

ELEVATOR CONTROL APPARATUS

FIELD

Embodiments described herein relate generally to an elevator control apparatus which senses a shake of a building due to an earthquake, a strong wind or the like and switches an operation of an elevator.

BACKGROUND

As high-rise buildings become higher, the natural frequency of each building drops, and resonance is likely to occur when an earthquake occurs or a strong wind blows. When the natural frequency of a building and that of a rope, such as a main rope and a governor rope, which is provided in a shaft of an elevator match, the rope is swayed greatly due to resonance. Accordingly, the rope contacts a device in the shaft or a shaft wall, thus causing a trapped-in-elevator accident.

To prevent the accident, recent elevators include a fail-safe device called "an emergency operation device." This is a technology in which when a building is shaken, a rope sway due to the shaking of the building is sensed, and when the amount of shake is a preset threshold or greater, an elevator car is traveled to an evacuation floor (non-resonant floor), and operation service is stopped.

In high-rise buildings, an observation elevator can be installed. The observation elevator ascends and descends between a lobby floor and an observation floor of the building to provide an operation service for moving passengers from the lobby floor to the observation floor, and vice versa.

In high-rise buildings, however, the rope of an elevator tends to be swayed greatly even though the buildings are shaken a little by an earthquake, a strong wind or the like. In observation elevators, therefore, when a lobby floor and an observation floor are both resonant floors, a rope increases in its sway

when an elevator car stops on the lobby floor or the observation floor, and the operation of the elevator will be stopped by the foregoing emergency operation device.

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SUMMARY

In general, according to one embodiment, there is provided an elevator control apparatus including an elevator car which ascends and descends by a rope provided in a shaft of a building, comprising: building
10 shake sensing means for sensing a shake of the building; and operation control means for when an amount of shaking of the building sensed by the building shake sensing means is a given amount or greater, restricting passengers' entry and exit
15 operations on a resonant floor where the rope is swayed greatly due to shaking of the building, to only entry or exit according to an operation mode of the elevator car, and controlling an operation of the elevator car.

There is also disclosed an elevator control
20 apparatus including an elevator car which ascends and descends by a rope provided in a shaft of a building, includes building shake sensing means for sensing a shake of the building; operation control means for when an amount of shaking of the building sensed by the
25 building shake sensing means is a given amount or greater, restricting passengers' entry and exit operations on a resonant floor where the rope is swayed greatly due to shaking of the building, to only entry or exit according to an operation mode of the elevator
30 car, and controlling an operation of the elevator car; and notification means for notifying the passengers that the operation control means restricts the passengers' entry and exit operations to only entry or exit.

35 According to another embodiment, there is provided an elevator control apparatus including a plurality of elevator cars in a shaft of a building, each of the

elevator cars ascending and descending by a rope provided in the shaft, the apparatus comprising: building shake sensing means for sensing a shake of the building; operation control means for when an amount of shaking of the building sensed by the building shake
5 sensing means is not smaller than a preset amount, restricting passengers' entry and exit operations on a resonant floor where the rope is swayed greatly due to shaking of the building, to only entry or exit for each
10 of the elevator cars, and controlling an operation of the elevator cars.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing a configuration of an elevator according to a first embodiment;

15 FIG. 2 is a block diagram showing a functional configuration of a control apparatus for the elevator according to the first embodiment;

FIG. 3 is a diagram showing a configuration of an elevator hall for the elevator according to the first
20 embodiment;

FIG. 4 is a graph showing a relationship between the sway (maximum displacement) of a main rope attached to a car of the elevator according to the first embodiment and the position of the car;

25 FIG. 5 is a graph showing a relationship between the sway (maximum displacement) of a main rope attached to a counterweight of the elevator according to the first embodiment and the position of the car;

FIG. 6 is a graph showing a relationship between
30 the sway (maximum displacement) of a compensating rope attached to the car of the elevator according to the

first embodiment and the position of the car;

FIG. 7 is a graph showing a relationship between the sway (maximum displacement) of a compensating rope attached to the counterweight of the elevator according to the first embodiment and the position of the car;

FIG. 8 is a diagram showing an example of an observation elevator according to the first embodiment;

FIG. 9 is an illustration of a one-way operation mode (first one-way operation) according to the first embodiment;

FIG. 10 is an illustration of another one-way operation mode (second one-way operation) according to the first embodiment;

FIG. 11 is a flowchart showing a processing operation of the control apparatus for the elevator according to the first embodiment;

FIG. 12 is a flowchart showing an operation in the one-way operation mode according to the first embodiment;

FIG. 13 is an illustration of a one-way operation mode according to a second embodiment;

FIG. 14 is a flowchart showing an operation in the one-way operation mode according to the second embodiment;

FIG. 15 is a diagram showing an example of an observation elevator according to a third embodiment;

FIG. 16 is a diagram illustrating an up-and-down operation mode according to the third embodiment;

FIG. 17 is a diagram illustrating a one-way operation mode (first one-way operation) according to the third embodiment;

FIG. 18 is a diagram illustrating a one-way operation mode (second one-way operation) according to the third embodiment;

FIG. 19 is a flowchart showing an operation of the one-way operation mode according to the third embodiment;

FIG. 20 is a block diagram showing a configuration of a group supervisory system according to a fourth embodiment;

5 FIG. 21 is a diagram showing an example of an observation elevator according to the fourth embodiment;

FIG. 22 is an illustration of a one-way operation mode (first one-way operation and second one-way operation) according to the fourth embodiment;

10 FIG. 23 is a flowchart showing an operation of the one-way operation mode according to the fourth embodiment;

FIG. 24 is a diagram showing an example of an observation elevator according to a fifth embodiment;

15 FIG. 25 is an illustration of a one-way operation mode (first one-way operation and second one-way operation) according to the fifth embodiment; and

FIG. 26 is a flowchart showing an operation of the one-way operation mode according to the fifth embodiment.
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DETAILED DESCRIPTION

Embodiments will be described with reference to the accompanying drawings.

(First Embodiment)

25 FIG. 1 is a diagram showing a configuration of an elevator according to a first embodiment. Assume here that one elevator 11 is installed in a building 10. In the first embodiment, the elevator 11 is used as an observation elevator and ascends and descends between a lobby floor of a lower floor and an observation floor
30 of an upper floor in the building 10.

As shown in FIG. 1, a hoist 12 serving as a drive source of the elevator 11 is placed in a machine room 10a in the topmost section of the building 10. In
35 machine-room-less elevators, the hoist 12 is placed in an upper section of a shaft 10b.

The hoist 12 comprises a main rope 13 wound around

it. An elevator car 14 is attached to one end of the main rope 13, and a counterweight 15 is attached to the other end of the main rope 13.

5 A compensating sheave 16 is placed in the bottommost section of the shaft 10b. A compensating rope 17 is attached to the lower section of the elevator car 14 and that of the counterweight 15 through the compensating sheave 16.

10 A car control apparatus 18 is provided on the elevator car 14 to control the opening and closing of a door 19 of the car 14 when the car 14 arrives at each of elevator halls 21a, 21b and 21c of the respective floors. The car control apparatus 18 is connected to a control apparatus 22 via a transmission cable 20 called
15 "a tail cord."

A load sensor 24 is provided on the bottom of the elevator car 14 to sense a load of the car 14. The number of passengers in the elevator car 14 can be estimated from the load sensed by the load sensor 24.
20 The load sensor 24 supplies its load sensing signal from the car control apparatus 18 to the control apparatus 22.

The control apparatus 22 is installed in the machine room 10a of the building 10. In machine-room-less elevators, it is installed in the shaft 10b. The
25 control apparatus 22 is configured by a computer including a CPU, a ROM and a RAM.

The control apparatus 22 performs a series of processes involved in operation control of the elevator
30 11, such as drive control of the hoist 12. The control apparatus 22 has a function of selecting an operation mode in accordance with the degree of shaking of the building 10 due to an earthquake, a strong wind or the like.

35 "Rope sway" means that a rope sways horizontally due to shaking of the building 10. The "rope" is a rope associated with the ascent and descent of the

elevator car 14. The elevator shown in FIG. 1 includes the main rope 13 and the compensating rope 17.

5 An acceleration sensor 23 is installed close to the upper portion of the building 10 to sense shaking of the building 10. The acceleration sensor 23 includes a two-axis acceleration sensor capable of sensing acceleration in the horizontal direction (x and y directions) of the building, and supplies its sensing signal to the control apparatus 22.

10 FIG. 2 is a block diagram showing a functional configuration of the control apparatus 22 of the elevator according to the first embodiment.

15 The control apparatus 22 includes a building shake sensing unit 31, an operation control unit 32, a storage unit 33 and a notification unit 34. The building shake sensing unit 31 senses an amount of shaking of the building 10 on the basis of an acceleration signal output from the acceleration sensor 23.

20 The operation control unit 32 controls the operation of the elevator car 14. In emergency operation, the operation control unit 32 stops the car 14 at the nearest floor and evacuates it to a floor (non-resonant floor) where ropes decrease in sway. In the first embodiment, the operation control unit 32 includes an operation mode selection unit 32a for selecting one of an up-and-down operation mode and a one-way operation mode on the basis of an amount of shaking of the building 10.

30 The "up-and-down operation mode" is a mode for an operation service for moving passengers by an up-and-down operation between lower floors and upper floors.

35 The "one-way mode" is a mode for an operation service for moving passengers by a one-way operation from a lower floor to an upper floor, and vice versa. When the one-way operation mode is selected, the operation control unit 32 restricts passengers' entry

and exit operations to only entry or exit on a resonant floor where ropes are swayed greatly due to shaking of the building 10.

5 The storage unit 33 stores different data items necessary for operating the elevator car 14. More specifically, the storage unit 33 stores data about a resonant floor where ropes are swayed greatly when the building 10 is shaken (for example, data indicating which floor corresponds to a resonant floor).

10 The notification unit 34 provides notification for restricting passengers' entry and exit operations to only entry or exit. As a notification method, a message is displayed or a voice announcement is made. A notification can be given using both a message and a
15 voice announcement.

 The elevator car 14 is provided with, for example, a door open button 42a, a door close button 42b, a speaker 43 and a display 44 as well as a destination floor button 41 corresponding to each floor. When a
20 passenger touches the destination floor button 41 to designate his or her destination floor, a signal corresponding to the designated destination floor is sent to the control apparatus 22 as a car call. Upon receiving the car call, the control apparatus 22
25 travels the elevator car 14 to the passenger's designated floor.

 The door open button 42a is an operation button by which a passenger gives an instruction to open the door. The door close button 42b is an operation button
30 by which a passenger gives an instruction to close the door. The speaker 43 outputs a voice message about passenger's entry and exit operations, which is output from the notification unit 34 of the operation control unit 32. The display 44 displays a message about
35 passenger's entry and exit operations, which is output from the notification unit 34 of the operation control unit 32.

As illustrated in FIG. 3, an elevator hall 21 (21a, 21b, 21c, etc.) of each floor is provided with a hall door 51, a hall call button 52, a speaker 53 and a display 54. The hall door 51 is engaged with a car door 19, and opens and closes when the elevator car 14 arrives at the elevator hall.

The hall call button 52 is a button for registering a hall call indicative of a destination direction, and includes an up-direction button and a down-direction button. On the lowermost floor, only the up-direction button is provided as the hall call button 52. On the uppermost floor, only the down-direction button is provided as the hall call button 52. When the hall call button 52 is operated to register a hall call, the hall call is sent to the control apparatus 22. Upon receiving the hall call, the control apparatus 22 travels the elevator car 14 to a floor in which the hall call is registered.

The speaker 53 outputs a voice message about passenger's entry and exit operations, which is output from the notification unit 34 of the operation control unit 32. The display 44 displays a message about passenger's entry and exit operations, which is output from the notification unit 34 of the operation control unit 32.

Here, the relationship between a rope sway and a car position will be described.

The term "rope" indicates the main rope 13 and compensating rope 17. More specifically, the main rope 13 is divided into a main rope 13a attached to the elevator car 14 and a main rope 13b attached to the counterweight 15. The compensating rope 17 is divided into a compensating rope 17a attached to the car 14 and a compensating rope 17b attached to the counterweight 15.

The length of each of the ropes 13a, 13b, 17a and 17b varies with the position of the elevator car 14.

Paying attention to the main rope 13, for example, when the car 14 stops at the lowermost floor, the main rope 13a attached to the car 14 is the longest, whereas the main rope 13b attached to the counterweight 15 is the shortest.

FIGS. 4-7 show an example of results of analysis of the relationship between the sway of the ropes 13a, 13b, 17a and 17b and the position of the car.

FIG. 4 is a graph showing a relationship between the sway (maximum displacement) of the main rope 13a attached to the elevator car 14 and the position of the car. FIG. 5 is a graph showing a relationship between the sway (maximum displacement) of the main rope 13b attached to the counterweight 15 and the position of the car.

The main rope 13a attached to the elevator car 14 has a characteristic that the car 14 sways the most greatly near the lowermost floor. The main rope 13b attached to the counter weight 15 has a characteristic that the car 14 sways the most greatly near the uppermost floor.

FIG. 6 is a graph showing a relationship between the sway (maximum displacement) of the compensating rope 17a attached to the elevator car 14 and the position of the car 14. FIG. 7 is a graph showing a relationship between the sway (maximum displacement) of the compensating rope 17b attached to the counterweight 15 of the elevator and the position of the car 14.

The compensating rope 17a attached to the elevator car 14 has a characteristic that the car 14 sways the most greatly on a floor which is a few floors up from the middle floor. The compensating rope 17b attached to the counterweight 15 has a characteristic that the car 14 sways the most greatly on a floor which is a few floors down from the middle floor.

FIGS. 4 to 7 each show a case where the building 10 is shaken by a fixed amount. The greater the amount

of shaking of the building 10, the greater the amount of sway of the ropes 13a, 13b, 17a and 17b. The relationship between the sway of the ropes and the position of the car varies with the characteristics of the building 10 and the elevator 11. A specific method for obtaining an amount of sway of the ropes 13a, 13b, 17a and 17b from the amount of shaking of the building 10 has been publicly known; thus, its detailed descriptions are omitted.

Assume that in the storage unit 33 of the control apparatus 22, a floor on which any one of the ropes 13a, 13b, 17a and 17b sways greatly is registered in advance as "a resonant floor" in terms of the relationship between the shaking of the building 10 and the position of the car.

FIG. 8 is a diagram showing an example of an observation elevator. In this example, the first floor of the lower floors of the building 10 is a lobby floor and the twentieth floor of the upper floors thereof is an observation floor. The elevator car 14 picks up passengers on the lobby floor and ascends to the observation floor. After that, the car 14 discharges all of the passengers on the observation floor and picks up passengers on the observation floor, and then descends to the lobby floor. This operation is repeated (up-and-down operation mode).

If at least one of the first and twentieth floors is a resonant floor, there is a possibility that when the building 10 is shaken, the ropes will increase in their sway at the resonant floor and the elevator car 14 will stop its operation service. In the first embodiment, therefore, when the building 10 is shaken by a given amount or greater, the up-and-down operation mode is switched to the one-way operation mode, thereby shortening a time period for which the car 14 stops at the resonant floor and preventing the ropes from increasing in their sway.

More specifically, as shown in FIGS. 9 and 10, there are a first one-way operation (ascent-only operation) in which the elevator car picks up passengers on the lobby floor and ascends to the observation floor and a second one-way operation (descent-only operation) in which the car picks up passengers on the observation floor and descends to the lobby floor. In the first one-way operation, the elevator car picks up passengers only on the lobby floor and discharges the passengers only on the observation floor. In the second one-way operation, the car picks up passengers only on the observation floor and discharges the passengers only on the lobby floor. It is thus possible to prevent the passengers from both entering and exiting the car on the lobby and observation floors of the resonant floors.

Hereinafter, an operation according to the first embodiment will be described in detail.

FIG. 11 is a flowchart showing a processing operation of the control apparatus 22 according to the first embodiment.

When the building 10 is shaken by an earthquake, a strong wind or the like, the acceleration sensor 23 installed in the machine room 10a supplies the control apparatus 22 with an acceleration signal corresponding to the amount of shaking of the building 10. The building shake sensing unit 31 installed in the control apparatus 22 senses an amount of shaking of the building 10 on the basis of an acceleration signal output from the acceleration sensor 23 (step A11).

The operation control unit 32 determines whether the amount of shaking of the building 10 sensed by the building shake sensing unit 31 is a given amount or greater (step A12). The given amount is preset in terms of the relationship between the shake of the building and the sway of the ropes.

When the amount of shaking of the building 10 is

less than the given amount (No in step A12), the operation control unit 32 performs an operation in the up-and-down operation mode (step A13). As illustrated in FIG. 8, in the up-and-down operation mode, the
5 elevator car 14 picks up passengers on the lobby floor, ascends to the observation floor, discharges all of the passengers on the observation floor, picks up passengers on the observation floor and descends to the lobby floor.

10 When the amount of shaking of the building 10 is the given amount or greater (Yes in step A12), the operation control unit 32 switches the up-and-down operation mode to the one-way operation mode (step A14). As illustrated in FIGS. 9 and 10, in the one-way
15 operation mode, the first one-way operation in which the elevator car 14 picks up passengers on the lobby floor and ascends to the observation floor and the second one-way operation in which the car 14 picks up passengers on the observation floor and descends to the
20 lobby floor, are performed. This one-way operation mode will be described in detail below with reference to FIG. 12.

The processing from step A11 to step A14 is repeated until the operation of the elevator is
25 completed (No in step A15). If the shaking of the building 10 is stopped during the one-way operation and the amount of shaking of the building 10 is less than the given amount, the one-way operation mode is switched to the up-and-down operation mode.

30 FIG. 12 is a flowchart showing an operation in the one-way operation mode according to the first embodiment. In the flowchart, "lower resonant floor" and "upper resonant floor" represent the lobby floor (first floor) and observation floor (twentieth floor)
35 for the observation elevator shown in FIG. 8. The fact that the lobby and observation floors are resonant floors, is stored beforehand in the storage unit 33.

When the up-and-down operation mode is switched to the one-way operation mode, the following first one-way operation is performed first.

5 When the operation control unit 32 confirms that the elevator car 14 has arrived at the lower resonant floor, or the lobby floor (Yes in step B11), the car 14 opens its door and picks up passengers (step B12).

10 Then, the operation control unit 32 causes the notification unit 34 to notify the passengers in the elevator car 14 that they are not allowed to exit the car 14 (step B13). Specifically, in order to control the exit of the passengers, the message "please do not exit the car as it is traveling one way only" is output by voice from the speaker 43 in the car 14 or it is
15 displayed on the display 44.

When the passengers enter the elevator car 14, the operation control unit 32 operates the car 14 to ascend toward the observation floor (up direction) (step B14). When the operation control unit 32 confirms that the
20 car 14 has arrived at the upper resonant floor, or the observation floor (Yes in step B15), it opens the door of the car 14 and discharges the passengers (step B16).

Then, the operation control unit 32 causes the notification unit 34 to notify the passengers on the
25 elevator hall 21 that they are not allowed to enter the elevator car 14 (step B17). Specifically, in order to control the entry of the passengers, the message "Please do not enter the car as it is traveling one way only " is output by voice from the speaker 53 at the
30 elevator hall 21 or it is displayed on the display 54.

When the passengers exit the elevator car 14, the operation control unit 32 operates the car 14 to descend toward the lobby floor (down direction) (step B18). When the car 14 arrives at the lower resonant
35 floor, or the lobby floor (Yes in step B19), the control unit 32 determines whether a given period of time (for example, ten minutes) has elapsed from the

start of the first one-way operation (step B20). If a given period of time has not elapsed (No in step B20), the operation control unit 32 picks up passengers on the lobby floor and repeats the first one-way operation (step B12). This operation is shown in FIG. 9.

If a given period of time has elapsed from the start of the first one-way operation (Yes in step B20), the operation control unit 32 operates the elevator car 14 to ascend toward the observation floor (up direction) (step B14), and then performs the following second one-way operation. In the second one-way operation, passengers can enter the car only on the observation floor and exit the car only on the lobby floor.

When the operation control unit 32 confirms that the elevator car 14 has arrived at the upper resonant floor, or the observation floor (Yes in step B22), it closes the door of the car 14 and picks up passengers (step B23).

Then, the operation control unit 32 causes the notification unit 34 to notify the passengers in the elevator car 14 that they are not allowed to exit the car 14 (step B24). Specifically, in order to control the exit of the passengers, the message "Please do not exit the car as it is traveling one way only" is output by voice from the speaker 43 in the car 14 or it is displayed on the display 44.

When the passengers enter the elevator car 14, the operation control unit 32 operates the car 14 to descend toward the lobby floor (down direction) (step B25). When the operation control unit 32 confirms that the car 14 has arrived at the lower resonant floor, or the lobby floor (Yes in step B26), it opens the door of the car 14 and discharges the passengers (step B27).

Then, the operation control unit 32 causes the notification unit 34 to notify the passengers on the elevator hall 21 that they are not allowed to enter the

elevator car 14 (step B28). Specifically, in order to control the entry of the passengers, the message "Please do not enter the car as it is traveling one way only" is output by voice from the speaker 53 in the elevator hall 21 or it is displayed on the display 54.

When the passengers exit the elevator car 14, the operation control unit 32 operates the car 14 to ascend toward the observation floor (up direction) (step B29). When the car 14 arrives at the upper resonant floor, or the observation floor (Yes in step B23), the operation control unit 32 determines whether a given period of time (for example, ten minutes) has elapsed from the start of the second one-way operation (step B31). If a given period of time has not elapsed (No in step B31), the operation control unit 32 picks up passengers on the observation floor and repeats the second one-way operation (step B23). This operation is shown in FIG. 10.

If a given period of time has elapsed from the start of the second one-way operation (Yes in step B31), the operation control unit 32 operates the elevator car 14 to descend toward the lobby floor (down direction) (step B32) and then performs the first one-way operation again.

As described above, since the one-way operation mode is selected when the building 10 is shaken by a given amount or greater, a time period for which the car stops at the resonant floor can be shortened, thereby preventing the ropes from increasing in sway and continuing to provide an operation service.

In the example of FIG. 12, the first and second one-way operations are switched to each other at regular time intervals. However, the first or second one-way operation can be selected in accordance with the congestion state on the lobby floor or the observation floor. The congestion state can be determined, for example, by analyzing video images of a

monitoring camera provided in the elevator hall of each floor. The operation control unit 32 performs the first one-way operation when it is detected from the analysis that a predetermined number of passengers or
5 more are waiting on the lobby floor and it performs the second one-way operation when it is detected from the analysis that a predetermined number of passengers or
10 more are waiting on the observation floor.

It is desirable to provide the elevator halls of
10 the lobby and observation floors with barriers for entry and exit as well as to notify passengers that they are not allowed to enter or exit a car during its one-way operation.

(Second Embodiment)

15 A second embodiment will be described below.

As shown in FIG. 8, the first floor of lower floors of the building 10 is a lobby floor and the twentieth floor of upper floors thereof is an observation floor. These floors are resonant floors.
20 Assume here that there are non-resonant floors near the lobby and observation floors. In the example of FIG. 8, the sixth and fifteenth floors are non-resonant floors.

"Non-resonant floors" are floors where ropes
25 decrease in sway. For example, the main rope 13a attached to the elevator car 14 has a characteristic that the car 14 sways the most greatly near the lowermost floor. Accordingly, as for the main rope 13a, a floor close to the lowermost floor is a resonant
30 floor. The main rope 13b attached to the counterweight 15 has a characteristic that the car 14 sways the most greatly near the uppermost floor. Accordingly, as for the main rope 13b, a floor close to the uppermost floor is a resonant floor.

35 The same holds true for the compensating rope 17a attached to the elevator car 14 and the compensating rope 17b attached to the counterweight 15. These ropes

sway greatly at resonant floors in accordance with the position of the car 14.

5 The resonant floors are obtained by analyzing sway characteristics of the ropes 13a, 13b, 17a and 17b comprehensively. In general, the ropes 13a, 13b, 17a and 17b decrease in sway near the middle of the building 10 and thus a floor near the middle of the building 10 is a non-resonant floor. This floor is set as an evacuation floor that is safe even though the car 10 14 stops.

In the second embodiment, the first and second one-way operations are alternately performed using the non-resonant floor. These operations are shown in FIG. 13.

15 FIG. 13 is an illustration of a one-way operation mode in the second embodiment.

When the up-and-down operation mode is switched to the one-way operation mode, a first one-way operation (ascent-only operation) in which the car picks up 20 passengers on the lobby floor and ascends to the observation floor is performed. The car discharges all of the passengers on the observation floor, descends, travels in an opposite direction at the non-resonant floor (fifteenth floor) close to the observation floor, 25 and returns to the observation floor. When the car arrives at the observation floor, it performs a second one-way operation (descent-only operation) in which the car picks up passengers on the observation floor and descends to the lobby floor.

30 After the car discharges all of the passengers on the lobby floor, it ascends, travels in an opposite direction at the non-resonant floor (sixth floor) near the lobby floor, and returns to the lobby floor. When the car arrives at the lobby floor, it performs a first 35 one-way operation in which the car picks up passengers and ascends to the observation floor again.

Hereinafter, an operation according to the second

embodiment will be described in detail.

FIG. 14 is a flowchart showing an operation in the one-way operation mode according to the second embodiment. In the flowchart, "lower resonant floor" and "upper resonant floor" represent the lobby floor and the observation floor for the observation elevator shown in FIG. 8. The fact that the lobby and observation floors are resonant floors, is stored beforehand in the storage unit 33. Data about the non-resonant floors is also stored beforehand in the storage unit 33.

When the up-and-down operation mode is switched to the one-way operation mode, the following first one-way operation is performed first.

When the operation control unit 32 confirms that the elevator car 14 has arrived at the lower resonant floor, or the lobby floor (Yes in step C11), the car 14 opens its door and picks up passengers (step C12).

Then, the operation control unit 32 causes the notification unit 34 to notify the passengers in the elevator car 14 that they are not allowed to exit the car 14 (step C13). Specifically, in order to control the exit of the passengers, the message "Please do not exit the car as it is traveling one way only" is output by voice from the speaker 43 in the car 14 or it is displayed on the display 44.

When the passengers enter the elevator car 14, the operation control unit 32 operates the car 14 to ascend toward the observation floor (up direction) (step C14). When the operation control unit 32 confirms that the car 14 has arrived at the upper resonant floor, or the observation floor (Yes in step C15), it opens the door of the car 14 and discharges the passengers (step C16).

Then, the operation control unit 32 causes the notification unit 34 to notify the passengers in the elevator hall 21 that they are not allowed to enter the elevator car 14 (step C17). Specifically, in order to

control the entry of the passengers, the message "Please do not enter the car as it is traveling one way only" is output by voice from the speaker 53 in the elevator hall 21 or it is displayed on the display 54.

5 When the passengers exit the elevator car 14, the operation control unit 32 operates the car 14 to descend (down direction) (step C18). When the car 14 travels to a non-resonant floor close to the observation floor (Yes in step C19), it travels in the
10 opposite direction and returns to the observation floor (step C20). This operation is shown on the left side of FIG. 13.

 When the elevator car 14 returns to the observation floor, the operation control unit 32
15 performs the following second one-way operation. In the second one-way operation, passengers can enter the car only on the observation floor and exit the car only on the lobby floor.

 When the operation control unit 32 confirms that
20 the elevator car 14 has arrived at the upper resonant floor, or the observation floor (Yes in step C21), it closes the door of the car 14 and picks up passengers (step C22).

 Then, the operation control unit 32 causes the
25 notification unit 34 to notify the passengers in the elevator car 14 that they are not allowed to exit the car 14 (step C23). Specifically, in order to control the exit of the passengers, the message "Please do not exit the car as it is traveling one way only" is output
30 by voice from the speaker 43 in the car 14 or it is displayed on the display 44.

 When the passengers enter the elevator car 14, the operation control unit 32 operates the car 14 to descend toward the lobby floor (down direction) (step
35 C24). When the operation control unit 32 confirms that the car 14 has arrived at the lower resonant floor, or the lobby floor (Yes in step C25), it opens the door of

the car 14 and discharges the passengers (step C26).

Then, the operation control unit 32 causes the notification unit 34 to notify the passengers on the elevator hall 21 that the passengers are not allowed to enter the elevator car 14 (step C27). Specifically, in order to control the entry of the passengers, the message "Please do not enter the car as it is traveling one way only" is output by voice from the speaker 53 at the elevator hall 21 or it is displayed on the display 54.

When the passengers exit the elevator car 14, the operation control unit 32 operates the car 14 to ascend (up direction) (step C28). When the car 14 travels to a non-resonant floor close to the lobby floor (Yes in step C29), it travels in the opposite direction and returns to the lobby floor (step C30). When the car 14 returns to the lobby floor, the first one-way operation is performed again. This operation is shown on the right side of FIG. 13.

As described above, even though the first one-way operation is performed and then the second one-way operation is performed by moving the car in the opposite direction on the non-resonant floor or the second one-way operation is performed and then the first one-way operation is performed by moving the car in the opposite direction on the non-resonant floor, a time period for which the car stops at the resonant floor can be shortened, thereby preventing the ropes from increasing in sway and continuing to provide an operation service.

In the example of FIG. 14, the car travels in the opposite direction at once on the non-resonant floor and returns to the observation floor or the lobby floor. However, the car may travel in the opposite direction after it stops at the non-resonant floor until a shake of the building stops, and return to the observation floor or the lobby floor. Accordingly,

when a shake of the building stops, the normal up-and-down operation can be resumed.

Furthermore, the car need not always travel in the opposite direction at the non-resonant floor, but it
5 may travel in the opposite direction near the non-resonant floor (between floors).

(Third Embodiment)

A third embodiment will be described hereinafter.

In the foregoing first and second embodiments, it
10 is assumed that passengers enter and exit the elevator car on the same floor. In the third embodiment, it is assumed that passengers enter and exit the elevator car on different floors.

FIG. 15 is a diagram showing an example of an
15 observation elevator according to the third embodiment. According to the specifications of the building 10, the floors on which passengers enter the elevator car differ from the floors on which they exit the elevator car. In this example, the first floor of the lower
20 floors of the building 10 is an entry-only floor (lobby floor), the second floor thereof is an exit-only floor, the twentieth floor of the upper floors thereof is an exit-only floor (observation floor), and the nineteenth floor thereof is an entry-only floor.

25 As shown in FIG. 16, the elevator car 14 picks up passengers on the entry-only floor (lobby floor) of the first floor and ascends to the exit-only floor (observation floor) of the twentieth floor. After that, the car 14 discharges all of the passengers on
30 the twentieth floor, and picks up passengers on the entry-only floor of the nineteenth floor and then descends to the arrival floor of the second floor. The car 14 discharges the passengers on the second floor and then returns to the entry-only floor of the first
35 floor. This operation is repeated (up-and-down operation mode).

If one of the first and second floors of the lower

floors or one of the twentieth and nineteenth floors of the upper floors is a resonant floor, there is a possibility that when the building 10 is shaken, the ropes will increase in their sway at the resonant floor and the elevator car 14 will stop its operation service. In the third embodiment, therefore, when the building 10 is shaken by a given amount or greater, the up-and-down operation mode is switched to the one-way operation mode, thereby shortening a time period for which the car 14 stops at the resonant floor and preventing the ropes from increasing in their sway.

More specifically, as shown in FIGS. 17 and 18, there are a first one-way operation (up-direction-only operation) in which the elevator car picks up passengers on the first floor of the lobby floor and ascends to the twentieth floor of the observation floor and a second one-way operation (down-direction-only operation) in which the car picks up passengers on the nineteenth floor, which is one floor down from the observation floor, and descends to the second floor, which is one floor up from the lobby floor. In the first one-way operation, the elevator car picks up passengers only on the lobby floor and discharges the passengers only on the observation floor. In the second one-way operation, the car picks up passengers only on the floor which is one floor down from the observation floor and discharges the passengers only on the floor which is one floor up from the lobby floor. It is thus possible to prevent the passengers from both entering and exiting the car on the lobby and observation floors of the resonant floors, or the floor which is one floor up from the lobby floor and the floor which is one floor down from the observation floor.

Hereinafter, an operation according to the third embodiment will be described in detail.

FIG. 19 is a flowchart showing an operation in the

one-way operation mode according to the third embodiment. In the flowchart, "lower entry-only floor (entry-only floor on the lower floor side)" and "upper exit-only floor (exit-only floor on the upper floor side)" represent the lobby floor (first floor) and the observation floor (twentieth floor) for the observation elevator shown in FIG. 15. Also, "upper entry-only floor (entry-only floor on the upper floor side)" and "lower exit-only floor (exit-only floor on the lower floor side)" represent the floor (nineteenth floor) which is one floor down from the observation floor and the floor (second floor) which is one floor up from the lobby floor. The fact that these floors are resonant floors, is stored beforehand in the storage unit 33.

When the up-and-down operation mode is switched to the one-way operation mode, the following first one-way operation is performed first.

When the operation control unit 32 confirms that the elevator car 14 has arrived at the lower entry-only floor, or the lobby floor (Yes in step D11), the car 14 opens its door and picks up passengers (step D12).

Then, the operation control unit 32 causes the notification unit 34 to notify the passengers in the elevator car 14 that they are not allowed to exit the car 14 (step D13). Specifically, in order to control the exit of the passengers, the message "Please do not exit the car as it is traveling one way only" is output by voice from the speaker 43 in the car 14 or it is displayed on the display 44.

When the passengers enter the elevator car 14, the operation control unit 32 operates the car 14 to ascend toward the observation floor (up direction) (step D14). When the operation control unit 32 confirms that the car 14 has arrived at the upper exit-only floor, or the observation floor (Yes in step D15), it opens the door of the car 14 and discharges the passengers (step D16).

Then, the operation control unit 32 causes the

notification unit 34 to notify the passengers on the elevator hall 21 that the passengers are not allowed to enter the elevator car 14 (step D17). Specifically, in order to control the entry of the passengers, the
5 message "Please do not enter the car as it is traveling one way only" is output by voice from the speaker 53 at the elevator hall 21 or it is displayed on the display 54.

When the passengers exit the elevator car 14, the
10 operation control unit 32 operates the car 14 to descend toward the lobby floor (down direction) (step D18). When the car 14 arrives at the lower entry-only floor, or the lobby floor (Yes in step D19), the operation control unit 32 determines whether a given
15 period of time (e.g., ten minutes) has elapsed from the start of the first one-way operation (step D20). If a given period of time has not elapsed (No in step D20), the operation control unit 32 picks up passengers on the lobby floor and repeats the first one-way operation
20 (step D12). This operation is shown in FIG. 17.

If a given period of time has elapsed from the start of the first one-way operation (Yes in step D20), the operation control unit 32 operates the elevator car 14 to ascend toward the floor which is one floor down
25 from the observation floor (up direction) (step D14) and then performs the following second one-way operation again. In the second one-way operation, passengers can enter the car only on the floor which is one floor down from the observation floor and exit the
30 car only on the floor which is one floor up from the lobby floor.

When the operation control unit 32 confirms that the elevator car 14 has arrived at the upper entry-only floor, or the floor which is one floor down from the observation floor (Yes in step D22), it closes the door
35 of the car 14 and picks up passengers (step D23).

Then, the operation control unit 32 causes the

notification unit 34 to notify the passengers in the elevator car 14 that the passengers are not allowed to exit the car 14 (step D24). Specifically, in order to control the exit of the passengers, the message "Please
5 do not exit the car as it is traveling one way only" is output by voice from the speaker 43 in the car 14 or it is displayed on the display 44.

When the passengers enter the elevator car 14, the operation control unit 32 operates the car 14 to
10 descend toward the floor which is one floor up from the lobby floor (down direction) (step D25). When the operation control unit 32 confirms that the car 14 has arrived at the lower entry-only floor, or the floor which is one floor up from the lobby floor (Yes in step
15 D26), it opens the door of the car 14 and discharges the passengers (step D27).

Then, the operation control unit 32 causes the notification unit 34 to notify the passengers on the elevator hall 21 that they are not allowed to enter the
20 elevator car 14 (step D28). Specifically, in order to control the entry of the passengers, the message "Please do not enter the car as it is traveling one way only" is output by voice from the speaker 53 at the elevator hall 21 or it is displayed on the display 54.

25 When the passengers exit the elevator car 14, the operation control unit 32 operates the car 14 to ascend toward the floor which is one floor down from the observation floor (up direction) (step D29). When the car 14 arrives at the upper entry-only floor, or the
30 floor which is one floor down from the observation floor (Yes in step D20), the operation control unit 32 determines whether a given period of time (e.g., ten minutes) has elapsed from the start of the second one-way operation (step D31). If a given period of time
35 has not elapsed (No in step D31), the operation control unit 32 picks up passengers on the floor which is one floor down from the observation floor and repeats the

second one-way operation (step D23). This operation is shown in FIG. 18.

5 If a given period of time has elapsed from the start of the second one-way operation (Yes in step D31), the operation control unit 32 operates the elevator car 14 to descend toward the lobby floor (down direction) (step D32) and then performs the first one-way operation again.

10 As described above, in the building structure in which passengers enter and exit the elevator car on different floors, the first and second one-way operations are switched to each other at regular time intervals; thus, it is possible to shorten a time period for which the car stops at the resonant floor and prevent the ropes from increasing in their sway.

15 In the example of FIG. 19, the first and second one-way operations are switched to each other at regular time intervals. However, the first or second one-way operation can be selected in accordance with the congestion state on the lower entry-only floor (lobby floor) or the upper entry-only floor (floor which is one floor down from the observation floor). The congestion state can be determined, for example, by analyzing video images of a monitoring camera provided in the elevator hall of each floor. The operation control unit 32 performs the first one-way operation when it is detected from the analysis that a predetermined number of passengers or more are waiting on the lower entry-only floor (lobby floor) and it performs the second one-way operation when it is detected from the analysis that a predetermined number of passengers or more are waiting on the upper entry-only floor (floor which is one floor down from the observation floor).

35 (Fourth Embodiment)

A fourth embodiment will be described hereinafter. The foregoing first to third embodiments are

directed to a single elevator including one elevator car. In contrast, the fourth embodiment is directed to a group supervisory system including a plurality of elevator cars.

5 FIG. 20 is a block diagram showing a configuration of the group supervisory system according to the fourth embodiment.

 In the fourth embodiment, a plurality of elevators are arranged in the building 10. In the example of
10 FIG. 20, a group of two elevators A and B is supervised; however, the number of elevators included in a group to be supervised is not limited to two, but three or more elevators can be included in the group.

 A group supervisory control apparatus 100 controls
15 the operation of each of the elevators in response to a hall call or a car call. The "hall call" represents a call signal registered by operating a hall call button provided at the elevator hall of each floor. The hall
20 call includes data about registered floors and destination directions (up direction/down direction). The "car call" represents a call signal registered by operating a destination floor button provided in an elevator car. The car call includes data about
25 destination floors.

 The group supervisory control apparatus 100
25 includes a building shake sensing unit 101, an operation control unit 102, a storage unit 103 and a notification unit 104. The building shake sensing unit
30 101 senses an amount of shaking of the building 10 on the basis of an acceleration signal output from the
35 acceleration sensor 23.

 The operation control unit 102 controls the operation of elevator cars 14a and 14b of the respective elevators. In the fourth embodiment, the
35 operation control unit 102 includes an operation mode selection unit 102a for selecting an operation mode of each of the elevators on the basis of an amount of

shaking of the building 10.

The storage unit 103 stores different data items necessary for operating the elevator cars 14a and 14b of the respective elevators. More specifically, the
5 storage unit 103 stores data about a resonant floor where ropes are swayed greatly when the building 10 is shaken (for example, information indicating which floor corresponds to a resonant floor).

The notification unit 104 provides notification
10 for restricting passengers' entry and exit operations to only enter or exit. As a notification method, a message is displayed or a voice announcement is made. A notification can be provided using both a message and a voice announcement.

15 The elevator control apparatus 105a controls the operation of the elevator car 14a of elevator A. The elevator control apparatus 105b controls the operation of the elevator car 14b of elevator B. A load sensor 24a is provided on the bottom of the car 14a and is
20 able to sense a load of the car 14a and estimate the number of passengers. Similarly, a load sensor 24b is provided on the bottom of the car 14b and is able to sense a load of the car 14b and estimate the number of passengers.

25 Assume that the elevator cars 14a and 14b are each provided with, for example, a door open button 42a, a door close button 42b, a speaker 43 and a display 44 as well as a destination floor button 41 corresponding to each floor, like the elevator car 14 shown in FIG. 2.
30 Also, assume that an elevator hall 21 (21a, 21b, 21c, etc.) of each floor is provided with a hall door 51, a hall call button 52, a speaker 53 and a display 54, as illustrated in FIG. 3.

FIG. 21 is a diagram showing an example of an
35 observation elevator according to the fourth embodiment. In this example, the building 10 includes an elevator car 14a of elevator A and an elevator car

14b of elevator B. In the building 10, the first floor of the lower floors is a lobby floor and the twentieth floor of the upper floors thereof is an observation floor.

5 Usually, the elevator cars 14a and 14b each pick up passengers on the lobby floor and ascend to the observation floor. After that, they discharge all of the passengers on the observation floor and pick up
10 passengers on the observation floor, and then descend to the lobby floor. This operation is repeated (up-and-down operation mode).

 If at least one of the first and twentieth floors is a resonant floor, there is a possibility that when the building 10 is shaken, the ropes will increase in
15 their sway at the resonant floor and the elevator cars 14a and 14b will stop their operation service. In the fourth embodiment, therefore, when the building 10 is shaken by a given amount or greater, the operation mode of each of the elevators is switched from the up-and-
20 down operation mode to the one-way operation mode, thereby shortening a time period for which the cars 14a and 14b stop at the resonant floor and preventing the ropes from increasing in their sway.

 More specifically, as shown in FIG. 22, the
25 elevator car 14a performs a first one-way operation (ascent-only operation) and the elevator car 14b performs a second one-way operation (descent-only operation). In the first one-way operation, the car 14a picks up passengers only on the lobby floor and
30 discharges the passengers only on the observation floor. In the second one-way operation, the car 14b picks up passengers only on the observation floor and discharges the passengers only on the lobby floor. It is thus possible to prevent the passengers from both
35 entering and exiting cars on the lobby and observation floors of the resonant floors.

 Hereinafter, an operation according to the fourth

embodiment will be described in detail.

FIG. 23 is a flowchart showing an operation in the one-way operation mode according to the fourth embodiment. In the flowchart, "lower resonant floor" and "upper resonant floor" represent the lobby floor and observation floor for the observation elevator shown in FIG. 21. The fact that the lobby and observation floors are resonant floors, is stored beforehand in the storage unit 103.

When the up-and-down operation mode is switched to the one-way operation mode, the operation control unit 102 in the group supervisory control apparatus 100 divides elevators A and B into two groups and controls the elevators to perform a first one-way operation in one of the groups and a second one-way operation in the other group. Assume here that elevator A performs the first one-way operation and elevator B performs the second one-way operation.

First, when the operation control unit 102 confirms that the elevator car 14a of elevator A has arrived at the lower resonant floor, or the lobby floor (step E11 → Yes in step E12), the car 14a opens its door and picks up passengers (step E13).

Then, the operation control unit 102 causes the notification unit 34 to notify the passengers in the elevator car 14a that they are not allowed to exit the car 14a (step E14). Specifically, in order to control the exit of the passengers, the message "Please do not exit the car as it is traveling one way only" is output by voice from the speaker 43 in the car 14a or it is displayed on the display 44.

When the passengers enter the elevator car 14a, the operation control unit 102 operates the car 14a to ascend toward the observation floor (up direction) (step E15). When the operation control unit 102 confirms that the car 14a has arrived at the upper resonant floor, or the observation floor (Yes in step

E16), it opens the door of the car 14a and discharges the passengers (step E17).

Then, the operation control unit 102 causes the notification unit 34 to notify the passengers on the
5 elevator hall 21 that they are not allowed to enter the elevator car 14a (step E18). Specifically, in order to control the entry of the passengers, the message "Please do not enter the car as it is traveling one way only" is output by voice from the speaker 53 at the
10 elevator hall 21 or it is displayed on the display 54.

When the passengers exit the elevator car 14a, the operation control unit 102 operates the car 14a to descend toward the lobby floor (down direction) (step E19) and repeats the first one-way operation (step
15 E12). This state is a movement of elevator A shown in FIG. 22.

When the operation control unit 102 confirms that the elevator car 14b of elevator B has arrived at the upper resonant floor, or the observation floor (step
20 E11 → Yes in step E20), it closes the door of the car 14b and picks up passengers (step E21).

Then, the operation control unit 102 causes the notification unit 34 to notify the passengers in the elevator car 14b that they are not allowed to exit the
25 car 14b (step E22). Specifically, in order to control the exit of the passengers, the message "Please do not exit the car as it is traveling one way only" is output by voice from the speaker 43 in the car 14b or it is displayed on the display 44.

30 When the passengers enter the elevator car 14b, the operation control unit 102 operates the car 14b to descend toward the lobby floor (down direction) (step E23). When the operation control unit 102 confirms that the car 14b has arrived at the lower resonant
35 floor, or the lobby floor (Yes in step E24), it opens the door of the car 14b and discharges the passengers (step E25).

Then, the operation control unit 102 causes the notification unit 34 to notify the passengers on the elevator hall 21 that they are not allowed to enter the elevator car 14b (step E26). Specifically, in order to control the entry of the passengers, the message "Please do not enter the car as it is traveling one way only" is output by voice from the speaker 53 at the elevator hall 21 or it is displayed on the display 54.

When the passengers exit the elevator car 14b, the operation control unit 102 operates the car 14b to ascend toward the observation floor (up direction) (step E27) and repeats the second one-way operation. This state is a movement of elevator B shown in FIG. 22.

As described above, when the group supervisory system includes a plurality of elevator cars, the first and second one-way operations are performed by different elevator cars. It is thus possible to shorten a time period for which the cars stop at the resonant floors, thereby preventing the ropes from increasing in their sway and continuing to provide an operation service.

The same as above is true of a group supervisory system including three or more elevator cars. In this case, the elevator cars are divided into at least two groups, and one of the groups performs the first one-way operation and the other group performs the second one-way operation.

The number of elevator cars which perform the first one-way operation and the number of elevator cars which perform the second one-way operation can be changed appropriately in accordance with the congestion state on the lobby floor or the observation floor.

It is desirable to provide the elevator halls of the lobby and observation floors with barriers for entry and exit as well as to notify passengers that they are not allowed to enter or exit the elevators

during their one-way operations.

(Fifth Embodiment)

A fifth embodiment will be described below.

5 In the fifth embodiment, it is assumed that a building structure in which passengers enter and exit a plurality of elevator cars on different floors, as in the foregoing third embodiment.

FIG. 24 is a diagram showing an example of an observation elevator according to the fifth embodiment.
10 The building 10 includes an elevator car 14a of elevator A and an elevator car 14b of elevator B. According to the specifications of the building 10, the floors on which passengers enter the elevator cars differ from the floors on which they exit the elevator cars. In this example, the first floor of the lower
15 floors of the building 10 is an entry-only floor (lobby floor), the second floor thereof is an exit-only floor, the twentieth floor of the upper floors thereof is an exit-only floor (observation floor), and the nineteenth floor thereof is an entry-only floor.
20

The elevator cars 14a and 14b of elevators A and B pick up passengers on the entry-only floor (lobby floor) of the first floor and ascend to the exit-only floor (observation floor) of the twentieth floor.
25 After that, the cars discharge all of the passengers on the twentieth floor, and pick up passengers on the entry-only floor of the nineteenth floor and then descend to the arrival floor of the second floor. The cars discharge the passengers on the second floor and
30 then returns to the entry-only floor of the first floor. This operation is repeated (up-and-down operation mode).

If one of the first and second floors of the lower floors or one of the twentieth and nineteenth floors of
35 the upper floors is a resonant floor, there is a possibility that when the building 10 is shaken, the ropes will increase in their sway at the resonant floor

and the elevator cars 14a and 14b will stop their operation service. In the fifth embodiment, therefore, when the building 10 is shaken by a given amount or greater, the operation mode of each elevator is
5 switched from the up-and-down operation mode to the one-way operation mode, thereby shortening a time period for which the cars 14a and 14b stop at the resonant floor and preventing the ropes from increasing in their sway.

10 More specifically, as shown in FIG. 25, the elevator car 14a performs a first one-way operation (ascent-only operation) and the elevator car 14b performs a second one-way operation (descent-only operation). In the first one-way operation, the car
15 14a picks up passengers only on the lobby floor and discharges the passengers only on the observation floor. In the second one-way operation, the car 14b picks up passengers only on the floor which is one floor down from the observation floor and discharges
20 the passengers only on the floor which is one floor up from the lobby floor. It is thus possible to prevent the passengers from both entering and exiting the cars on the lobby and observation floors of the resonant floors, or the floor which is one floor up from the
25 lobby floor and the floor which is one floor down from the observation floor.

Hereinafter, an operation according to the fifth embodiment will be described in detail.

FIG. 26 is a flowchart showing an operation in the
30 one-way operation mode according to the fifth embodiment. In the flowchart, "lower entry-only floor (lower entry-only floor on the lower floor side)" and "upper exit-only floor (exit-only floor on the upper floor side)" represent the lobby floor (first floor)
35 and the observation floor (twentieth floor) for the observation elevator shown in FIG. 25. Also, "upper entry-only floor (entry-only floor on the upper floor

side)" and "lower exit-only floor (exit-only floor on the lower floor side)" represent the floor (nineteenth floor) which is one floor down from the observation floor and the floor (second floor) which is one floor up from the lobby floor. The fact that these floors are resonant floors, is stored beforehand in the storage unit 33.

When the up-and-down operation mode is switched to the one-way operation mode, the operation control unit 102 in the group supervisory control apparatus 100 divides elevators A and B into two groups and controls the elevators to perform a first one-way operation in one of the groups and a second one-way operation in the other group. Assume here that elevator A performs the first one-way operation and elevator B performs the second one-way operation.

First, when the operation control unit 102 confirms that the elevator car 14a of elevator A has arrived at the lower entry-only floor, or the lobby floor (step F11 → Yes in step F12), the car 14a opens its door and picks up passengers (step F13).

Then, the operation control unit 102 causes the notification unit 34 to notify the passengers in the elevator car 14a that they are not allowed to exit the car 14a (step F14). Specifically, in order to control the exit of the passengers, the message "Please do not exit the car as it is traveling one way only" is output by voice from the speaker 43 in the car 14a or it is displayed on the display 44.

When the passengers enter the elevator car 14a, the operation control unit 102 operates the car 14a to ascend toward the observation floor (up direction) (step F15). When the operation control unit 102 confirms that the car 14a has arrived at the upper exit-only floor, or the observation floor (Yes in step F16), it opens the door of the car 14a and discharges the passengers (step F17).

Then, the operation control unit 102 causes the notification unit 34 to notify the passengers on the elevator hall 21 that they are not allowed to enter the elevator car 14a (step F18). Specifically, in order to control the entry of the passengers, the message "Please do not enter the car as it is traveling one way only" is output by voice from the speaker 53 at the elevator hall 21 or it is displayed on the display 54.

When the passengers exit the elevator car 14a, the operation control unit 102 operates the car 14a to descend toward the lobby floor (down direction) (step F19) and repeats the first one-way operation (step F12). This state is a movement of elevator A shown in FIG. 25.

When the operation control unit 102 confirms that the elevator car 14b of elevator B has arrived at the upper entry-only floor, or the floor which is one floor down from the observation floor (step F11 → Yes in step F20), it closes the door of the car 14b and picks up passengers (step F21).

Then, the operation control unit 102 causes the notification unit 34 to notify the passengers in the elevator car 14b that they are not allowed to exit the car 14b (step F22). Specifically, in order to control the exit of the passengers, the message "Please do not exit the car as it is traveling one way only" is output by voice from the speaker 43 in the car 14b or it is displayed on the display 44.

When the passengers enter the elevator car 14b, the operation control unit 102 operates the car 14b to descend toward the floor which is one floor up from the lobby floor (down direction) (step F23). When the operation control unit 102 confirms that the car 14b has arrived at the lower entry-only floor, or the floor which is one floor up from the lobby floor (Yes in step F24), it opens the door of the car 14b and discharges the passengers (step F25).

Then, the operation control unit 102 causes the notification unit 34 to notify the passengers on the elevator hall 21 that they are not allowed to enter the elevator car 14b (step F26). Specifically, in order to
5 control the entry of the passengers, the message "Please do not enter the car as it is traveling one way only" is output by voice from the speaker 53 at the elevator hall 21 or it is displayed on the display 54.

When the passengers exit the elevator car 14b, the
10 operation control unit 102 operates the car 14b to ascend toward the floor which is one floor down from the observation floor (up direction) (step F27) and repeats the second one-way operation. This state is a movement of elevator B shown in FIG. 26.

15 As described above, in the building structure in which passengers enter and exit the elevator car on different floors, the first and second one-way operations are performed by different elevator cars. It is thus possible to shorten a time period for which
20 the cars stop at the resonant floors, thereby preventing the ropes from increasing in their sway and continuing to provide an operation service.

The same as above is true of a group supervisory system including three or more elevator cars. In this
25 case, the elevator cars are divided into at least two groups, and one of the groups performs the first one-way operation and the other group performs the second one-way operation.

The number of elevator cars which perform the
30 first one-way operation and the number of elevator cars which perform the second one-way operation can be changed appropriately in accordance with the congestion state on the lobby floor or the observation floor. For example, when the number of passengers on the
35 observation floor increases, the number of elevator cars which perform the second one-way operation can be increased.

Furthermore, the number of elevator cars which perform the first one-way operation and the number of elevator cars which perform the second one-way operation can be changed appropriately in accordance with a preset period of time. For example, the number of elevator cars which perform the second one-way operation is increased in a period of time in the afternoon when the number of passengers on the observation floor increases.

(Modification 1)

In the foregoing embodiments, when the amount of shaking of the building 10 is much greater than the given amount in step A11 shown in FIG. 11, the number of passengers who enter an elevator car in the one-way operation mode can be limited. More specifically, the given amount in step A11 shown in FIG. 11 is defined as a first given amount, and a second given amount is set as one larger than the first given amount. When the amount of shaking of the building 10 is not smaller than the second given amount, the number of passengers who enter an elevator car in the one-way operation mode can be limited.

The number of passengers who enter an elevator car can be estimated from the load of the car sensed by the load sensor 24 (24a, 24b). For example, when the number of passengers who enter the car is limited to half the rated number of passengers, the car closes its door automatically and starts to travel, for example, while sounding a buzzer alarm at the time of sensing the load of the car corresponding to half the rated number of passengers.

When the amount of shaking of the building 10 is not smaller than the second given amount, the door closing time in the one-way operation mode can be made shorter than that in the normal mode to shorten a period of time for which the elevator car 14 (14a, 14b) stops further.

(Modification 2)

In the foregoing embodiments, the amount of sway of ropes can be estimated on the basis of the amount of shaking of the building 10 and the position of the car, and the one-way operation mode can be selected when the amount of sway of ropes is a given amount or greater.

The amount of shaking of the building 10 can be sensed from an acceleration signal output from the acceleration sensor 23. The position of the car can be sensed from, for example, a pulse signal which is output from a pulse generator (not shown) attached to the rotating shaft of the hoist 12 in synchronization with the rotation of the hoist 12. The amount of sway of ropes can be obtained by computation using a predetermined function expression. The detail descriptions of a specific computation method are omitted because the method is publicly known.

According to at least one of the foregoing embodiments, there can be provided an elevator control apparatus capable of preventing the ropes from being swayed due to a resonance caused when the building is shaken and continuing an operation service.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

WHAT IS CLAIMED IS:

1. An elevator control apparatus including an elevator car which ascends and descends by a rope provided in a shaft of a building, comprising:

5 building shake sensing means for sensing a shake of the building; and

operation control means for when an amount of shaking of the building sensed by the building shake sensing means is a given amount or greater, restricting
10 passengers' entry and exit operations on a resonant floor where the rope is swayed greatly due to shaking of the building, to only entry or exit according to an operation mode of the elevator car, and controlling an operation of the elevator car.

15 2. The elevator control apparatus according to claim 1, wherein the operation control means restricts passengers' entry and exit operations to only enter or exit on both an upper floor and a lower floor of the building when at least one of the upper floor and the
20 lower floor corresponds to the resonant floor, and controls an operation of the elevator car.

3. The elevator control apparatus according to claim 2, wherein the operation control means performs a first one-way operation in which the elevator car picks
25 up passengers on the lower floor, ascends and discharges the passengers on the upper floor and a second one-way operation in which the elevator car picks up passengers on the upper floor, descends and discharges the passengers on the lower floor..

30 4. The elevator control apparatus according to claim 3, wherein the operation control means selects one of the first one-way operation and the second one-way operation at preset time intervals.

35 5. The elevator control apparatus according to claim 3, wherein the operation control means selects one of the first one-way operation and the second one-way operation in accordance with a congestion state of

the upper floor or the lower floor of the building.

6. The elevator control apparatus according to claim 3, wherein the operation control means performs the second one-way operation in which the elevator car discharges passengers on the upper floor by the first one-way operation, then travels in an opposite direction on a non-resonant floor close to the upper floor, and returns to the upper floor, and

the operation control means performs the first one-way operation in which the elevator car discharges passengers on the lower floor by the second one-way operation, then travels in an opposite direction on a non-resonant floor close to the lower floor, and returns to the lower floor.

7. The elevator control apparatus according to claim 2, wherein the upper floor and the lower floor of the building each have a structure including an entry-only floor and an exit-only floor,

the operation control means performs a first one-way operation in which the elevator car picks up passengers on the entry-only floor of the upper floor, ascends and discharges the passengers on the exit-only floor of the upper floor, and

the operation control means performs a second one-way operation in which the elevator car picks up passengers on the entry-only floor of the upper floor, descends and discharges the passengers on the exit-only floor of the lower floor.

8. The elevator control apparatus according to claim 7, wherein the operation control means selects one of the first one-way operation and the second one-way operation at preset time intervals.

9. An elevator control apparatus including a plurality of elevator cars in a shaft of a building, each of the elevator cars ascending and descending by a rope provided in the shaft, the apparatus comprising: building shake sensing means for sensing a shake

of the building; and

operation control means for when an amount of shaking of the building sensed by the building shake sensing means is not smaller than a preset amount, restricting passengers' entry and exit operations on a resonant floor where the rope is swayed greatly due to shaking of the building, to only enter or exit for each of the elevator cars, and controlling an operation of the elevator cars.

10 10. The elevator control apparatus according to claim 9, wherein the operation control means restricts passengers' entry and exit operations to only enter or exit on both an upper floor and a lower floor of the building when at least one of the upper floor and the lower floor corresponds to the resonant floor, and controls an operation of the elevator cars.

15 11. The elevator control apparatus according to claim 10, wherein the operation control means divides the elevator cars into at least two groups,

20 in one of the groups, the operation control means performs a first one-way operation in which the elevator cars pick up passengers on the lower floor, ascend and discharge the passengers on the upper floor, and

25 in the other group, the operation control means performs a second one-way operation in which the elevator cars pick up passengers on the upper floor, descend and discharge the passengers on the lower floor.

30 12. The elevator control apparatus according to claim 11, wherein the upper floor and the lower floor of the building each have a structure including an entry-only floor and an exit-only floor,

35 in the one of the groups, the operation control means performs a first one-way operation in which the elevator cars pick up passengers on the entry-only floor of the lower floor, ascend and discharge the

passengers on the exit-only floor of the upper floor,
and

5 in the other group, the operation control means
performs a second one-way operation in which the
elevator cars pick up passengers on the entry-only
floor of the upper floor, descend and discharge the
passengers on the exit-only floor of the lower floor.

10 13. The elevator control apparatus according to
claim 11, wherein the operation control means changes
the number of elevator cars that perform the first one-
way operation and the number of elevator cars that
perform the second one-way operation in accordance with
a congestion state of the upper floor or the lower
floor.

15 14. The elevator control apparatus according to
claim 11, wherein the operation control means changes
the number of elevator cars that perform the first one-
way operation and the number of elevator cars that
perform the second one-way operation in accordance with
20 a preset period of time.

25 15. The elevator control apparatus according to
one of claims 1 and 9, further comprising notification
means for notifying the passengers that the operation
control means restricts the passengers' entry and exit
operations to only entry or exit.