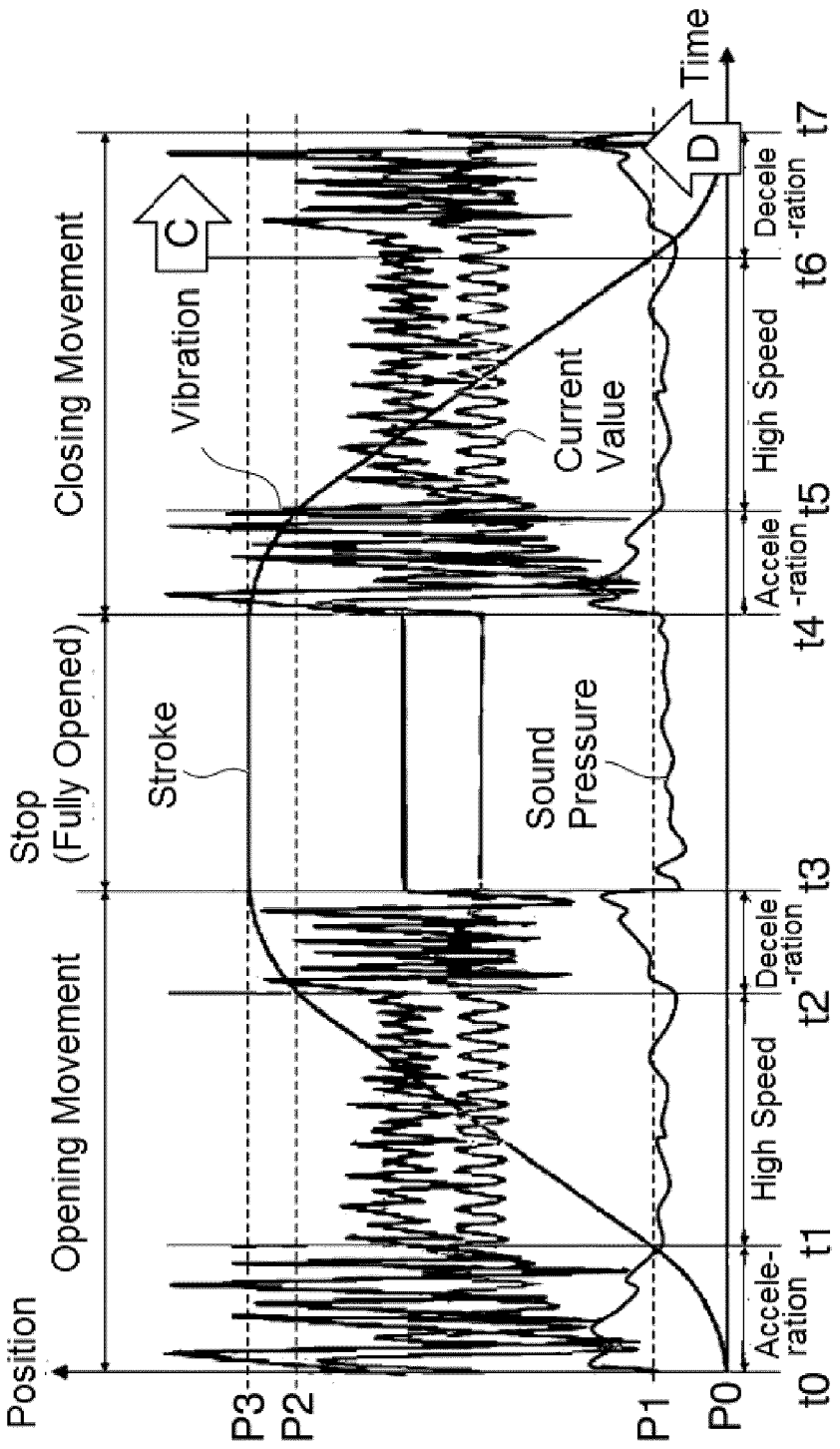
Position
Time
Opening Movement
Stop
(Fully Opened)
Closing Movement
Stroke
Vibration
Current
Value
Sound
Pressure
C
D
P3
P2
P1
P0
t0
t1
t2
t3
t4
t5
t6
t7
Accele-
ration
High Speed
Decele
-ration
Accele
-ration
High Speed
Decele
-ration

Fig. 8

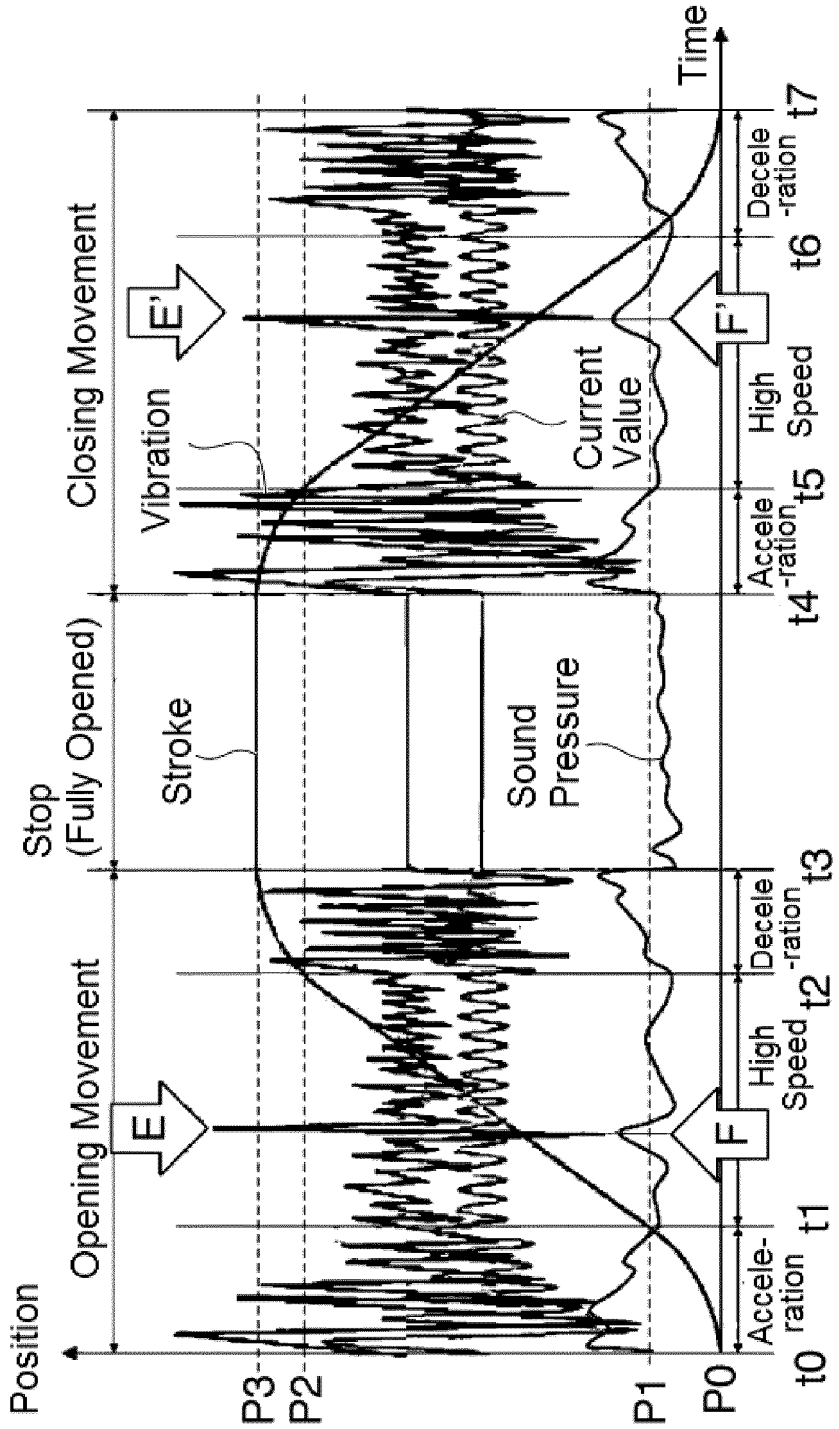
Position
Time
Opening Movement
Stop
(Fully Opened)
Closing Movement
E
E'
F
F'
Stroke
Vibration
Sound
Pressure
Current
Value
P0
P1
P2
P3
t0
t1
t2
t3
t4
t5
t6
t7
Accele-
ration
High
Speed
Decele
-ration

Fig. 9

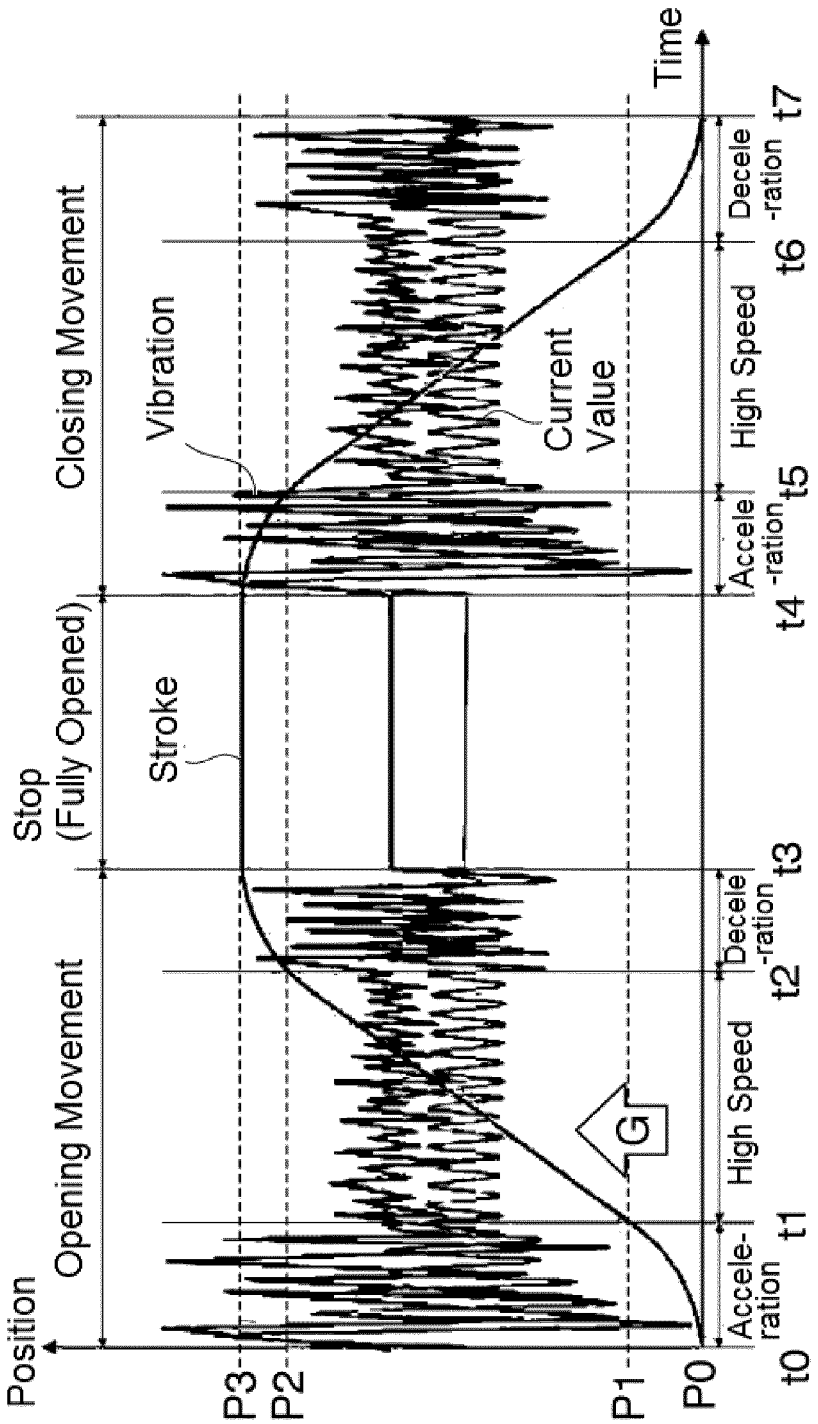
Time
Position
Opening Movement
Closing Movement
Stop
(Fully Opened)
Stroke
Vibration
Current
Value
G
P0
P1
P2
P3
t0
t1
t2
t3
t4
t5
t6
t7
Accele-
ration
High Speed
Decele
-ration
Accele
-ration
High Speed
Decele
-ration

Fig. 10

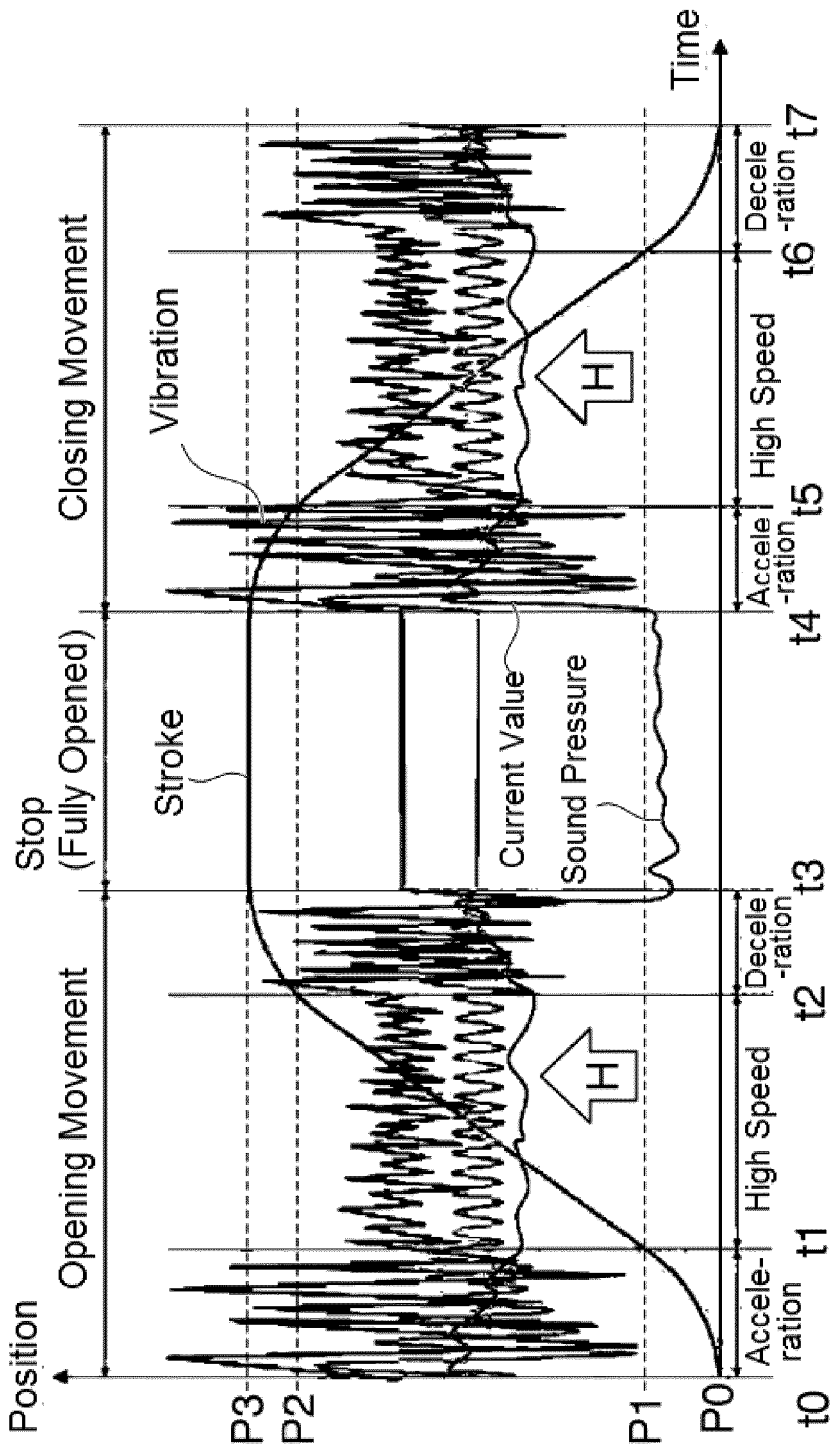
Position
Time
Opening Movement
Stop
(Fully Opened)
Closing Movement
Vibration
Stroke
Current Value
Sound Pressure
P3
P2
P1
P0
t0
t1
t2
t3
t4
t5
t6
t7
Accele-ration
High Speed
Decele-ration
Accele-ration
High Speed
Decele-ration
H
H

Fig. 11

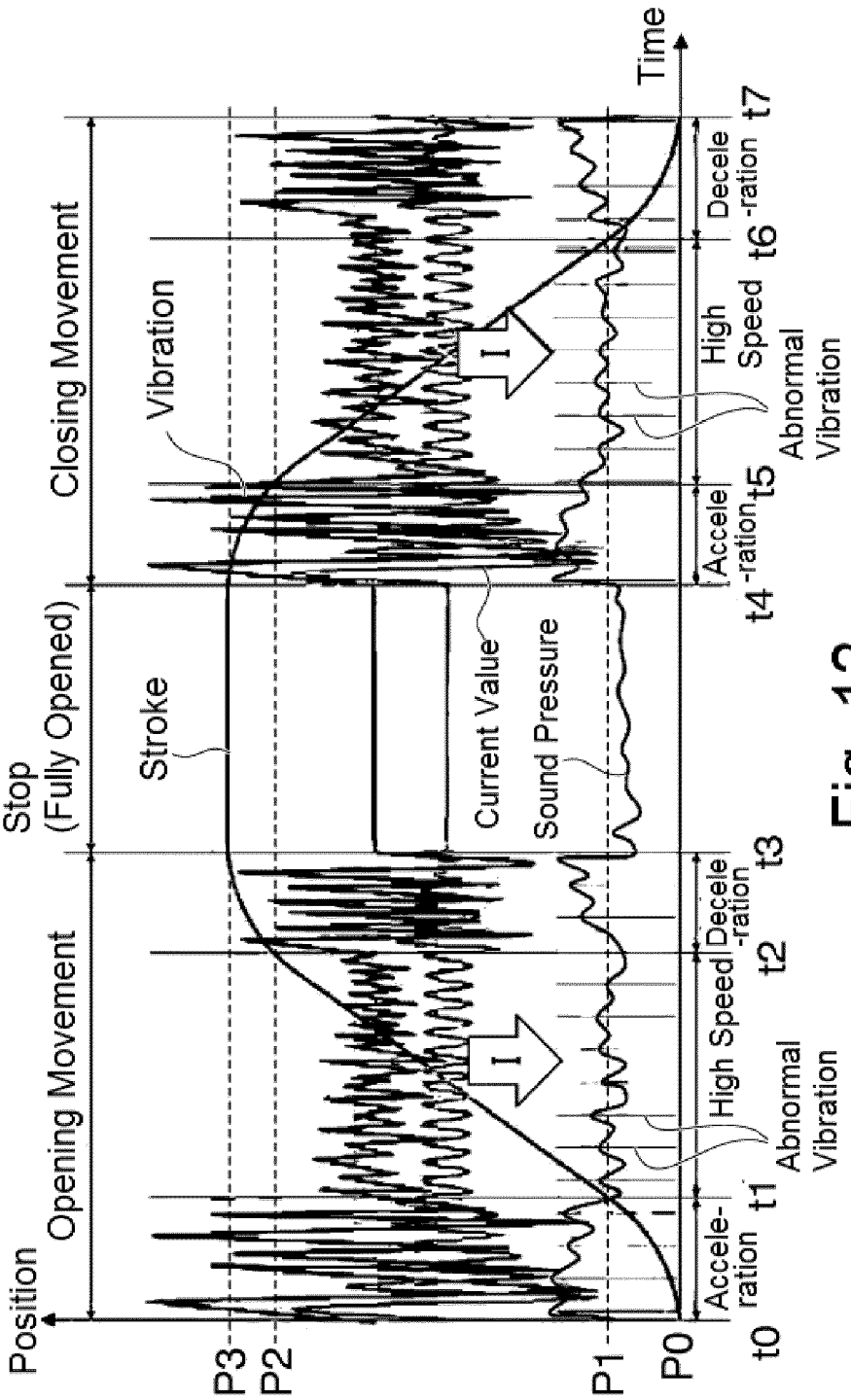
Position
Time
Opening Movement
Closing Movement
Stop
(Fully Opened)
Stroke
Vibration
Current Value
Sound Pressure
P0
P1
P2
P3
t0
t1
t2
t3
t4
t5
t6
t7
Accele-ration
High Speed
Abnormal Vibration
Decele-ration
I

Fig. 12

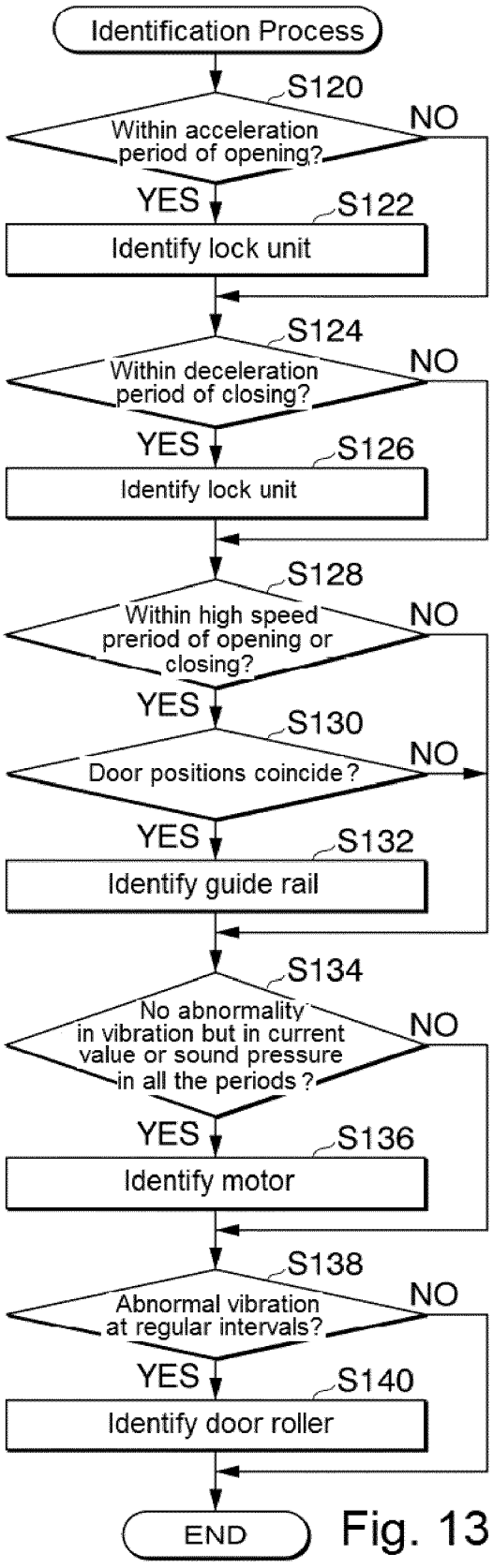
Identification Process
S120
Within acceleration period of opening?
NO
YES
S122
Identify lock unit
S124
Within deceleration period of closing?
NO
YES
S126
Identify lock unit
S128
Within high speed preriod of opening or closing?
NO
YES
S130
Door positions coincide?
NO
YES
S132
Identify guide rail
S134
No abnormality in vibration but in current value or sound pressure in all the periods?
NO
YES
S136
Identify motor
S138
Abnormal vibration at regular intervals?
NO
YES
S140
Identify door roller
END

Fig. 13

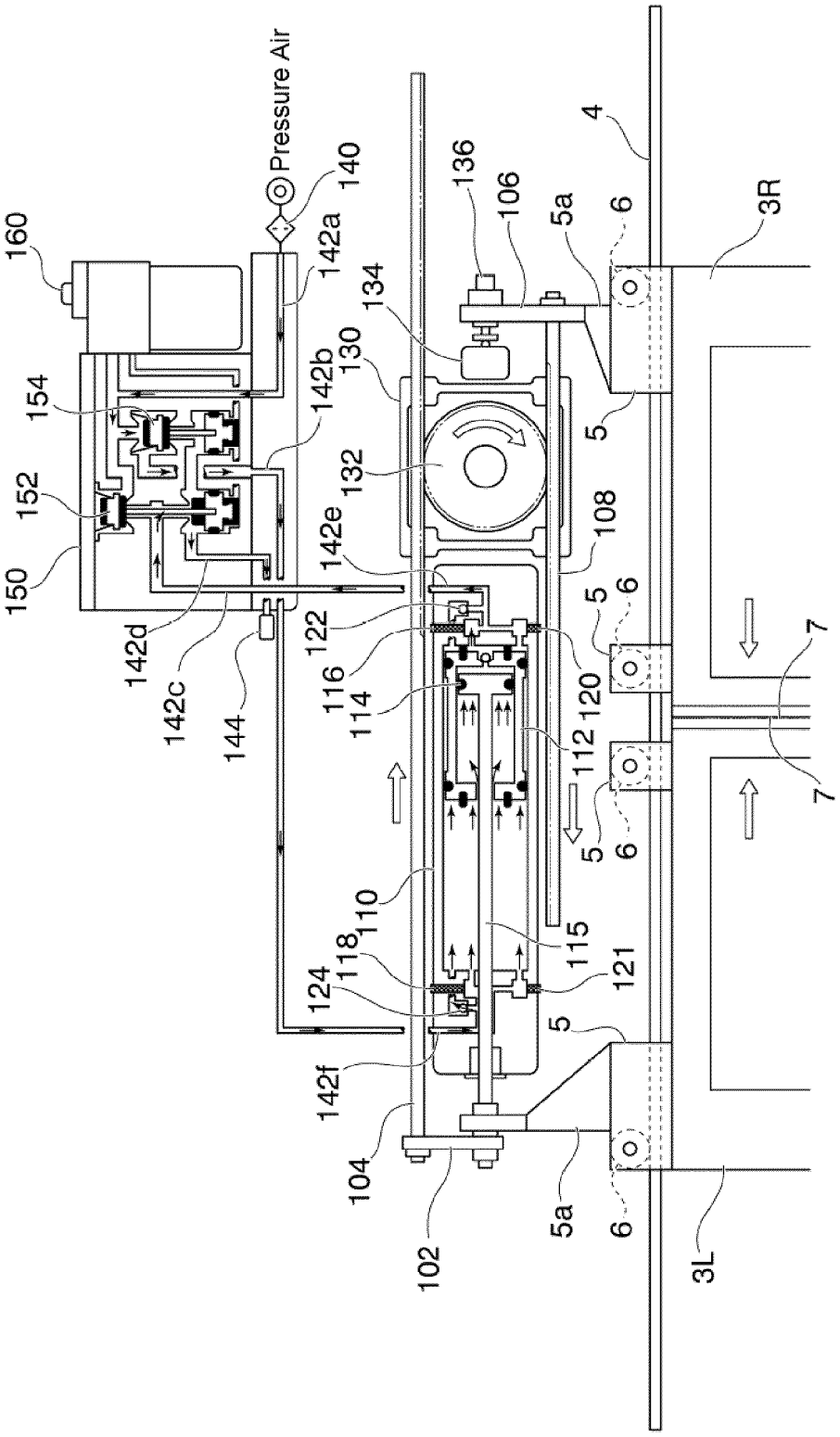
Pressure Air
160
140
142a
136
106
5a
6
4
3R
134
130
142b
154
132
152
108
142e
150
5
122
116
114
120
112
142d
142c
144
7
110
115
118
121
124
5
142f
104
102
5a
6
3L
Y
X

Fig. 14

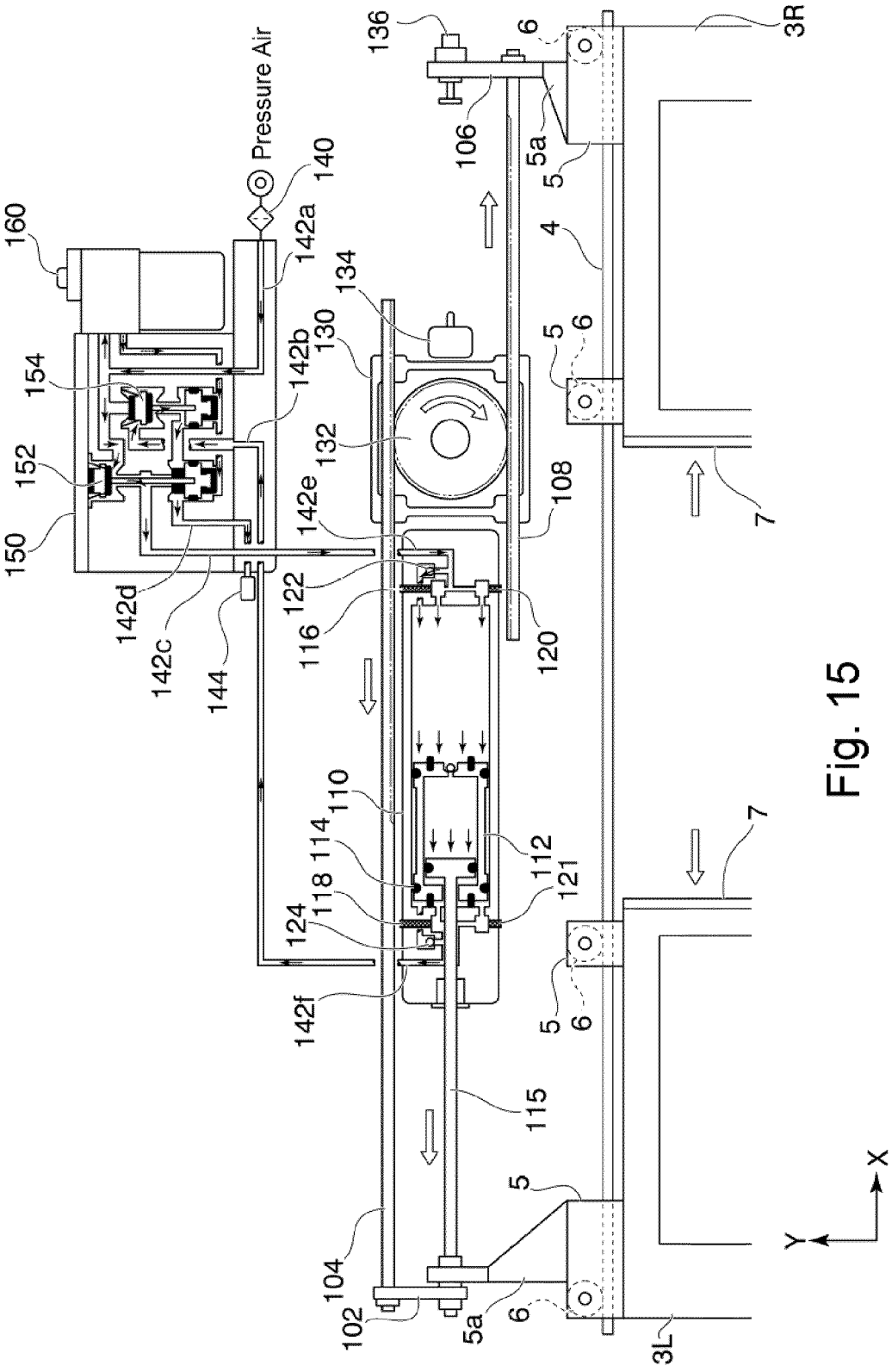
Pressure Air
140
160
142a
154
142b
152
150
142d
142c
144
136
106
6
5a
5
3R
4
134
130
132
108
142e
122
116
120
110
114
118
124
142f
112
121
115
104
102
3L
7
X
Y

Fig. 15

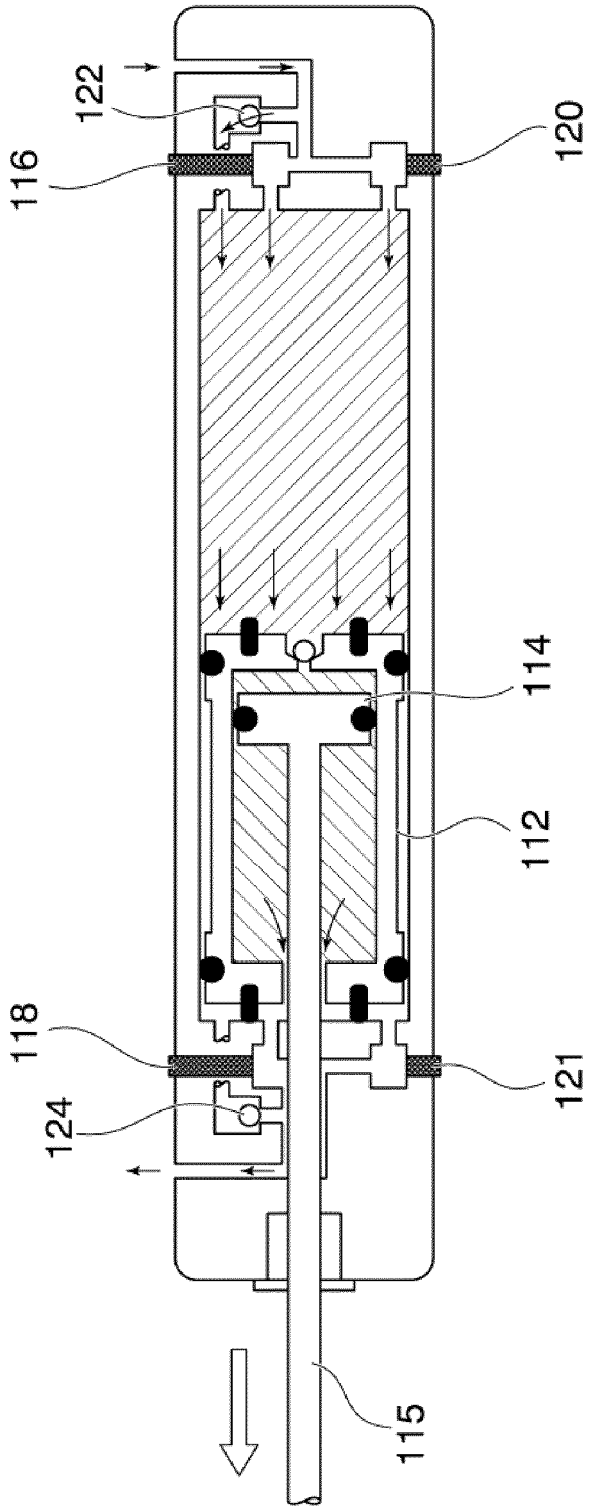

Fig. 16

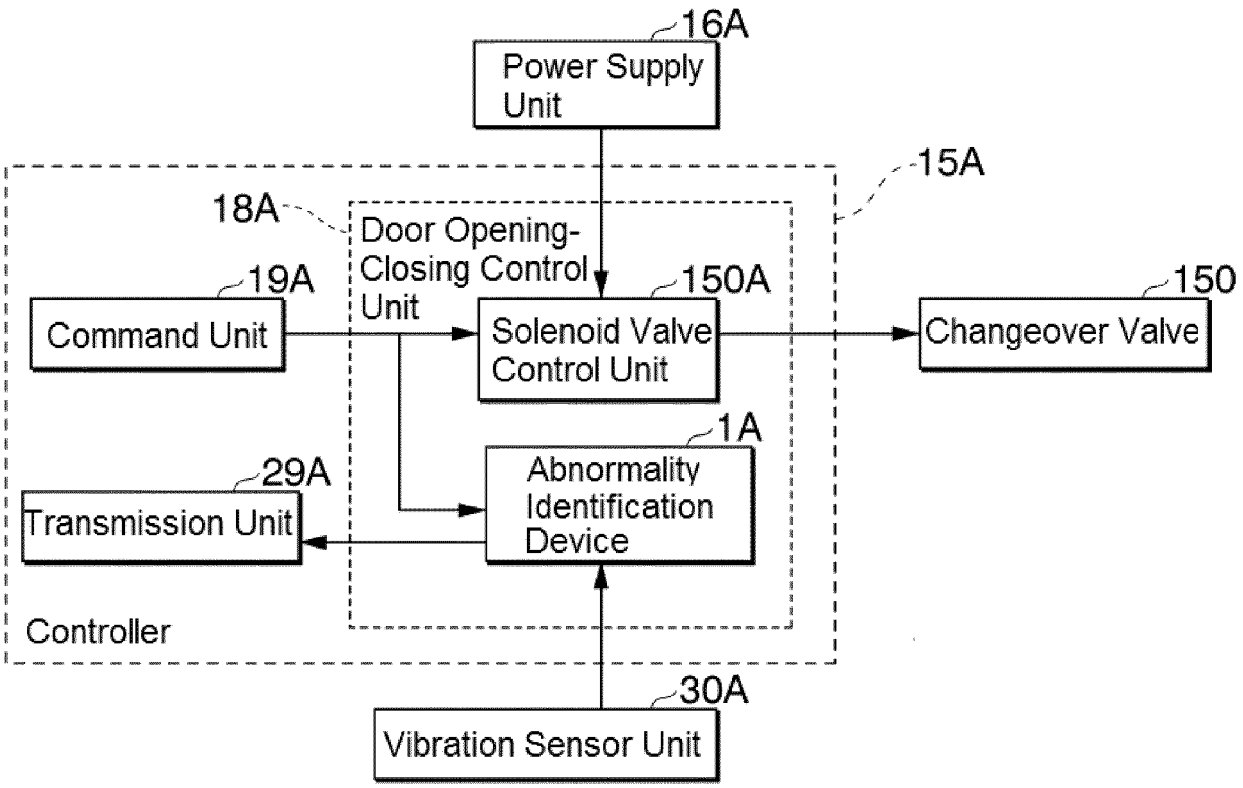
16A
Power Supply Unit
15A
18A
Door Opening-Closing Control Unit
19A
Command Unit
150A
Solenoid Valve Control Unit
150
Changeover Valve
1A
Abnormality Identification Device
29A
Transmission Unit
Controller
30A
Vibration Sensor Unit

Fig. 17

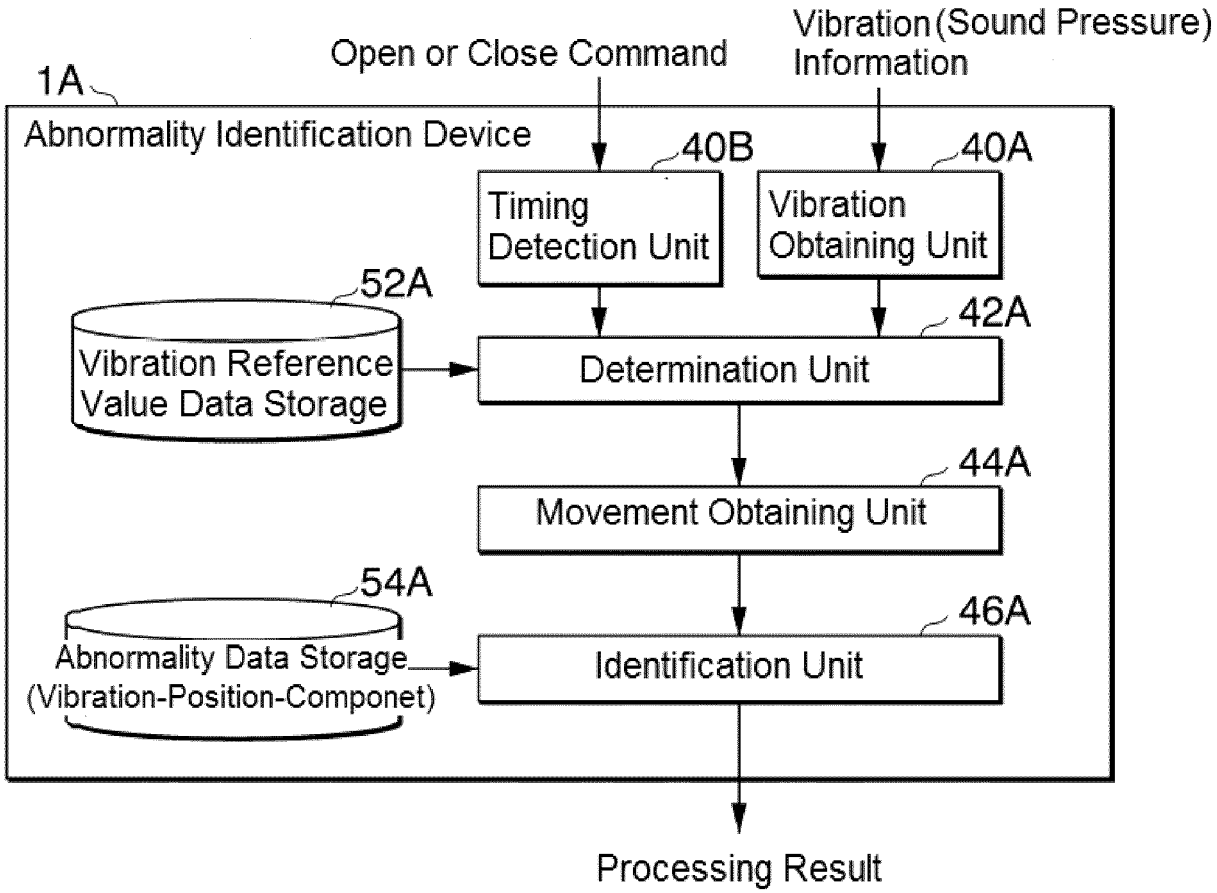
Open or Close Command
Vibration (Sound Pressure) Information
1A
Abnormality Identification Device
40B
40A
Timing Detection Unit
Vibration Obtaining Unit
52A
42A
Vibration Reference Value Data Storage
Determination Unit
44A
Movement Obtaining Unit
54A
46A
Abnormality Data Storage (Vibration-Position-Componet)
Identification Unit
Processing Result

Fig. 18

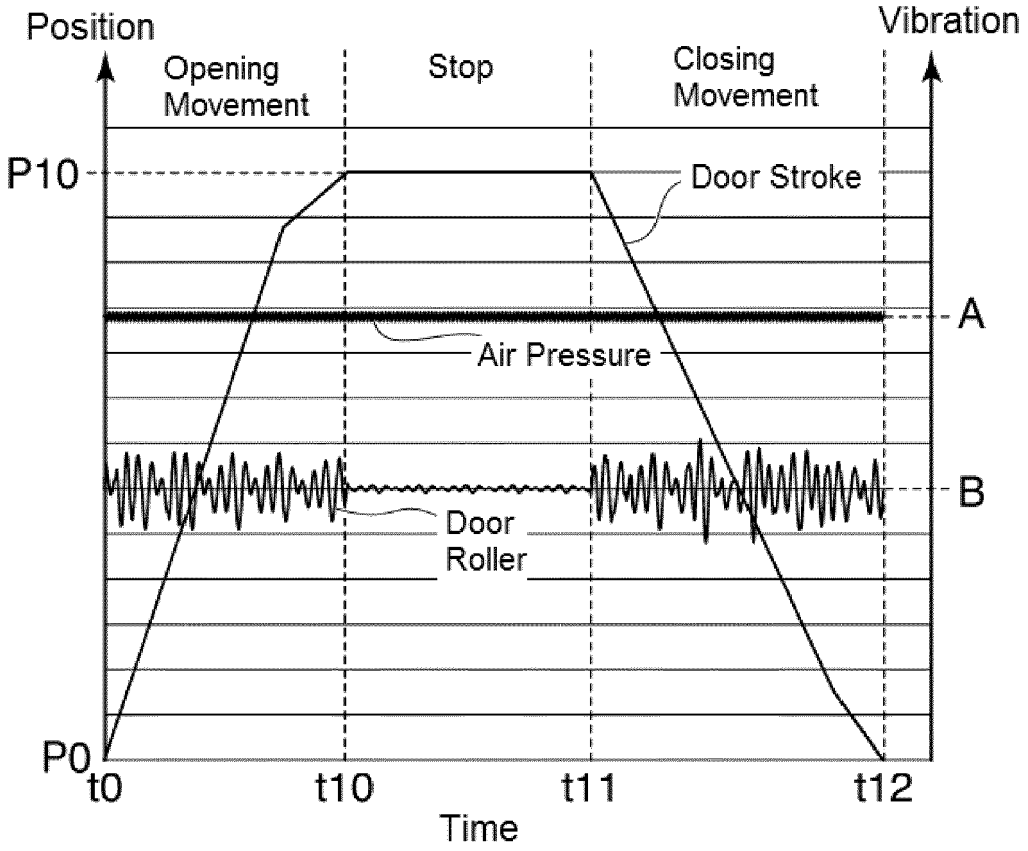
Position
Vibration
Opening Movement
Stop
Closing Movement
P10
Door Stroke
A
Air Pressure
B
Door Roller
P0
t0
t10
t11
t12
Time

Fig. 19

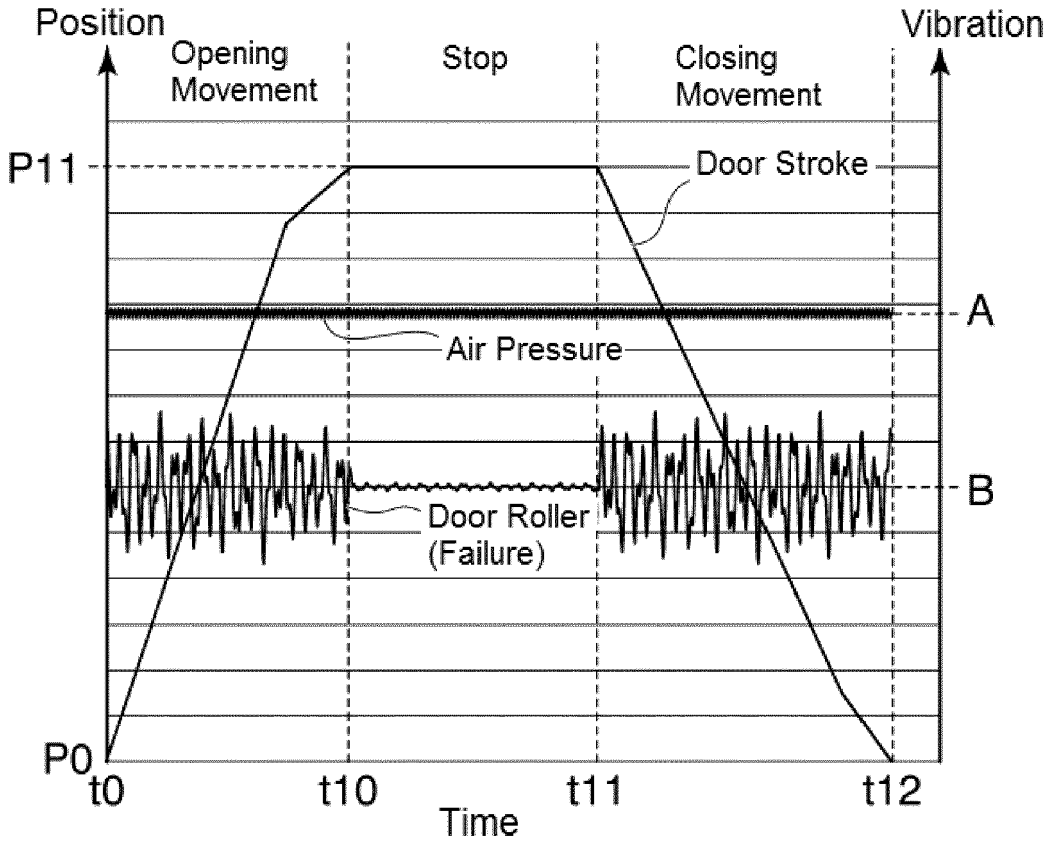
Position
Vibration
Opening Movement
Stop
Closing Movement
P11
Door Stroke
A
Air Pressure
B
Door Roller (Failure)
P0
t0
t10
t11
t12
Time

Fig. 20

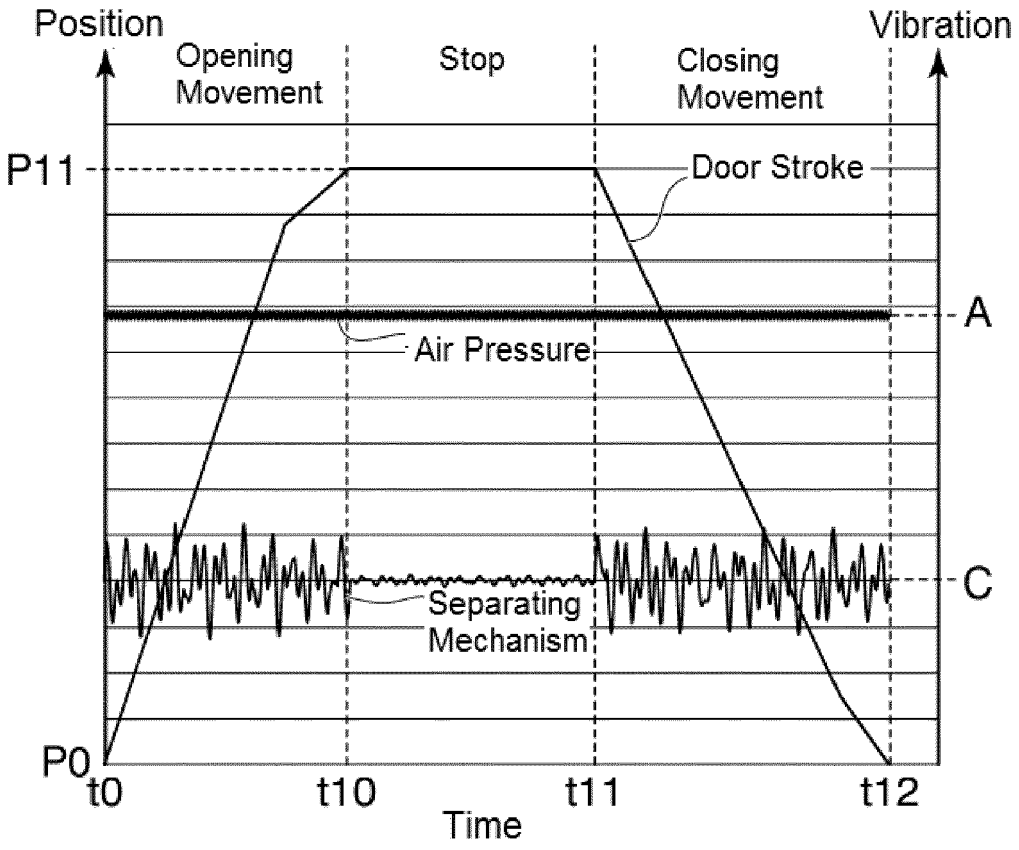
Position
Vibration
Opening Movement
Stop
Closing Movement
P11
Door Stroke
A
Air Pressure
C
Separating Mechanism
P0
t0
t10
t11
t12
Time

Fig. 21

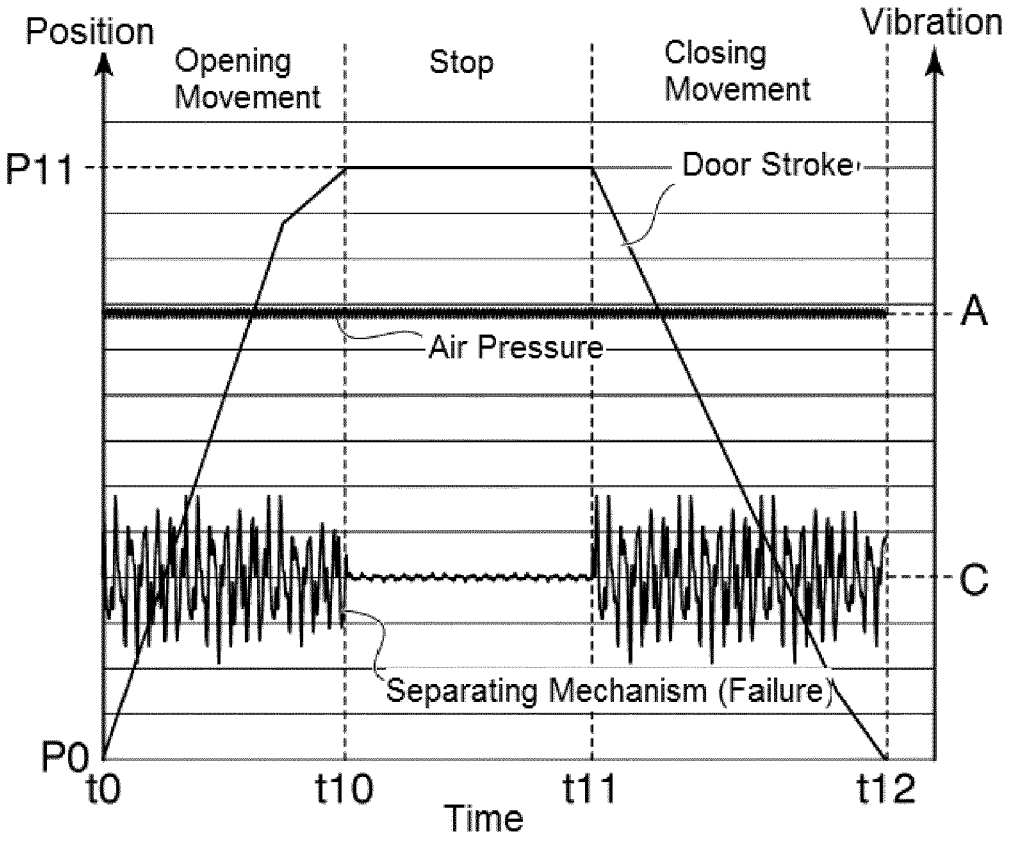
Position
Vibration
Opening Movement
Stop
Closing Movement
P11
Door Stroke
A
Air Pressure
C
Separating Mechanism (Failure)
P0
t0
t10
t11
t12
Time

Fig. 22

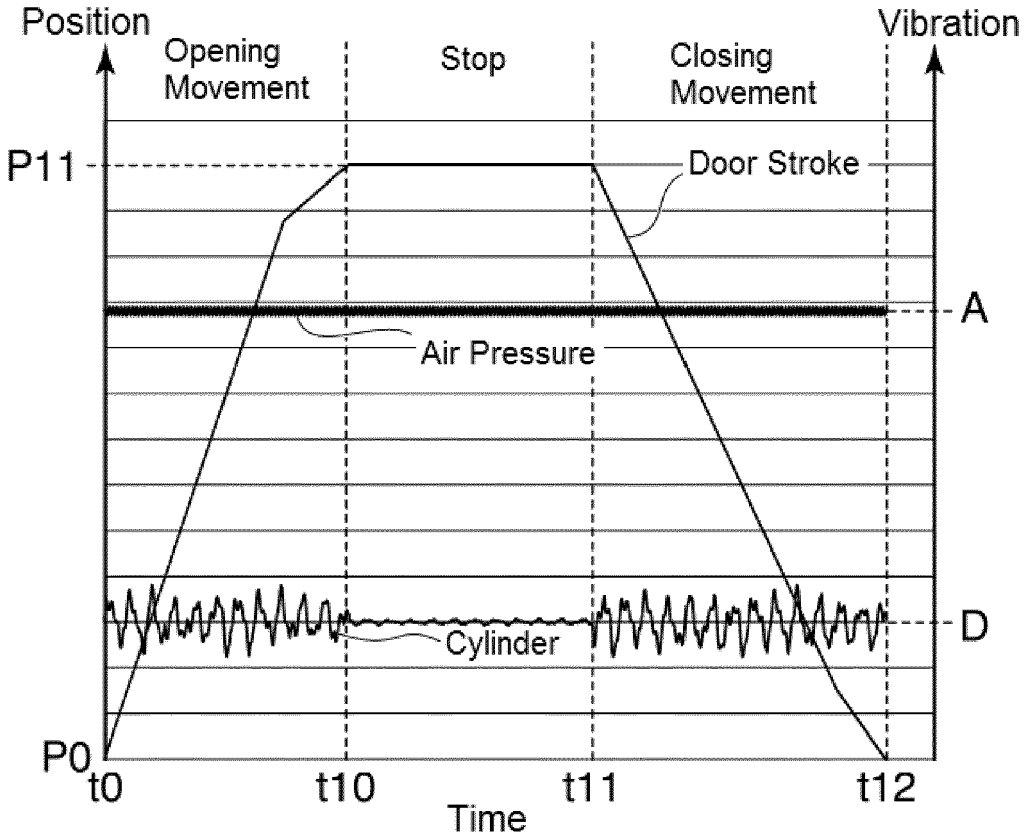
Position
Vibration
Opening Movement
Stop
Closing Movement
P11
Door Stroke
A
Air Pressure
D
Cylinder
P0
t0
t10
t11
t12
Time

Fig. 23

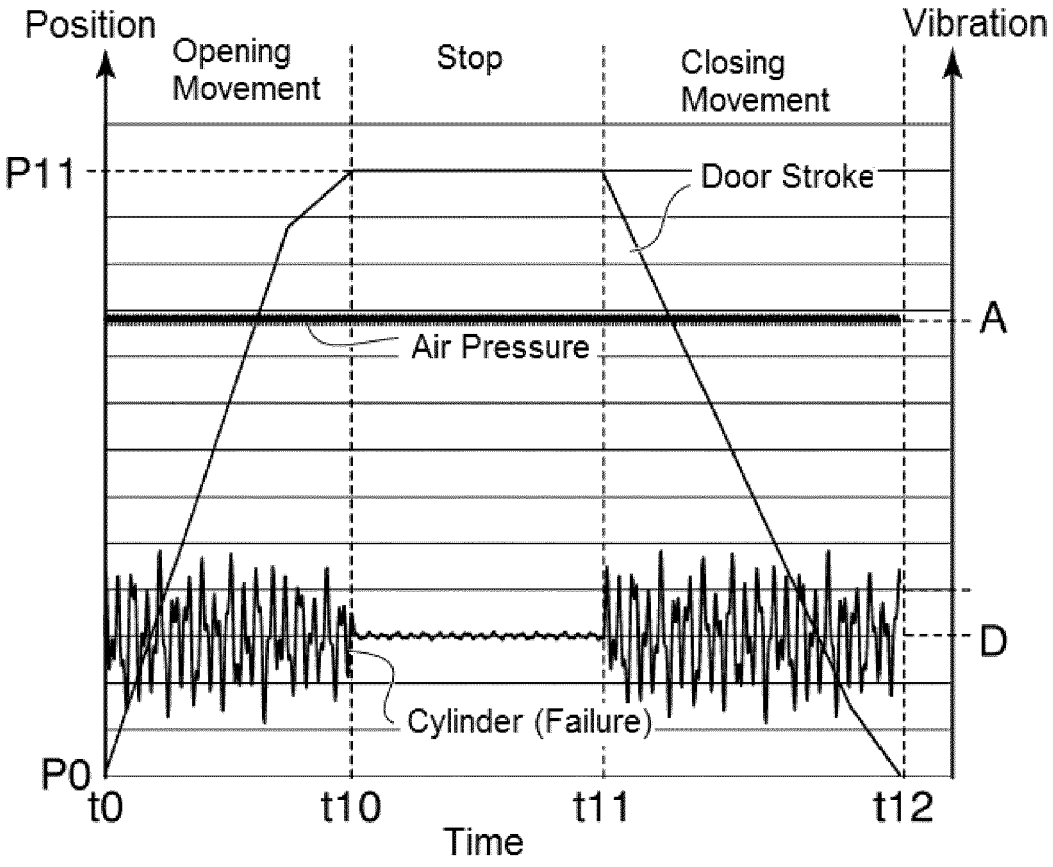
Position
Vibration
Opening Movement
Stop
Closing Movement
P11
Door Stroke
A
Air Pressure
D
Cylinder (Failure)
P0
t0
t10
t11
t12
Time

Fig. 24

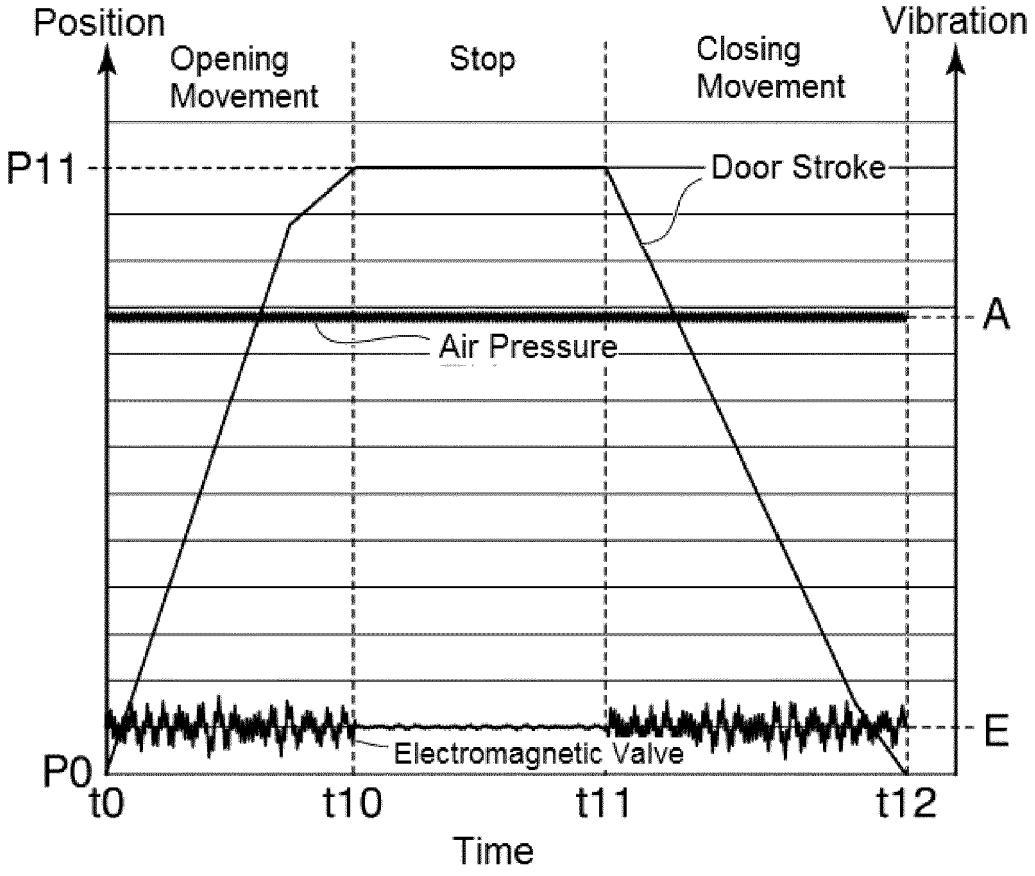
Position
Vibration
Opening Movement
Stop
Closing Movement
P11
Door Stroke
A
Air Pressure
E
Electromagnetic Valve
P0
t0
t10
t11
t12
Time

Fig. 25

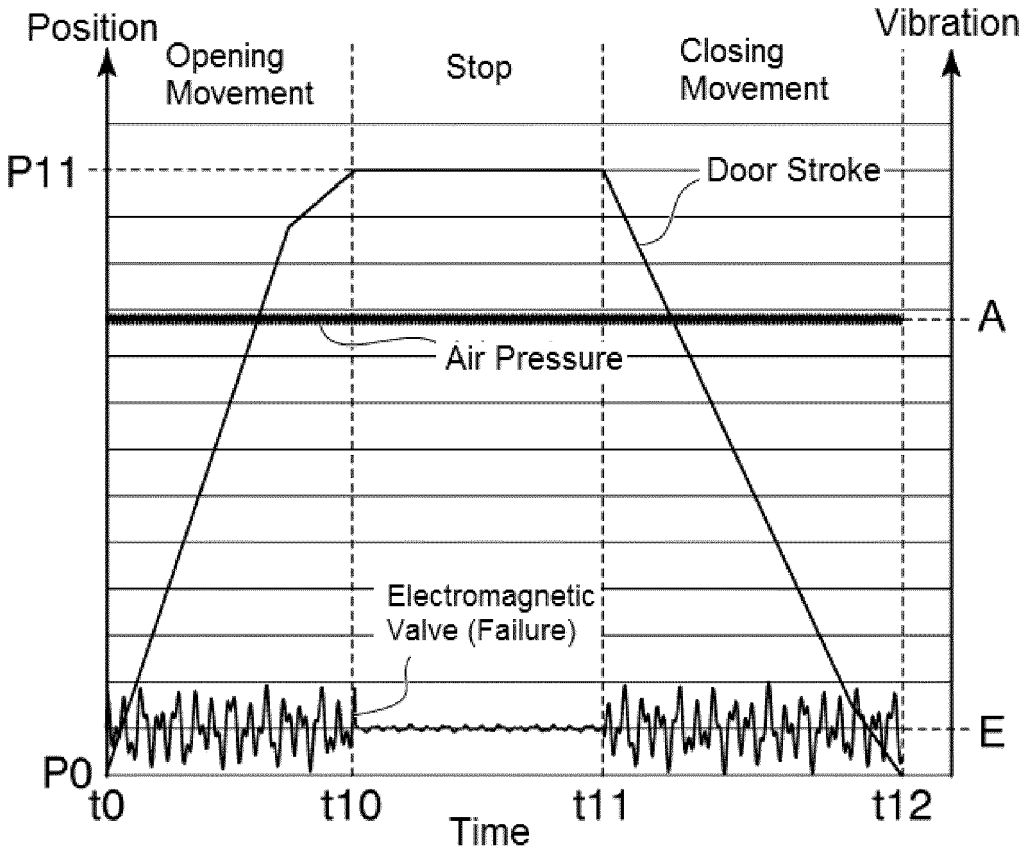
Position
Opening Movement
Stop
Closing Movement
Vibration
P11
Door Stroke
A
Air Pressure
Electromagnetic Valve (Failure)
E
P0
t0
t10
t11
t12
Time

Fig. 26

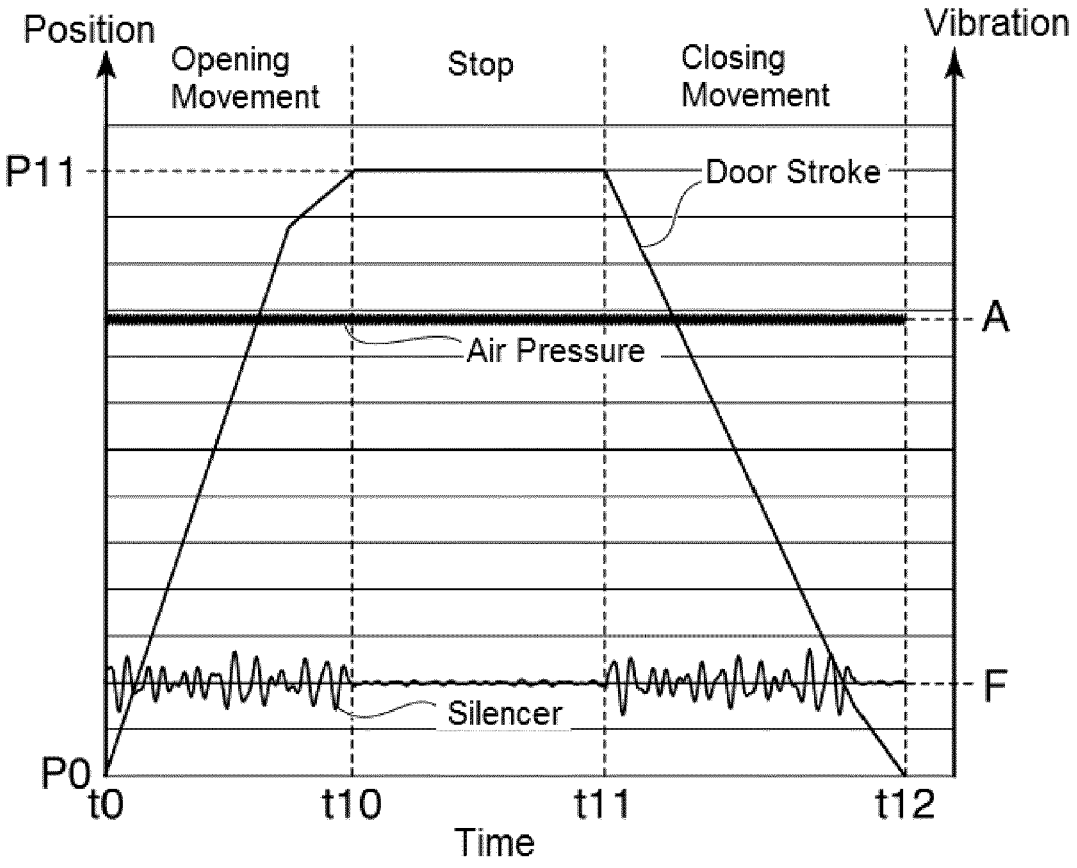
Position
Vibration
Opening Movement
Stop
Closing Movement
P11
Door Stroke
A
Air Pressure
F
Silencer
P0
t0
t10
t11
t12
Time

Fig. 27

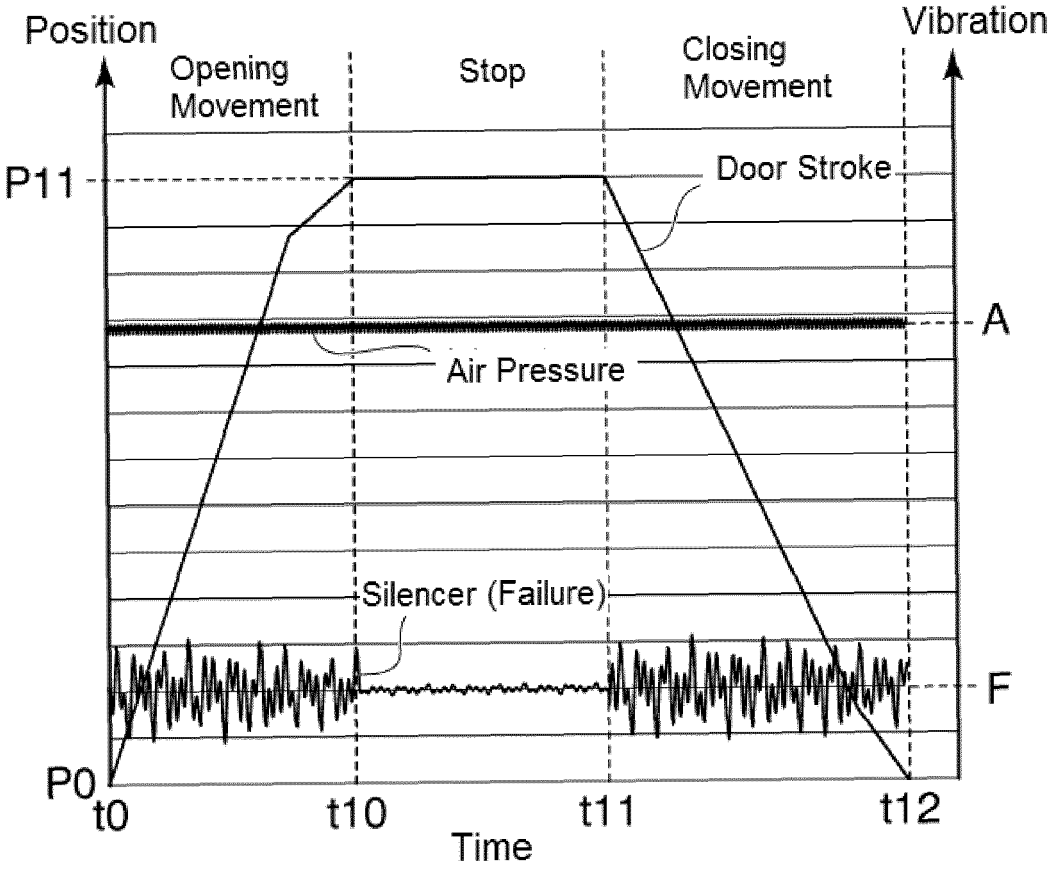
Position
Vibration
Opening Movement
Stop
Closing Movement
P11
Door Stroke
A
Air Pressure
Silencer (Failure)
F
P0
t0
t10
t11
t12
Time

Fig. 28

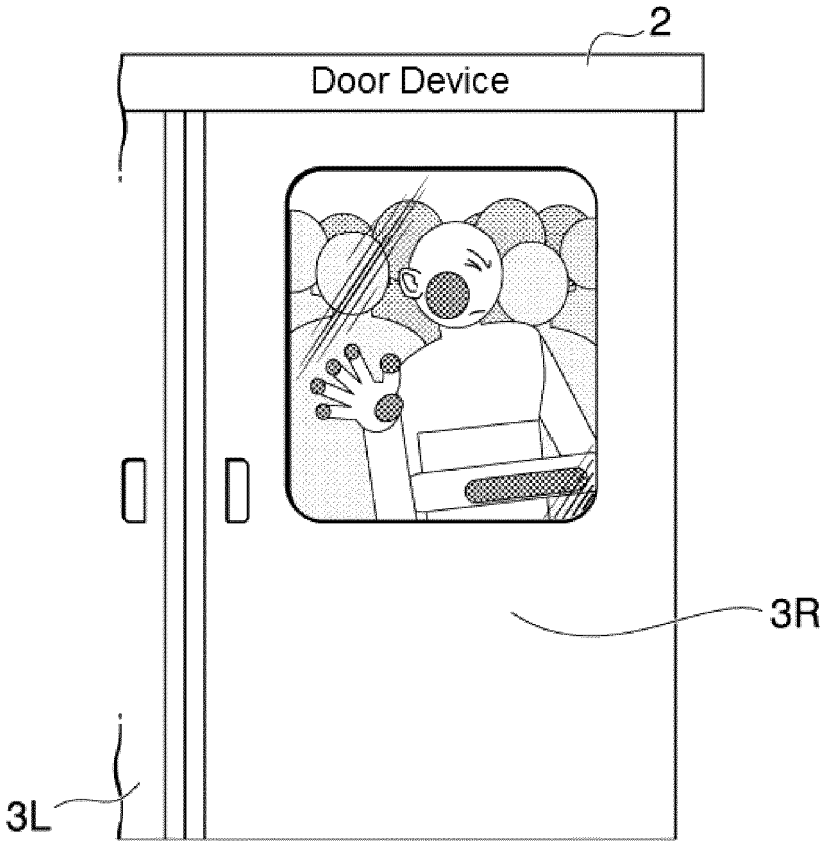

Fig. 29

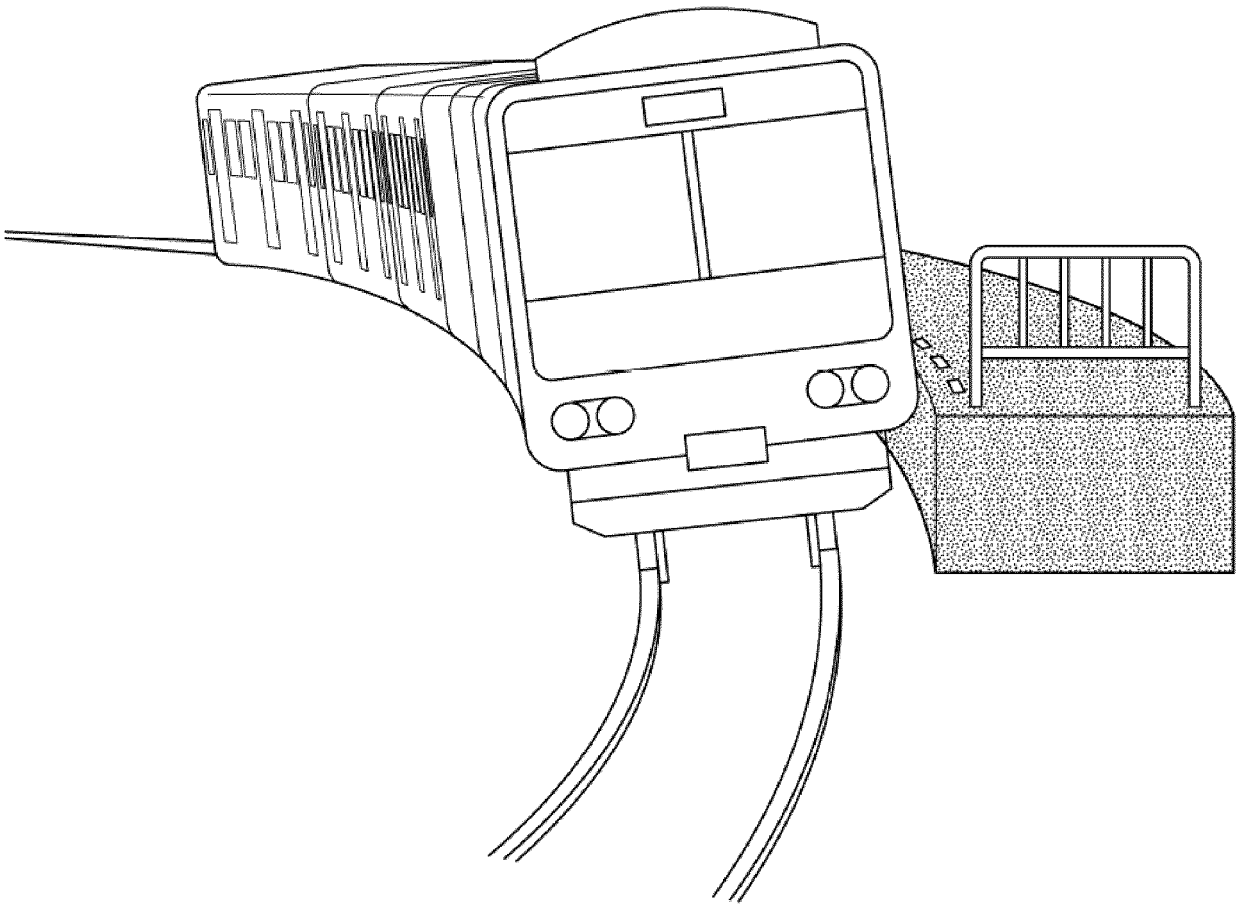

Fig. 30

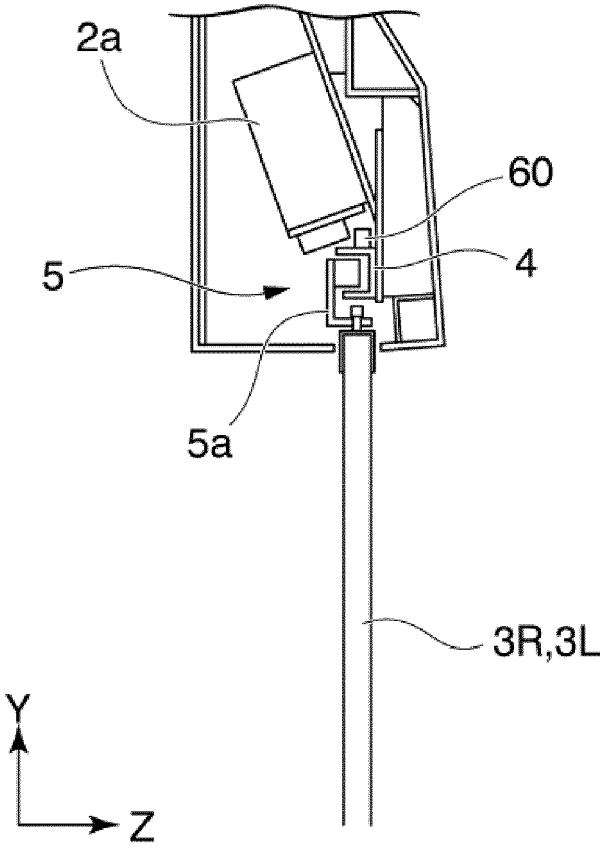

Fig. 31

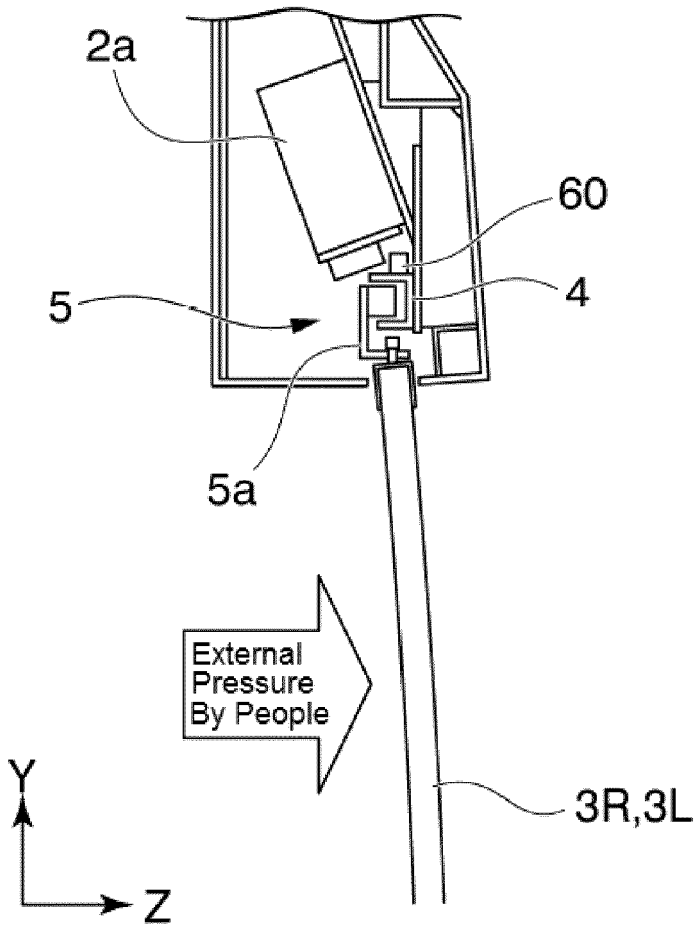

Fig. 32

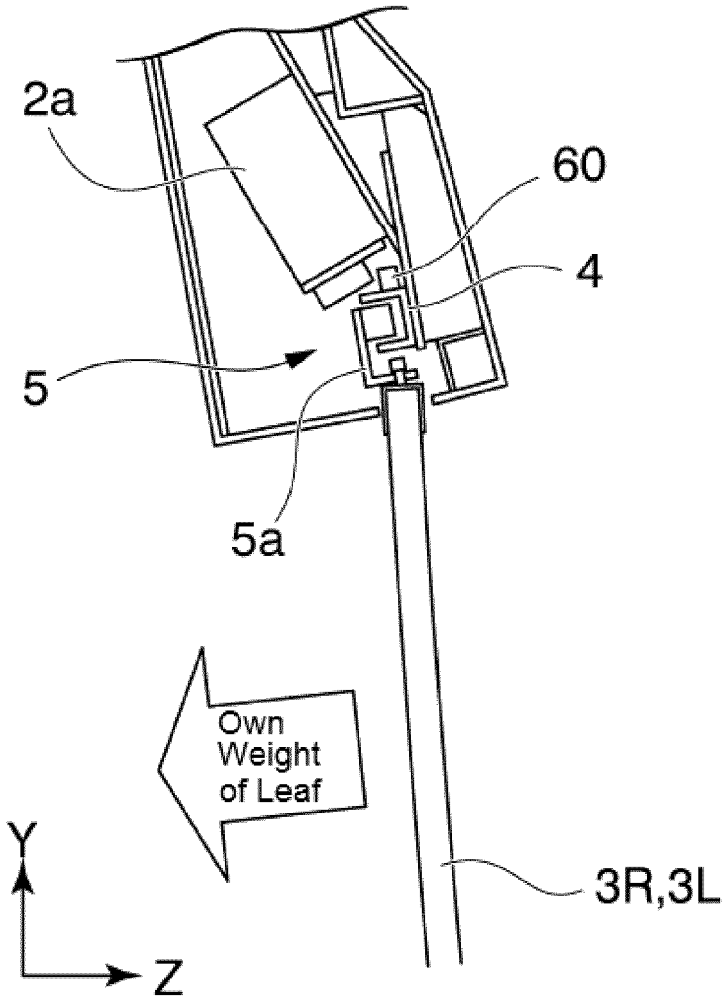

Fig. 33

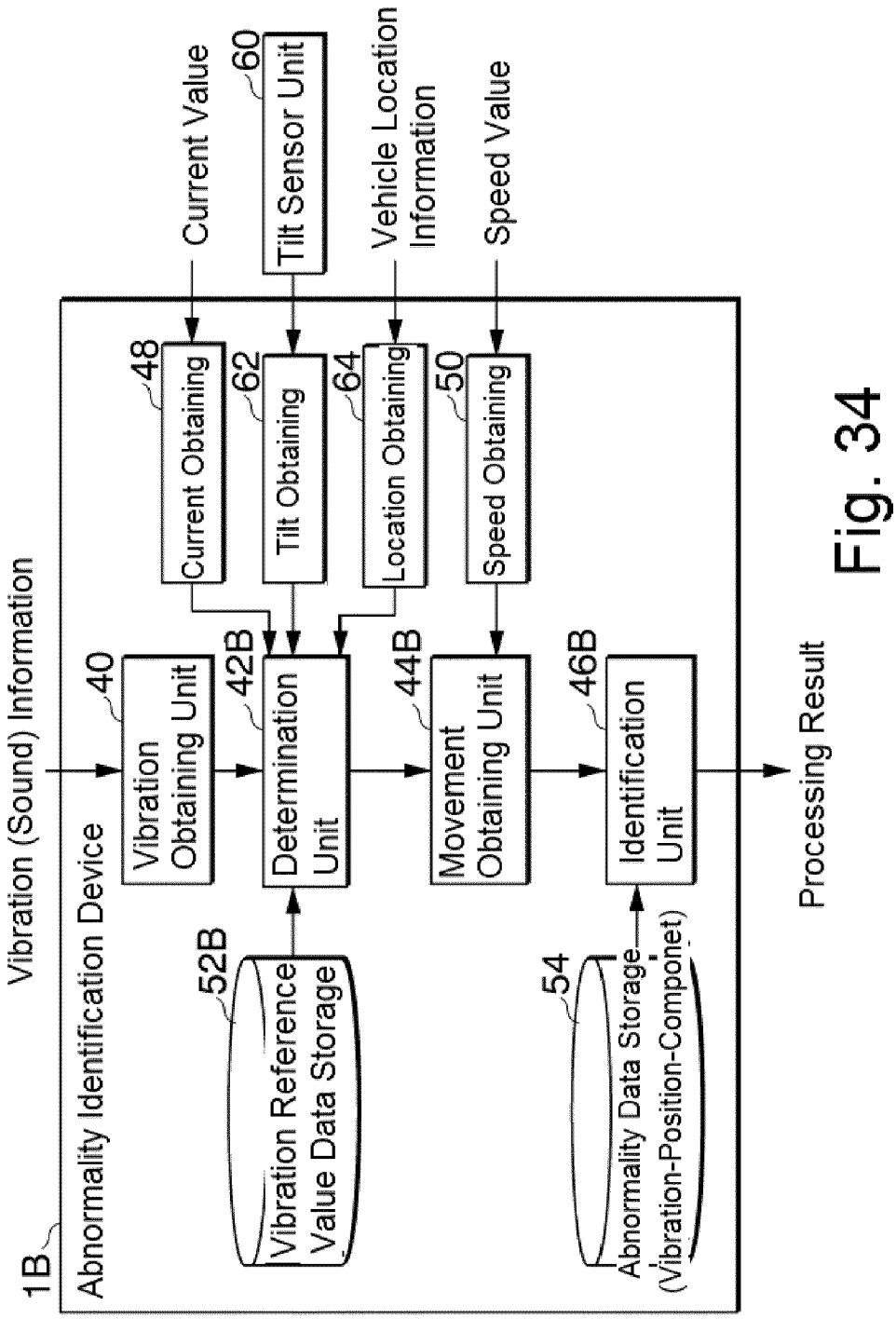
Vibration (Sound) Information
1B
Abnormality Identification Device
40
Vibration Obtaining Unit
42B
Determination Unit
44B
Movement Obtaining Unit
46B
Identification Unit
Processing Result
52B
Vibration Reference Value Data Storage
54
Abnormality Data Storage (Vibration-Position-Componet)
48
Current Obtaining
62
Tilt Obtaining
64
Location Obtaining
50
Speed Obtaining
Current Value
60
Tilt Sensor Unit
Vehicle Location Information
Speed Value

Fig. 34

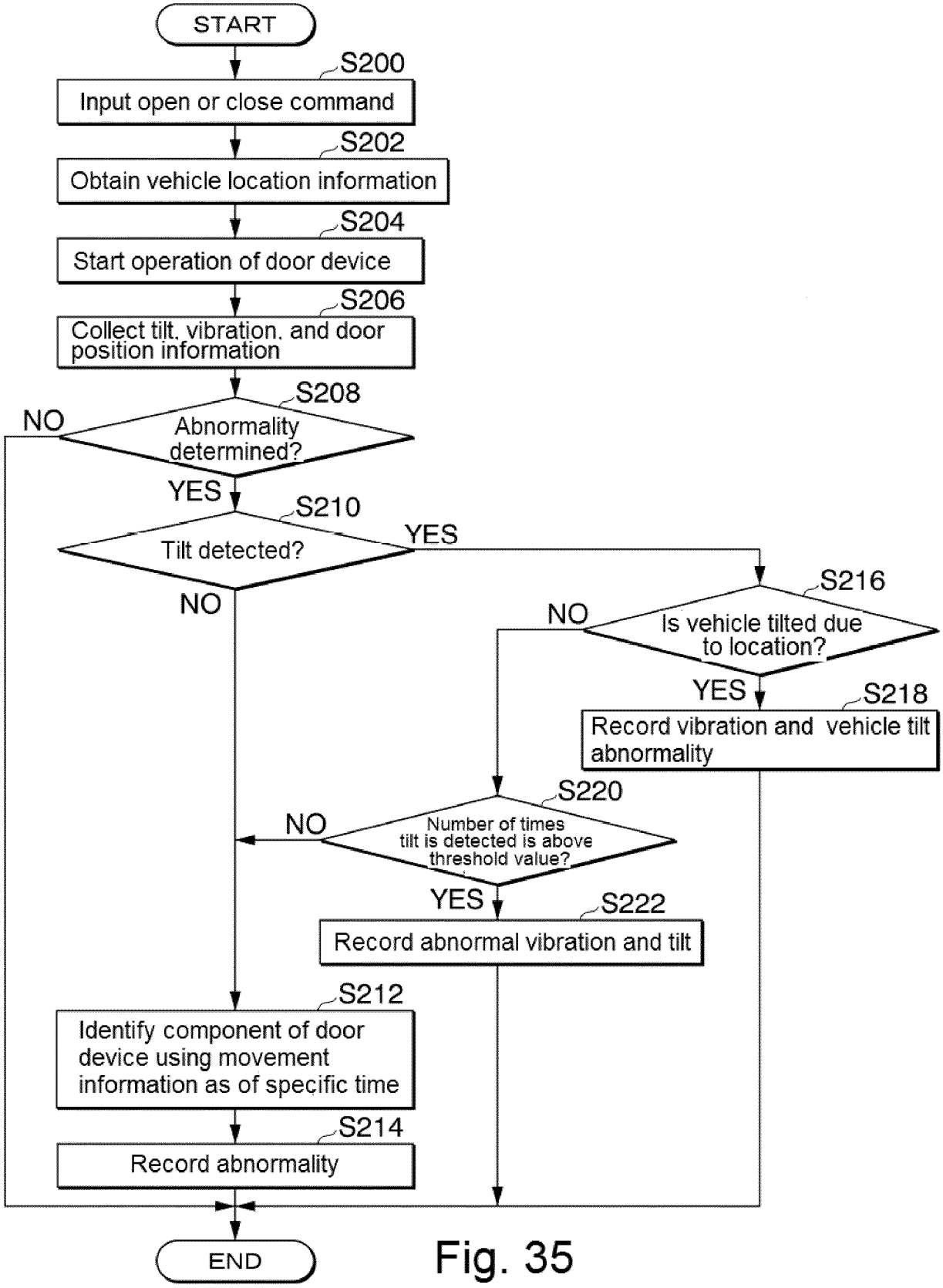
START
S200
Input open or close command
S202
Obtain vehicle location information
S204
Start operation of door device
S206
Collect tilt, vibration, and door position information
S208
Abnormality determined?
NO
YES
S210
Tilt detected?
YES
NO
S216
Is vehicle tilted due to location?
NO
YES
S218
Record vibration and vehicle tilt abnormality
S220
Number of times tilt is detected is above threshold value?
NO
YES
S222
Record abnormal vibration and tilt
S212
Identify component of door device using movement information as of specific time
S214
Record abnormality
END

Fig. 35

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 7739

DOCUMENTS CONSIDERED TO BE RELEVANT

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

E05F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 December 2023	Prieto, Daniel

CATEGORY OF CITED DOCUMENTS

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