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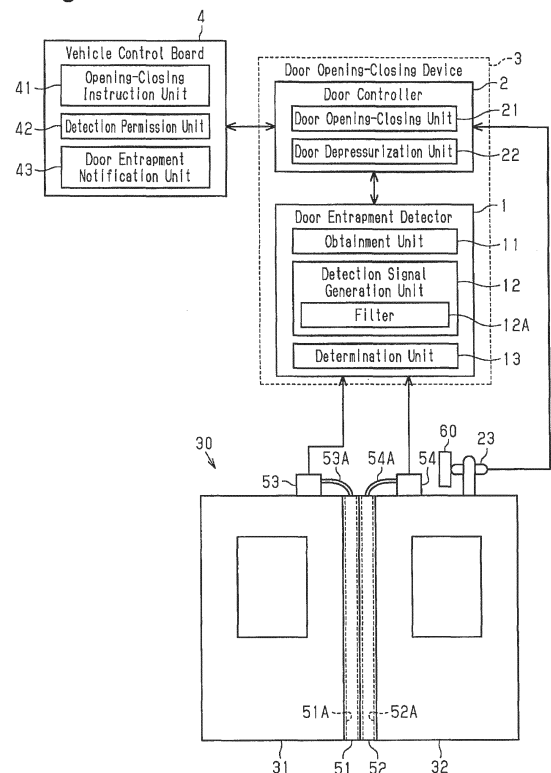
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(54) **DOOR ENTRAPMENT DETECTOR AND DOOR OPENING-CLOSING DEVICE**

(57) A door entrapment detector (1) is configured to detect whether or not a door (30) for opening and closing an entrance of a vehicle is in an entrapment state. The door entrapment detector (1) includes an obtainment unit (11) obtaining an output signal from a detection sensor (53, 54) that detects deformation of elastic members (51, 52) attached to a leading edge of the door (30), a detection signal generation unit (12) performing a process for reducing an effect of vibration that is caused by traveling of the vehicle and included in the output signal obtained by the obtainment unit (11) to generate a detection signal, and a determination unit (13) determining whether or not the door (30) is in an entrapment state based on the detection signal generated by the detection signal generation unit (12).

Fig.1



Description

[0001] The present invention relates to a door entrapment detector and a door opening-closing device for a door that opens and closes an entrance of a vehicle.

[0002] There is a door entrapment detector for detecting door entrapment, that is, entrapment of an object by a door that opens and closes an entrance of a vehicle (for example, refer to Japanese Laid-Open Patent Publication No. 2016-159847).

[0003] Japanese Laid-Open Patent Publication No. 2016-159847 describes a door entrapment detector that includes a pressure switch. The pressure switch outputs a signal in accordance with deformation of an elastic member attached to the leading edge of a door. The door entrapment detector detects entrapment by the door based on the output result of the pressure switch.

[0004] With the door entrapment detector described above, when the pressure switch detects pressure changes caused by vibration when the vehicle is traveling, a false door entrapment signal may be triggered. Thus, in this case, detecting actual door entrapment may have a lower accuracy.

[0005] To solve the problem, it is an object of the present invention to provide a door entrapment detector and a door opening-closing device that increase the accuracy for detecting door entrapment.

[0006] To achieve the above object, a door entrapment detector is provided that is configured to detect whether or not a door for opening and closing an entrance of a vehicle is in an entrapment state. The door entrapment detector includes an obtainment unit, a detection signal generation unit, and a determination unit. The obtainment unit obtains an output signal from a detection sensor detecting deformation of an elastic member attached to a leading edge of the door. The detection signal generation unit performs a process for reducing an effect of vibration that is caused by traveling of the vehicle and included in the output signal obtained by the obtainment unit to generate a detection signal. The determination unit determines whether or not the door is in an entrapment state based on the detection signal generated by the detection signal generation unit.

[0007] With the configuration described above, the process for reducing the effect of vibration caused by the traveling of the vehicle is performed, and whether or not the door is in an entrapment state is determined. This limits erroneous detection of door entrapment caused by vibration of the vehicle. As a result, the accuracy for detecting door entrapment is increased.

[0008] Preferably, in the door entrapment detector, generation of the detection signal with the detection signal generation unit includes reduction of a frequency component of vibration caused by the traveling of the vehicle from the output signal obtained by the obtainment unit.

[0009] When the vehicle is traveling, the output signal from the detection sensor includes a frequency compo-

nent of vibration of the vehicle. With the configuration described above, the frequency component of vibration of the vehicle included in the output signal is reduced. This limits erroneous detection of door entrapment caused by vibration of the vehicle. The detection signal generated by reducing a frequency component of vibration caused by the traveling of the vehicle may be a signal including only a specified frequency band other than the frequency of vibration caused by the traveling of the vehicle.

[0010] Preferably, in the door entrapment detector, generation of the detection signal with the detection signal generation unit includes reduction of different frequency components depending on the travel state of the vehicle.

[0011] Frequency components of vibration of the vehicle may differ depending on the travel state of the vehicle. With the configuration described above, frequency components are reduced in accordance with the travel state of the vehicle. Thus, the accuracy for detecting door entrapment is further increased.

[0012] Preferably, in the door entrapment detector, determination with the determination unit is performed by comparing the detection signal with a determination value that differs depending on the travel state of the vehicle.

[0013] Vibration of the vehicle may differ depending on the travel state of the vehicle. With the configuration described above, the accuracy for detecting door entrapment is further increased.

[0014] Preferably, in the door entrapment detector, the output signal is one of output signals obtained by the obtainment unit in a predetermined period, the detection signal generation unit counts the number of output signals that are included in the output signals and exceed a predetermined reference value, the detection signal generation unit uses the counted number as the detection signal, and when the counted number is greater than or equal to a threshold value, the determination unit determines that the door is in an entrapment state.

[0015] When the vehicle is traveling, the detection member may detect vibration of the vehicle. With the configuration described above, output signals that are included in the output signals obtained by the obtainment unit in the predetermined period and exceed the predetermined reference value are counted. When the counted number is greater than or equal to the threshold value, it is determined that the door is in an entrapment state. This limits detection of vibration caused by the traveling of the vehicle.

[0016] Preferably, in the door entrapment detector, the determination unit changes the threshold value in accordance with the speed of the vehicle.

[0017] With the configuration described above, the threshold value is changed in accordance with the speed of the vehicle. Thus, the accuracy for detecting door entrapment is further increased.

[0018] Preferably, in the door entrapment detector, the determination unit changes the threshold value when re-

ceiving a drive start signal of the vehicle.

[0019] When the drive start signal of the vehicle is received, the vehicle receives driving force and starts to travel. Thus, with the configuration described above, when it is determined that the vehicle is traveling, the door entrapment detection process is performed.

[0020] Preferably, in the door entrapment detector, the determination unit changes the threshold value when receiving a brake release signal of the vehicle.

[0021] When the brake release signal of the vehicle is received, the vehicle is released from the braking and may travel freely depending on the geography. Thus, with the configuration described above, when it is determined that the vehicle is traveling, the door entrapment detection process is performed.

[0022] Preferably, the door entrapment detector further includes the detection sensor that may be a pressure sensor detecting pressure of a hollow portion in the elastic member.

[0023] To achieve the above object, a door opening-closing device is provided that includes a door controller controlling opening and closing of the door. The door controller includes an obtainment unit, a detection signal generation unit, and a determination unit. The obtainment unit obtains an output signal from a detection sensor detecting deformation of an elastic member attached to a leading edge of the door. The detection signal generation unit performs a process for reducing an effect of vibration that is caused by traveling of the vehicle and included in the output signal obtained by the obtainment unit to generate a detection signal. The determination unit determines whether or not the door is in an entrapment state based on the detection signal generated by the detection signal generation unit.

[0024] With the configuration described above, the process for reducing the effect of vibration caused by the traveling of the vehicle and included in the output signal is performed, and whether or not the door is in an entrapment state is determined. This limits erroneous detection of door entrapment caused by vibration of the vehicle. As a result, the accuracy for detecting door entrapment is increased.

[0025] According to the present invention, the accuracy for detecting door entrapment is increased.

[0026] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

[0027] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a block diagram showing a schematic structure of a door opening-closing device including a door entrapment detector according to a first embodiment.

Fig. 2 is a graph showing an example of a detection signal obtained by the door entrapment detector of the first embodiment.

Fig. 3 is a graph showing an example of a detection signal obtained by the door entrapment detector of the first embodiment.

Fig. 4 is a flowchart showing a door entrapment detection process performed by the door entrapment detector of the first embodiment.

Fig. 5 is a flowchart showing a door entrapment detection process performed by a door entrapment detector according to a second embodiment.

Fig. 6 is a block diagram showing a schematic structure of a door opening-closing device including a door entrapment detector according to a third embodiment.

Figs. 7(a) to 7(d) are diagrams showing a door entrapment detection process performed by the door entrapment detector of the third embodiment where Fig. 7(a) shows vehicle speed, Fig. 7(b) shows variation pressure, Fig. 7(c) shows activation and deactivation of a pressure switch, and Fig. 7(d) shows whether or not door entrapment is detected.

Fig. 8 is a flowchart showing the door entrapment detection process performed by the door entrapment detector of the third embodiment.

Figs. 9(a) to 9(d) are diagrams showing a door entrapment detection process performed by a door entrapment detector according to a fourth embodiment where Fig. 9(a) shows vehicle speed, Fig. 9(b) shows variation pressure, Fig. 9(c) shows activation and deactivation of a pressure switch, and Fig. 9(d) shows whether or not door entrapment is detected.

Fig. 10 is a flowchart showing a door entrapment detection process performed by the door entrapment detector of the fourth embodiment.

Fig. 11 is a diagram showing a door controller including a door entrapment detector according to a modified embodiment.

First Embodiment

[0028] A door entrapment detector according to a first embodiment will now be described with reference to Figs. 1 to 4. The door entrapment detector is arranged on a door that opens and closes an entrance of a vehicle, such as a train, to detect door entrapment, that is, entrapment of an object by the door.

[0029] As shown in Fig. 1, a door 30 of a vehicle is a double door and includes a first door 31 and a second door 32 respectively located at the left side and the right side in the drawing. The door 30 opens and closes in accordance with operation of a pneumatic cylinder. The door 30 is driven and controlled by a door controller 2. The door controller 2 controls the pneumatic cylinder to open and close the door 30. The device for driving the door 30 is not limited to a pneumatic cylinder and may be, for example, an electric motor.

[0030] The door 30 is provided with a door entrapment detector 1 detecting entrapment of an object by the door 30. The door entrapment detector 1 is electrically connected to the door controller 2 to intercommunicate with the door controller 2 using signals. The door controller 2 is electrically connected to a vehicle control board 4, which is installed in, for example, an operation cab to control the vehicle, to intercommunicate with the vehicle control board 4 using signals. A device including the door controller 2 and the door entrapment detector 1 is referred to as a door opening-closing device 3.

[0031] The door controller 2 includes a door opening-closing unit 21 controlling the opening and closing of the door 30 and a door depressurization unit 22 performing depressurization control when the door is fully closed. The door opening-closing unit 21 controls the driving of the pneumatic cylinder using pneumatic pressure of a compressor (not shown) to move the door 30 between a fully-open state and a fully-closed state. When the door 30 is in the fully-closed state, the door depressurization unit 22 attenuates the driving of the pneumatic cylinder in the closing direction for a predetermined time from when the door 30 becomes the fully-closed state. Thus, if an object carried by a passenger is trapped between the first door 31 and the second door 32, the passenger may open the door 30 to release the object from the door entrapment. The configuration of the door depressurization unit 22 may be omitted.

[0032] The vehicle control board 4 includes an opening-closing instruction unit 41 instructing the door controller 2 to open and close the door 30, a detection permission unit 42 permitting detection of door entrapment, and a door entrapment notification unit 43 issuing a notification of door entrapment. The opening-closing instruction unit 41 is operated by an operator of the vehicle to send an opening instruction or a closing instruction to the door controller 2. When the opening instruction is input to the door controller 2, the door opening-closing unit 21 moves the door 30 to an open state. When the closing instruction is input to the door controller 2, the door opening-closing unit 21 moves the door 30 to a closed state. The detection permission unit 42 is operated by the operator to output a detection instruction when a door entrapment detection process is performed. The detection permission unit 42 does not output the detection instruction when the door entrapment detection process is not performed. When the door entrapment detector 1 detects door entrapment, the door entrapment notification unit 43 illuminates a lamp arranged on the vehicle control board 4 or otherwise shows information related to the door entrapment detection.

[0033] A first elastic member 51, which is formed from an elastic material such as rubber, is attached to the leading edge of the first door 31. The first elastic member 51 is tubular and has an empty space 51A inside the first elastic member 51. When an object is trapped by the door 30, the first elastic member 51 deforms, and the volume of the empty space 51A changes. A second elas-

tic member 52, which is formed from an elastic material such as rubber, is attached to the leading edge of the second door 32. The second elastic member 52 is tubular and has an empty space 52A inside the second elastic member 52. When an object is trapped by the door 30, the second elastic member 52 deforms, and the volume of the empty space 52A changes. The empty spaces 51A and 52A correspond to a hollow portion of an elastic member.

[0034] A first detection sensor 53 is arranged on the first door 31 to detect deformation of the first elastic member 51. The first detection sensor 53 is a pressure sensor detecting pressure of the empty space 51A in the first elastic member 51. The pressure obtained when the door 30 is closed is referred to as a reference pressure. The first detection sensor 53 outputs a variation pressure with respect to the reference pressure as an output signal. The first detection sensor 53 is attached to the upper portion of the first door 31 and is connected to the upper end of the empty space 51A of the first elastic member 51 via a tube 53A. The first detection sensor 53 may be a component of the door entrapment detector 1. Further, the first detection sensor 53 and the first elastic member 51 may be components of the door entrapment detector 1.

[0035] A second detection sensor 54 is arranged on the second door 32 to detect deformation of the second elastic member 52. The second detection sensor 54 is a pressure sensor detecting pressure of the empty space 52A in the second elastic member 52. The second detection sensor 54 outputs a variation pressure with respect to the reference pressure, which is the pressure obtained when the door 30 is closed, as an output signal. The second detection sensor 54 is attached to the upper portion of the second door 32 and is connected to the upper end of the empty space 52A in the second elastic member 52 via a tube 54A. The second detection sensor 54 may be a component of the door entrapment detector 1. Further, the second detection sensor 54 and the second elastic member 52 may be components of the door entrapment detector 1.

[0036] The door 30 includes a door closing switch 23 detecting that the door 30 is closed. The door closing switch 23 is installed on the second door 32 so that when the door 30 is closed and the second door 32 reaches a predetermined position, the door closing switch 23 comes into contact with a contact portion 60 attached to the body of the vehicle. When in contact with the contact portion 60, the door closing switch 23 outputs a door closing signal to the door controller 2 to indicate that the door 30 is closed. The door closing signal is transmitted to the vehicle control board 4 via the door controller 2. The door closing switch 23 may be installed on the first door 31.

[0037] The door entrapment detector 1 includes an obtainment unit 11 obtaining the output signals from the first detection sensor 53 and the second detection sensor 54, a detection signal generation unit 12 generating a detection signal used for determination, and a determi-

nation unit 13 determining whether or not the door 30 is in an entrapment state.

[0038] The obtainment unit 11 obtains a first output signal, which is the output signal from the first detection sensor 53.

[0039] The detection signal generation unit 12 performs a process for reducing an effect of vibration caused by traveling of the vehicle and included in the output signal obtained by the obtainment unit 11 to generate a detection signal. More specifically, the detection signal generation unit 12 causes the first output signal obtained by the obtainment unit 11 to pass through a filter 12A to generate a first detection signal in which frequency components of vibration of the vehicle are reduced, and transmits the first detection signal to the determination unit 13. The detection signal generation unit 12 includes the filter 12A. Since frequency components of vibration of the vehicle tend to be a high frequency, a low-pass filter is effectively used as the filter 12A. The filter 12A removes signals having frequencies that are, for example, 6 Hz or higher. The detection signal generation unit 12 obtains a second output signal, which is the output signal from the second detection sensor 54, causes the second output signal to pass through the filter 12A to generate a second detection signal in which frequency components of vibration of the vehicle are reduced, and transmits the second detection signal to the determination unit 13.

[0040] The determination unit 13 determines whether or not the door 30 is in an entrapment state based on the detection signal generated by the detection signal generation unit 12. The determination unit 13 determines whether or not the door 30 is in an entrapment state by comparing the detection signal received from the detection signal generation unit 12 with a determination value. When the detection signal is greater than the determination value, the determination unit 13 determines that the door 30 is in an entrapment state. More specifically, when at least one of the first detection signal and the second detection signal received from the detection signal generation unit 12 is greater than the determination value, the determination unit 13 determines that the door 30 is in an entrapment state. Determination that the door 30 is in an entrapment state when just one of the first detection signal and the second detection signal is greater than the determination value increases the possibility of quickly detecting the door entrapment. If it is determined that the door 30 is in an entrapment state when the first detection signal and the second detection signal are both greater than the determination value, the possibility of accurately detecting door entrapment is increased.

[0041] The reduction of frequency components of vibration of the vehicle through the filter 12A will now be described with reference to Figs. 2 and 3.

[0042] Fig. 2 shows output signals output from the detection sensors 53 and 54. The left side in Fig. 2 shows an output signal X1 when the vehicle is at a standstill and the door 30 is in an entrapment state. The output signal X1 has a low frequency. The right side in Fig. 2 shows

an output signal X2 when the vehicle is traveling with travel vibration. The output signal X2 has a high frequency. The amplitude of the output signal X2 including travel vibration is referred to as a first amplitude W1. Thus, the determination value for determination of whether or not the door 30 is in an entrapment state needs to be a first determination value T1 that is greater than the first amplitude W1. With the first determination value T1, a left peak M1 of the door entrapment cannot be detected, and values that are greater than the left peak M1 such as a right peak M2 of the door entrapment can only be detected. Thus, output signals output from the detection sensors 53 and 54 are passed through the filter 12A to obtain the detection signals shown in Fig. 3.

[0043] Fig. 3 shows detection signals obtained by passing the output signals through the filter 12A. The left side in Fig. 3 shows a detection signal Y1 when the vehicle is at a standstill and the door 30 is in an entrapment state. The right side in Fig. 3 shows a detection signal Y2 when the vehicle is traveling with travel vibration. The amplitude of the detection signal Y2 including travel vibration is smaller than the first amplitude W1 and is referred to as a second amplitude W2. Thus, the determination value for determination of whether or not the door 30 is in an entrapment state may be a second determination value T2 that is smaller than the first determination value T1. With the second determination value T2, the left peak M1, which is smaller than the right peak M2, of the door entrapment is detected.

[0044] The door entrapment detection process performed by the door entrapment detector 1 will now be described with reference to Fig. 4.

[0045] The door entrapment detector 1 determines whether or not a door closing instruction is received (step S11). More specifically, when a door closing instruction output from the vehicle control board 4 is received via the door controller 2, the door 30 will be closed. Thus, the door entrapment detector 1 starts to detect whether or not the door 30 is in an entrapment state. If the door closing instruction is not received (step S11: NO), the door entrapment detector 1 waits for a door closing instruction.

[0046] If the door closing instruction is received (step S11: YES), the door entrapment detector 1 obtains a detection signal (step S12). More specifically, when the first output signal is received from the first detection sensor 53, the obtainment unit 11 causes the first output signal to pass through the filter 12A to generate the first detection signal in which frequency components of vibration of the vehicle are reduced. When the second output signal is received from the second detection sensor 54, the obtainment unit 11 causes the second output signal to pass through the filter 12A to generate the second detection signal in which frequency components of vibration of the vehicle are reduced. The obtainment unit 11 transmits the first detection signal and the second detection signal to the determination unit 13.

[0047] The door entrapment detector 1 determines

whether or not the detection signal is greater than the determination value (step S13). More specifically, if the determination unit 13 determines that the detection signal is less than or equal to the determination value T2 (step S13: NO), the determination unit 13 determines whether or not a termination condition is satisfied (step S17). If the termination condition is not satisfied (step S17: NO), the determination unit 13 proceeds to step S12 and continues the process. If the termination condition is satisfied (step S17: YES), the determination unit 13 proceeds to step S16. The termination condition is a condition that does not require the door entrapment detection process, such as a condition in which a predetermined time has elapsed since the vehicle started traveling, a condition in which the rear end of the vehicle has passed the end of a platform, or a condition in which the speed of the vehicle exceeds a predetermined speed.

[0048] If the determination unit 13 determines that the detection signal is greater than the determination value T2 (step S13: YES), the determination unit 13 determines that the door 30 is in an entrapment state (step S14). More specifically, even when the output signal includes travel vibration of the vehicle, the determination unit 13 makes a determination based on the detection signal obtained by causing the output signal to pass through the filter 12A. Thus, the determination is made using the second determination value T2, which is smaller than the first determination value T1 used for determination of the output signal.

[0049] In other words, in the process of steps S12, S13, and S17, the determination unit 13 continues to obtain detection signals and continues to make determinations until the detection value exceeds greater than the determination value T2 or the termination condition is satisfied.

[0050] The door entrapment detector 1 outputs a door entrapment detection (step S15). If the determination unit 13 determines that the door 30 is in an entrapment state, the determination unit 13 reports the door entrapment detection to the door controller 2 to output the door entrapment detection to the vehicle control board 4 via the door controller 2.

[0051] Subsequently, the door entrapment detector 1 stops obtaining detection signals (step S16) and ends the door entrapment detection process. More specifically, the obtainment unit 11 stops receiving output signals. Alternatively, the obtainment unit 11 may cause the first detection sensor 53 and the second detection sensor 54 to stop outputting output signals or may cause the first detection sensor 53 and the second detection sensor 54 to stop detecting pressure.

[0052] The door entrapment detector 1 uses the detection sensors 53 and 54 and thus differs from a typical detector that uses a detection switch to detect door entrapment. The door entrapment detector 1 uses pressure variations caused by deformation of the elastic members 51 and 52 to reduce frequency components of vibration of the vehicle.

[0053] The present embodiment has the advantages

described below.

(1) The process for reducing the effect of vibration caused by the traveling of the vehicle is performed, and whether or not the door 30 is in an entrapment state is determined. This limits erroneous detection of door entrapment caused by vibration of the vehicle. As a result, the accuracy for detecting door entrapment is increased.

(2) Frequency components of vibration of the vehicle included in the output signal are reduced. This limits erroneous detection of door entrapment caused by vibration of the vehicle.

15 Second Embodiment

[0054] A door entrapment detector according to a second embodiment will now be described with reference to Fig. 5. The door entrapment detection process of the second embodiment differs from that of the first embodiment in that the travel state of the vehicle is taken into consideration when determination is made. The description will focus on the differences from the first embodiment.

[0055] The door entrapment detector 1 obtains travel state information indicating the travel state of the vehicle from the vehicle control board 4 via the door controller 2. The travel state information indicates, for example, states of the vehicle including a standstill, traveling (powered-traveling), and braking (brake) and speed of the vehicle.

[0056] The filter 12A of the detection signal generation unit 12 of the door entrapment detector 1 removes different frequency components depending on the travel state of the vehicle. As the speed of the vehicle increases, the lower limit of a frequency that is removed by the filter 12A is raised because the frequency of an output signal caused by the travel vibration increases. Additionally, when the speed of the vehicle is assumed to increase based on the state of the vehicle, the lower limit of a frequency that is removed by the filter 12A is raised. When the speed of the vehicle is assumed to decrease based on the state of the vehicle, the lower limit of a frequency that is removed by the filter 12A is lowered.

[0057] The determination unit 13 of the door entrapment detector 1 makes a determination using different determination values depending on the travel state of the vehicle. As the speed of the vehicle increases, the determination value is increased because door entrapment is less likely to occur. Additionally, when the speed of the vehicle is assumed to increase based on the state of the vehicle, the determination value is increased. When the speed of the vehicle is assumed to decrease based on the state of the vehicle, the determination value is decreased.

[0058] As shown in Fig. 5, if the door closing instruction is received (step S11: YES), the door entrapment detector 1 obtains the travel state information (step S21). More specifically, the door entrapment detector 1 obtains the

travel state information from the vehicle control board 4 via the door controller 2.

[0059] The door entrapment detector 1 sets the filter 12A in accordance with the travel state (step S22). More specifically, the detection signal generation unit 12 changes the lower limit of a frequency that is removed by the filter 12A in accordance with the travel state.

[0060] The door entrapment detector 1 obtains a detection signal (step S23). More specifically, the obtainment unit 11 obtains output signals from the first detection sensor 53 and the second detection sensor 54. The detection signal generation unit 12 causes the output signals to pass through the filter 12A to generate a detection signal in which frequency components of vibration of the vehicle are reduced, and transmits the detection signal to the determination unit 13.

[0061] The door entrapment detector 1 sets the determination value in accordance with the travel state (step S24). More specifically, the determination unit 13 changes the determination value in accordance with the travel state.

[0062] The door entrapment detector 1 determines whether or not the door 30 is in an entrapment state by comparing the detection signal that has passed through the filter 12A, which is set in accordance with the travel state, with the determination value that is set in accordance with the travel state (step S13).

[0063] Subsequently, the process of steps S14 to S17 is performed in the same manner as the first embodiment, and the door entrapment detection process is ended.

[0064] The second embodiment has the advantages described below in addition to the advantages (1) and (2) of the first embodiment.

- (3) Frequency components of vibration of the vehicle may differ depending on the travel state of the vehicle. Reduction of frequency components in accordance with the travel state of the vehicle further increases the accuracy for detecting door entrapment.
- (4) Different determination values are used depending on the travel state of the vehicle. This further increases the accuracy for detecting door entrapment.

Third Embodiment

[0065] A door entrapment detector according to a third embodiment will now be described with reference to Figs. 6 to 8. The door entrapment detector of the third embodiment differs from that of the first embodiment in the determination of whether or not the door 30 is in an entrapment state. The description will focus on the differences from the first embodiment.

[0066] A first detection sensor 73, which is arranged on the first door 31, is a pressure switch outputting an output signal when variation pressure of the empty space 51A in the first elastic member 51 exceeds a determination value. The first detection sensor 73 is connected to

the empty space 51A by a tube 73A. A second detection sensor 74, which is arranged on the second door 32, is a pressure switch outputting an output signal when variation pressure of the empty space 52A in the second elastic member 52 exceeds a determination value. The second detection sensor 74 is connected to the empty space 52A by a tube 74A.

[0067] The detection signal generation unit 12 of the door entrapment detector 1 does not include the filter 12A. The detection signal generation unit 12 counts the number of output signals included in first output signals output from the first detection sensor 73 and second output signals output from the second detection sensor 74 and exceeding a predetermined reference value (determination value). The detection signal generation unit 12 transmits the counted number to the determination unit 13 as a detection signal.

[0068] The door entrapment detector 1 receives a powered-traveling start signal from the vehicle control board 4 via the door controller 2. The powered-traveling start signal is output in a powered-traveling state, for example, when speed X km/hour reaches 5 km/hour.

[0069] The detection signal generation unit 12 counts the number of output signals that are included in output signals obtained by the obtainment unit 11 in a predetermined period and exceed the predetermined reference value (determination value) and uses the counted number as a detection signal. When the counted number is greater than or equal to a threshold value, the determination unit 13 determines that the door 30 is in an entrapment state. More specifically, when the number of output signals that are included in at least one of the first output signals and the second output signals received from the obtainment unit 11 and exceed the predetermined reference value (determination value) is greater than or equal to the threshold value, the determination unit 13 determines that the door 30 is in an entrapment state. If the door 30 being in an entrapment state is determined when the number of output signals that are included in just one of the first output signals and the second output signals and exceeding the predetermined reference value (determination value) is greater than or equal to the threshold value, the possibility of quickly detecting door entrapment increases. If the door 30 being in an entrapment state is determined when the number of output signals that are included in both of the first output signals and the second output signals and exceed the predetermined reference value (determination value) is greater than or equal to the threshold value, the possibility of accurately detecting door entrapment increases.

[0070] The determination unit 13 reduces the effect of vibration caused by the traveling of the vehicle by changing the threshold value in accordance with whether the vehicle is traveling or at a standstill and determines whether or not the door 30 is in an entrapment state. The determination unit 13 obtains the powered-traveling start signal from the vehicle control board 4 via the door controller 2 as a drive start signal.

[0071] As shown in Figs. 7(a) to 7(d), when the powered-traveling start signal is received from the vehicle control board 4, the determination unit 13 determines that the vehicle is traveling and sets the threshold value to a second threshold value. The second threshold value is, for example, two. When the vehicle is traveling and two output signals are received, the determination unit 13 determines that the door 30 is in an entrapment state. When the vehicle is traveling, the travel vibration may cause the first detection sensor 73 and/or the second detection sensor 74 to output an output signal. Thus, the threshold value for the vehicle being traveling is set to a greater number than the threshold value for the vehicle at a standstill.

[0072] When the powered-traveling start signal is not received, the determination unit 13 determines that the vehicle is at a standstill and sets the threshold value to a first threshold value. The first threshold value is, for example, one. When the vehicle is at a standstill and one output signal is received, the determination unit 13 determines that the door 30 is in an entrapment state.

[0073] As shown in Fig. 8, if the door closing instruction is received (step S11: YES), the door entrapment detector 1 obtains an output signal (step S31). More specifically, the obtainment unit 11 obtains output signals from the first detection sensor 73 and the second detection sensor 74. The detection signal generation unit 12 counts the number of output signals that are included in the output signals obtained by the obtainment unit 11 in a predetermined period and exceed the predetermined reference value (determination value). The detection signal generation unit 12 transmits the counted number to the determination unit 13 as a detection signal.

[0074] The door entrapment detector 1 determines whether or not the powered-traveling start signal is received (step S32). More specifically, the determination unit 13 determines whether or not the vehicle is traveling based on whether or not the powered-traveling start signal is received. If the determination unit 13 determines that the powered-traveling start signal is received (step S32: YES), the determination unit 13 sets the threshold value to the second threshold value (step S38).

[0075] If the determination unit 13 determines that the powered-traveling start signal is not received (step S32: NO), the determination unit 13 sets the threshold value to the first threshold value (step S33).

[0076] The door entrapment detector 1 determines whether or not the number of output signals included in the output signals and exceeding the predetermined reference value (determination value) has reached the threshold value (step S34). More specifically, if the determination unit 13 determines that the number of output signals included in the output signals and exceeding the predetermined reference value (determination value) has not reached the threshold value (step S34: NO), the determination unit 13 determines whether or not the termination condition is satisfied (step S17). If the termination condition is not satisfied (step S17: NO), the deter-

mination unit 13 proceeds to step S31 and continues the process. If the termination condition is satisfied (step S17: YES), the determination unit 13 proceeds to step S37.

[0077] If the determination unit 13 determines that the number of output signals included in the output signals and exceeding the predetermined reference value (determination value) has reached the threshold value (step S34: YES), the determination unit 13 determines that the door 30 is in an entrapment state (step S35). More specifically, the determination unit 13 sets a threshold value different in accordance with whether the vehicle is traveling or at a standstill and makes a determination. Thus, even when output signals are output due to the travel vibration of the vehicle, the determination unit 13 reduces the effect of vibration caused by the traveling of the vehicle. As shown in Figs. 9(a) to 9(d), when the vehicle is at a standstill and one of the output signals exceeds the predetermined reference value (determination value), the number of output signals reaches the first threshold value, or one. Thus, the determination unit 13 determines that the door 30 is in an entrapment state. After it is determined that the door 30 is not in an entrapment state at a standstill, when the vehicle is traveling and two of the output signals exceed the predetermined reference value (determination value), the number of output signals reaches the second threshold value, or two. Thus, the determination unit 13 determines that the door 30 is in an entrapment state.

[0078] In other words, in the process of steps S31 to S34 and S17, the determination unit 13 continues to obtain output signals and continues to make determinations until the number of output signals included in the output signals and exceeding the predetermined reference value (determination value) reaches the threshold value or the termination condition is satisfied.

[0079] Subsequently, the door entrapment detector 1 stops obtaining detection signals (step S37) and ends the door entrapment detection process. More specifically, the obtainment unit 11 may stop receiving output signals. Alternatively, the obtainment unit 11 may cause the first detection sensor 73 and the second detection sensor 74 to stop outputting output signals or may cause the first detection sensor 73 and the second detection sensor 74 to stop detecting pressure.

[0080] The third embodiment has the advantages described below in addition to the advantage (1) of the first embodiment.

(5) The number of output signals included in the output signals obtained by the obtainment unit 11 in the predetermined period and exceeding the predetermined reference value (determination value) is counted. When the counted number is greater than or equal to the threshold value, it is determined that the door 30 is in an entrapment state. This limits detection of vibration caused by the traveling of the vehicle.

(6) When the powered-traveling start signal of the vehicle is received, the vehicle receives driving force and starts to travel. Thus, when it is determined that the vehicle is traveling, the door entrapment detection process is performed.

Fourth Embodiment

[0081] A door entrapment detector according to a fourth embodiment will now be described with reference to Figs. 9 and 10. The door entrapment detector of the fourth embodiment differs from that of the third embodiment in the determination of whether the vehicle is traveling or at a standstill. The description will focus on the differences from the third embodiment.

[0082] When the brake is released, the door entrapment detector 1 receives a brake release signal from the vehicle control board 4 via the door controller 2. The determination unit 13 determines whether the vehicle is traveling or at a standstill based on whether or not the brake release signal is received.

[0083] As shown in Figs. 9(a) to 9(d), when the brake release signal is received from the vehicle control board 4, the determination unit 13 determines that the vehicle is traveling and sets the threshold value to the second threshold value. The second threshold value is, for example, two. When the vehicle is traveling and two of the output signals exceed the predetermined reference value, the determination unit 13 determines that the door 30 is in an entrapment state. When the vehicle is traveling, the travel vibration may cause the first detection sensor 73 and/or the second detection sensor 74 to output an output signal. Thus, the threshold value for the vehicle being traveling is set to a greater number than the threshold value for the vehicle at a standstill.

[0084] When the brake release signal is not received, the determination unit 13 determines that the vehicle is at a standstill and sets the threshold value to the first threshold value. The first threshold value is, for example, one. When the vehicle is at a standstill and one of the output signals exceeds the predetermined reference value (determination value), the determination unit 13 determines that the door 30 is in an entrapment state.

[0085] As shown in Fig. 10, if the door closing instruction is received (step S11: YES), the door entrapment detector 1 obtains an output signal (step S31). More specifically, the obtainment unit 11 obtains output signals from the first detection sensor 73 and the second detection sensor 74. The detection signal generation unit 12 counts the number of output signals that are included in the output signals obtained by the obtainment unit 11 in a predetermined period and exceed the predetermined reference value (determination value). The detection signal generation unit 12 transmits the counted number to the determination unit 13 as a detection signal.

[0086] The door entrapment detector 1 determines whether or not the vehicle is at a standstill (step S42). More specifically, the determination unit 13 determines

whether or not the vehicle is at a standstill based on whether or not the brake release signal is received. If the determination unit 13 determines that the brake release signal is not received, that is, the vehicle is at a standstill (step S42: YES), the determination unit 13 sets the threshold value to the first threshold value (step S33).

[0087] If the determination unit 13 determines that the brake release signal is received, that is, the vehicle is traveling (step S42: NO), the determination unit 13 sets the threshold value to the second threshold value (step S38).

[0088] Subsequently, the process of steps S34 to S37 and S17 is performed in the same manner as the third embodiment, and the door entrapment detection process is ended.

[0089] The fourth embodiment has the advantage described below in addition to the advantage (1) of the first embodiment and the advantage (5) of the third embodiment.

(7) When the brake release signal of the vehicle is received, the vehicle is released from the braking and the vehicle may travel freely depending on the geography. Thus, when it is determined that the vehicle is traveling, the door entrapment detection process is performed.

[0090] The above-described embodiments may be modified as follows.

[0091] In the above-described embodiments, the first detection sensors 53 and 73 and the second detection sensors 54 and 74 are attached to the upper portion of the corresponding door. However, the first detection sensors 53 and 73 and the second detection sensors 54 and 74 may be attached to any position.

[0092] In the first and second embodiments, the output signals of both the first detection sensor 53 and the second detection sensor 54 are used to determine whether or not the door 30 is in an entrapment state. Instead, the output signal of only one of the first detection sensor 53 and the second detection sensor 54 may be used to determine whether or not the door 30 is in an entrapment state.

[0093] In the third and fourth embodiments, the detection signals of both the first detection sensor 73 and the second detection sensor 74 are used to determine whether or not the door 30 is in an entrapment state. Instead, the detection signal of only one of the first detection sensor 73 and the second detection sensor 74 may be used to determine whether or not the door 30 is in an entrapment state.

[0094] In the second embodiment, the filter 12A removes different frequency components depending on the travel state of the vehicle, and different determination values are used depending on the travel state of the vehicle. However, only one of the filter 12A that removes different frequency components depending on the travel state of the vehicle and the determination values that

differ depending on the travel state of the vehicle may be used.

[0095] In the first and second embodiments, the filter 12A of the detection signal generation unit 12 removes signals having a frequency including frequency components of vibration of the vehicle or higher. Instead, the filter 12A of the detection signal generation unit 12 may remove signals having a frequency including only frequency components of vibration of the vehicle.

[0096] In the third and fourth embodiments, when the vehicle is traveling, the threshold value for a determination is set to the second threshold value. Instead, the threshold value may be changed in accordance with the speed of the vehicle. More specifically, as the speed of the vehicle increases, the threshold value is set from the second threshold value to a third threshold value and then a fourth threshold value. Preferably, the threshold value is set so that the first threshold value < the second threshold value < the third threshold value < the fourth threshold value. With such a setting, the threshold value is changed in accordance with the speed of the vehicle, and the accuracy for detecting door entrapment is further increased. The phrase "the threshold value is changed in accordance with the speed of the vehicle" includes the threshold value being changed in accordance with the vehicle is traveling or at a standstill.

[0097] In the third and fourth embodiments, the door entrapment detector 1 includes the detection signal generation unit 12 and the determination unit 13. Instead, the determination unit 13 may perform the function of the detection signal generation unit 12. More specifically, the determination unit 13 may count the number of output signals included in the output signals obtained by the obtainment unit 11 in the predetermined period and exceeding the predetermined reference value (determination value) and determine that the door 30 is in an entrapment state when the counted number is greater than or equal to the threshold value.

[0098] In the first and second embodiments, a pressure sensor is used as the detection sensor. In the third and fourth embodiments, a pressure switch is used as the detection sensor. However, for example, a strain sensor may be used to directly measure a deformation amount of the elastic members 51 and 52. More specifically, the phrase "detecting deformation of an elastic member" includes not only a mode indirectly detecting deformation of the elastic member by detecting a change in the pressure of the hollow portion in the elastic member but also a mode directly detecting deformation of the elastic member.

[0099] In the above-described embodiments, as shown in Fig. 11, the door controller 2 may perform the function of the door entrapment detector 1. More specifically, the door controller 2 includes the obtainment unit 11, the detection signal generation unit 12, and the determination unit 13 in addition to the door opening-closing unit 21 and the door depressurization unit 22.

[0100] It should be apparent to those skilled in the art

that the present invention may be embodied in many other specific forms without departing from the scope of the invention. For example, one or more of the components may be omitted from the components described in the embodiments (or one or more aspects thereof). Further, components in different embodiments may be appropriately combined.

[0101] The present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

Claims

1. A door entrapment detector (1) configured to detect whether or not a door (30) for opening and closing an entrance of a vehicle is in an entrapment state, the door entrapment detector (1) being **characterized by:**

an obtainment unit (11) obtaining an output signal from a detection sensor (53, 54; 73, 74), the detection sensor (53, 54; 73, 74) detecting deformation of an elastic member (51, 52) attached to a leading edge of the door (30);

a detection signal generation unit (12) performing a process for reducing an effect of vibration that is caused by traveling of the vehicle and included in the output signal obtained by the obtainment unit (11) to generate a detection signal; and

a determination unit (13) determining whether or not the door (30) is in an entrapment state based on the detection signal generated by the detection signal generation unit (12).

2. The door entrapment detector (1) according to claim 1, wherein generation of the detection signal with the detection signal generation unit (12) includes reduction of a frequency component of vibration caused by the traveling of the vehicle from the output signal obtained by the obtainment unit (11).
3. The door entrapment detector (1) according to claim 2, wherein generation of the detection signal with the detection signal generation unit (12) includes reduction of different frequency components depending on the state of the vehicle.
4. The door entrapment detector (1) according to claim 2 or 3, wherein determination with the determination unit (13) is performed by comparing the detection signal with a determination value that differs depending on the state of the vehicle.
5. The door entrapment detector (1) according to claim

1, wherein

the output signal is one of output signals obtained by the obtainment unit (11) in a predetermined period,

the detection signal generation unit (12) counts the number of output signals that are included in the output signals and exceed a predetermined reference value,

the detection signal generation unit (12) uses the counted number as the detection signal, and when the counted number is greater than or equal to a threshold value, the determination unit (13) determines that the door (30) is in an entrapment state.

6. The door entrapment detector (1) according to claim 5, wherein the determination unit (13) changes the threshold value in accordance with the speed of the vehicle.
7. The door entrapment detector (1) according to claim 5 or 6, wherein the determination unit (13) changes the threshold value when receiving a drive start signal of the vehicle.
8. The door entrapment detector (1) according to claim 5 or 6, wherein the determination unit (13) changes the threshold value when receiving a brake release signal of the vehicle.
9. The door entrapment detector (1) according to any one of claims 1 to 8, further **characterized by** the detection sensor (53, 54), wherein the detection sensor (53, 54) is a pressure sensor detecting pressure of a hollow portion (51A, 52A) in the elastic member (51, 52).
10. A door opening-closing device (3) configured to open and close a door (30) of a vehicle, the door opening-closing device (3) being **characterized by** a door controller (2) controlling opening and closing of the door (30), wherein the door controller (2) includes an obtainment unit (11) obtaining an output signal from a detection sensor (53, 54; 73, 74), the detection sensor (53, 54; 73, 74) detecting deformation of an elastic member (51, 52) attached to a leading edge of the door (30), a detection signal generation unit (12) performing a process for reducing an effect of vibration that is caused by traveling of the vehicle and included in the output signal obtained by the obtainment unit (11) to generate a detection signal, and a determination unit (13) determining whether or not the door (30) is in an entrapment state based on the detection signal generated by the detection signal generation unit (12).

Fig.1

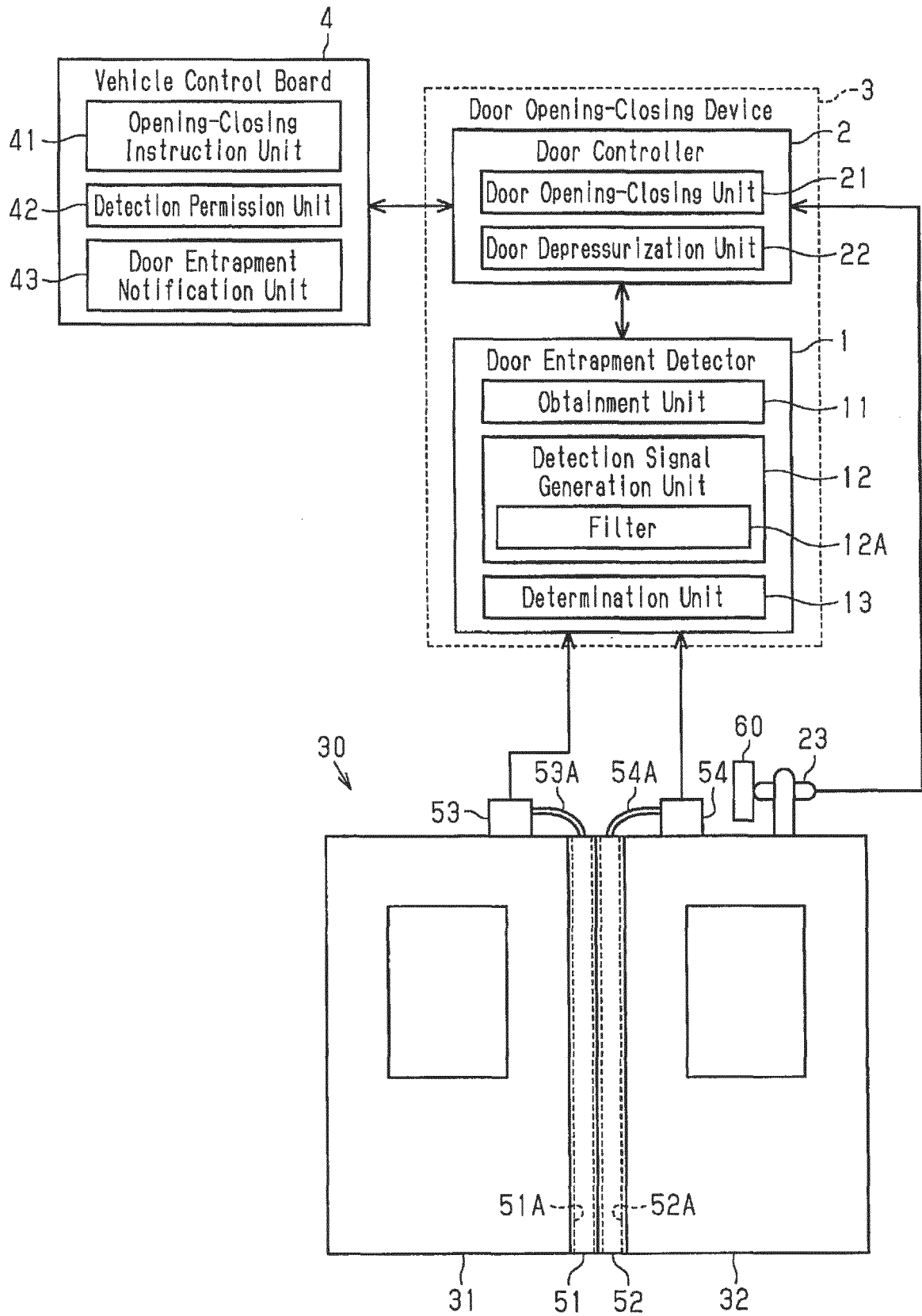


Fig.2

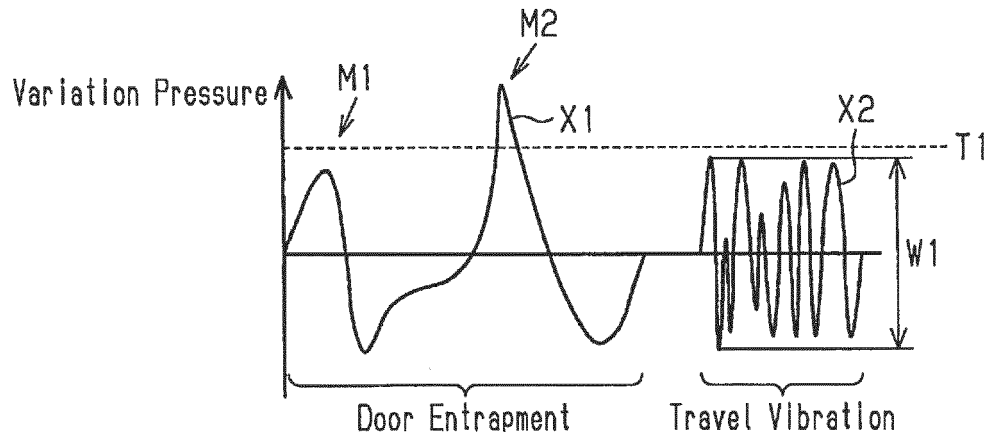


Fig.3

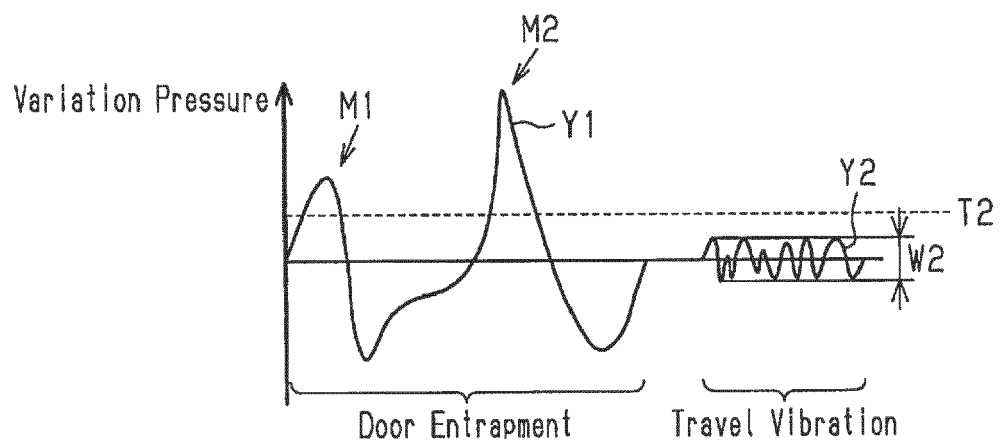


Fig.4

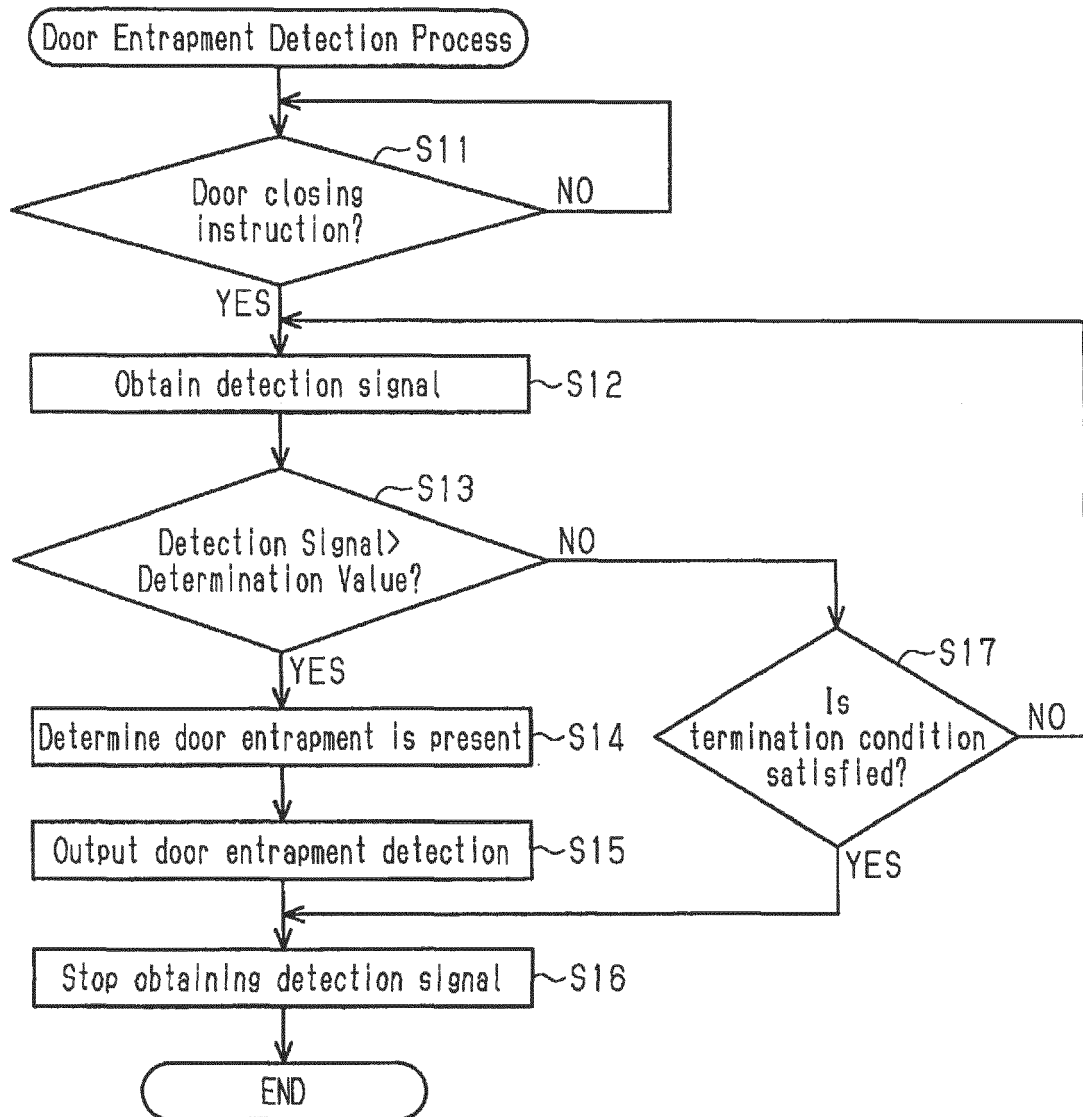


Fig.5

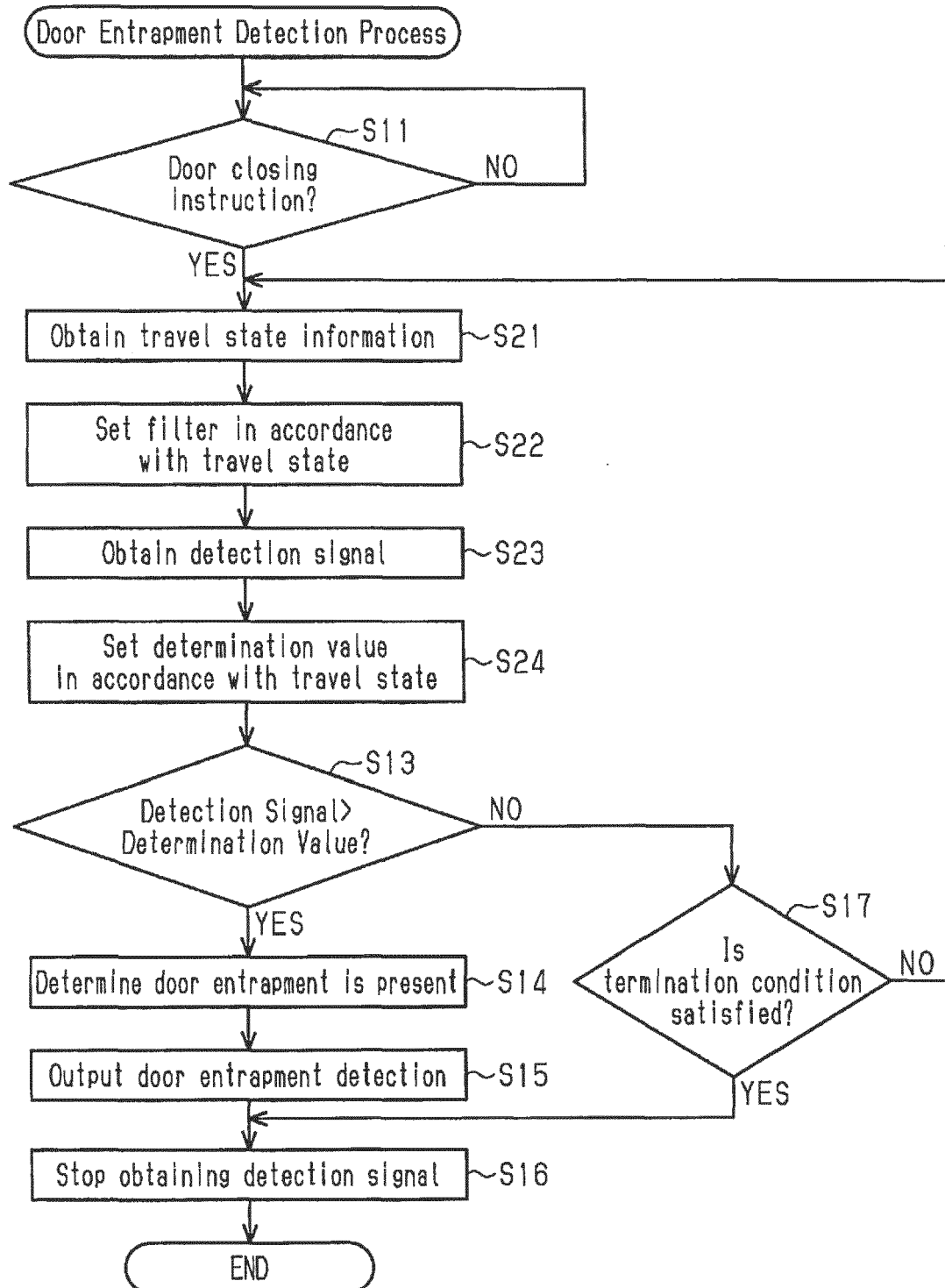


Fig.6

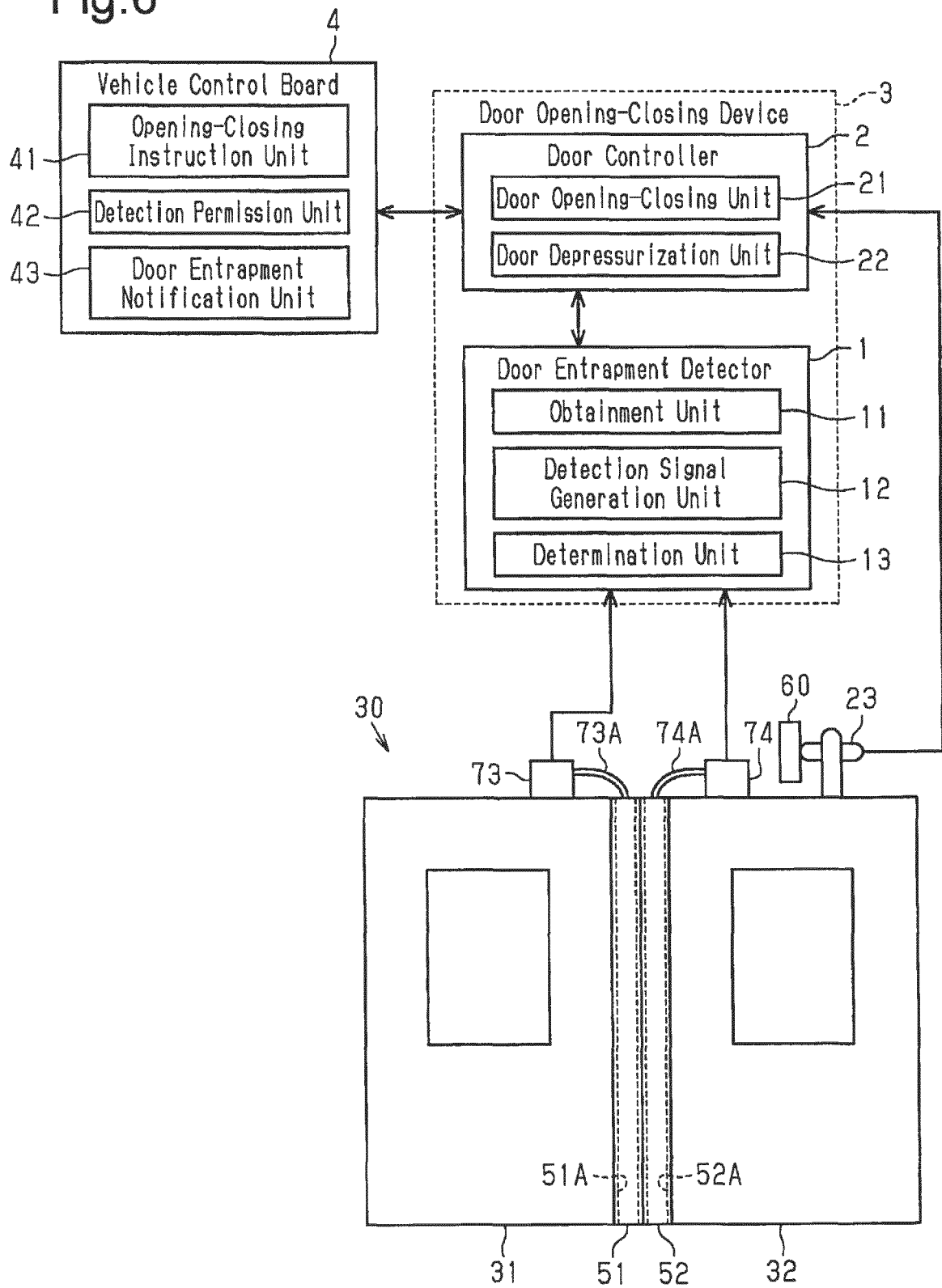


Fig.7(a)

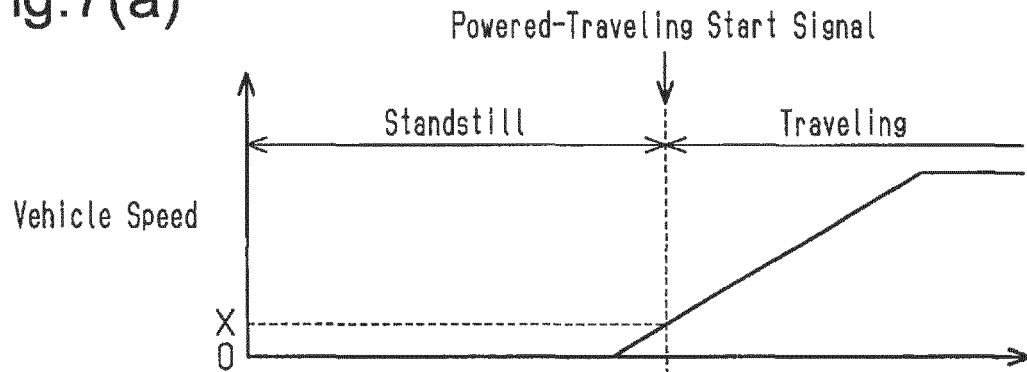


Fig.7(b)

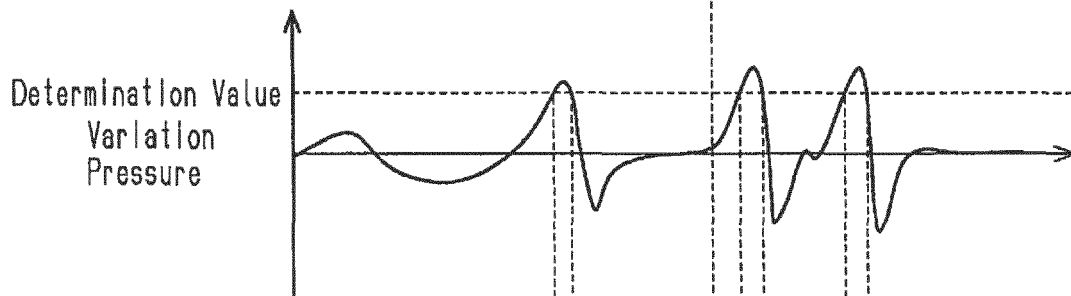


Fig.7(c)

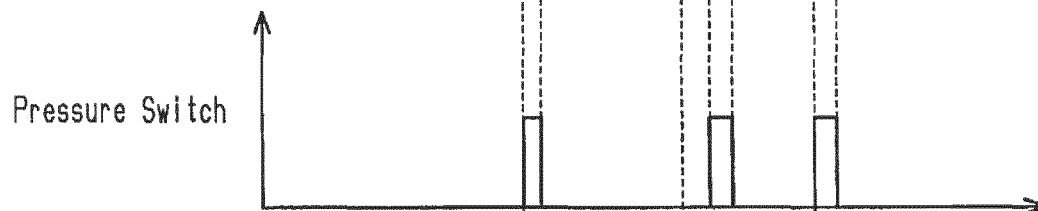


Fig.7(d)

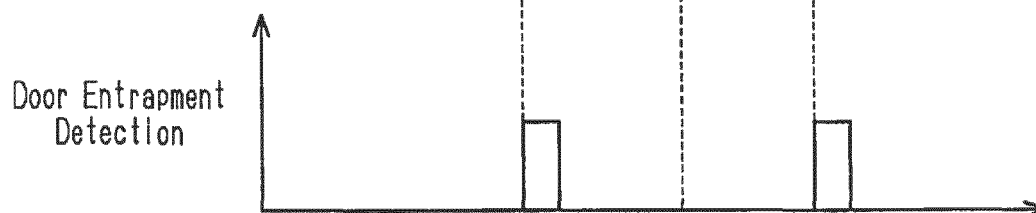


Fig.8

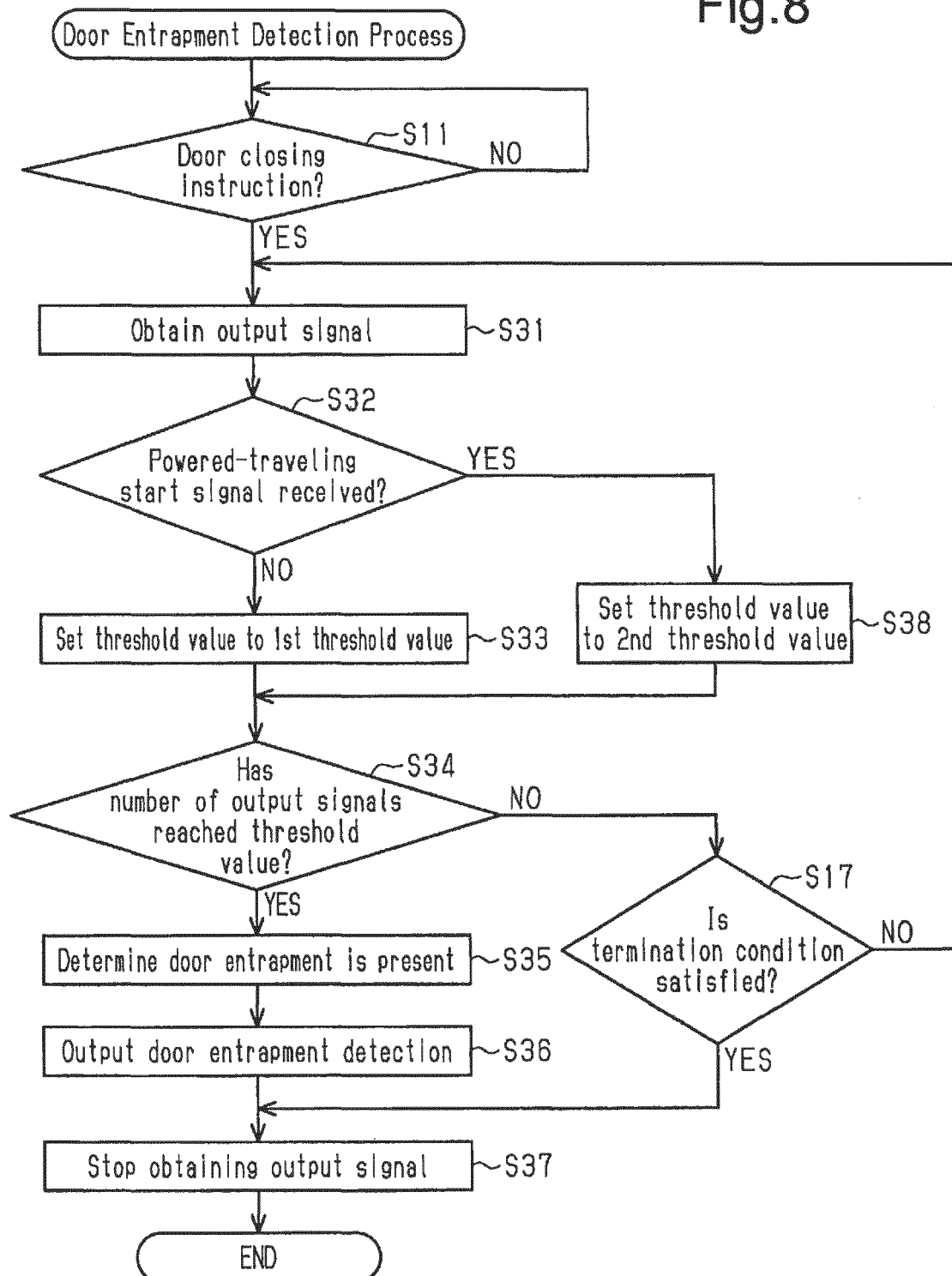


Fig.9(a)

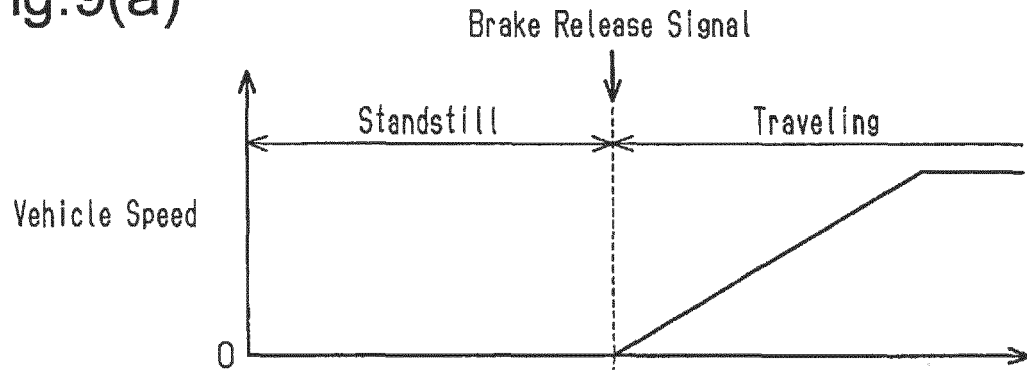


Fig.9(b)

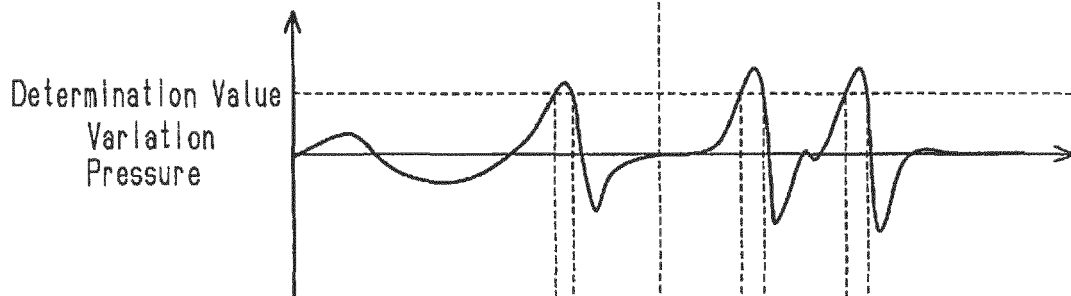


Fig.9(c)

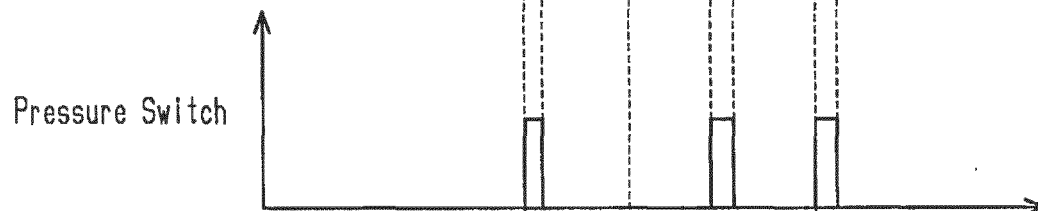


Fig.9(d)

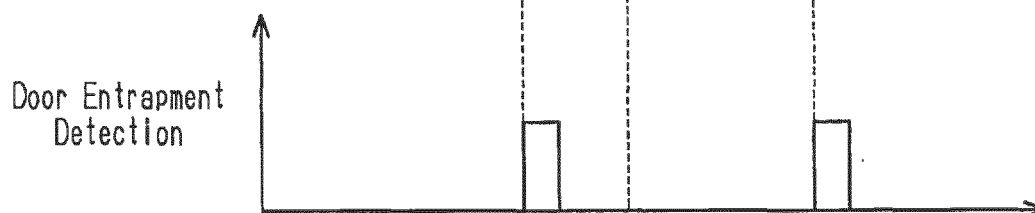


Fig.10

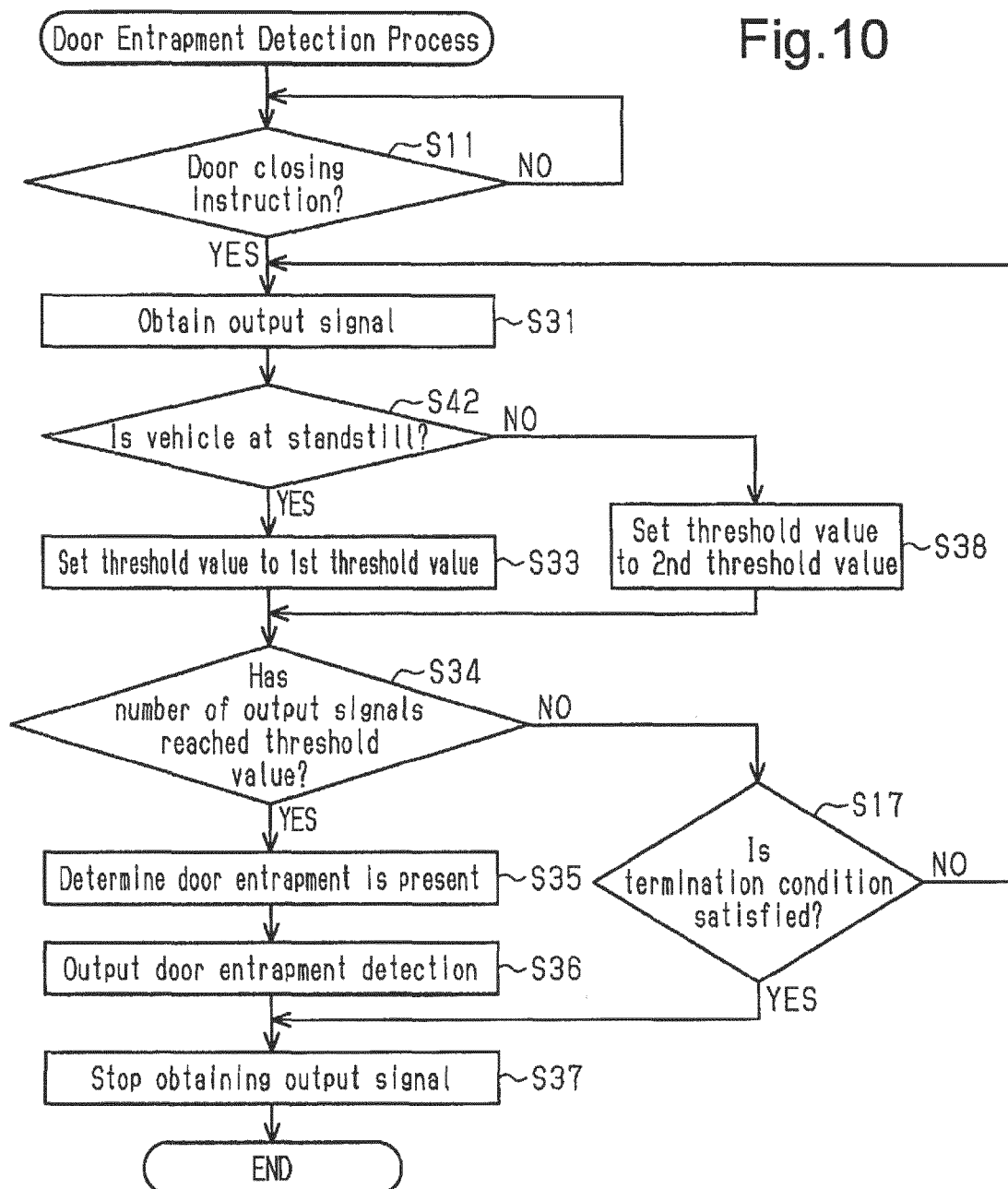
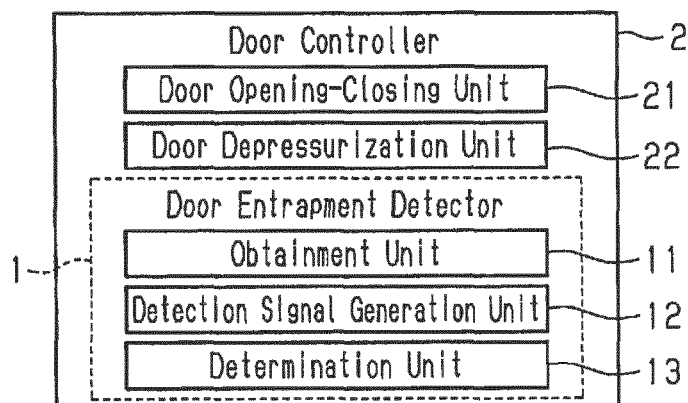


Fig.11





EUROPEAN SEARCH REPORT

Application Number
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X	WO 2004/090273 A1 (MATSUSHITA ELECTRIC IND CO LTD [JP]; OGINO HIROYUKI; UEDA SHIGEKI; KAS) 21 October 2004 (2004-10-21) * paragraphs [0060] - [0065]; figures *	1-10	INV. E05F15/42 E05F15/47
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			TECHNICAL FIELDS SEARCHED (IPC)
			E05F
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 March 2019	Examiner Witasse-Moreau, C
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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22-03-2019

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