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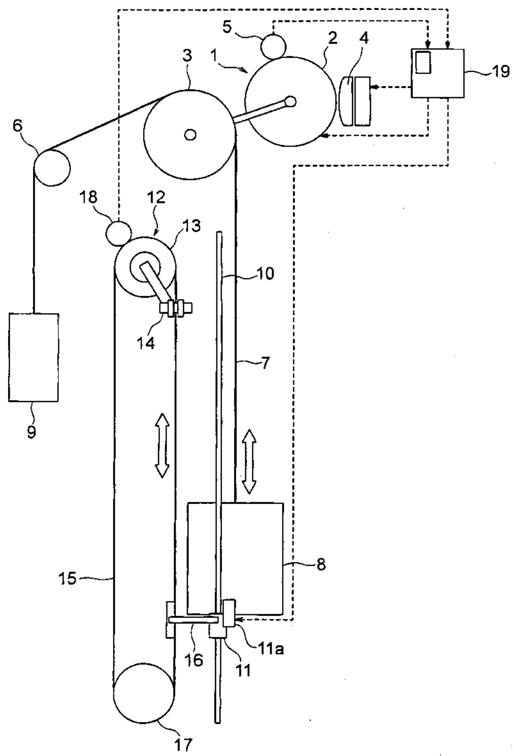
(54) ELEVATOR DEVICE

(57) In an elevator apparatus, a safety gear makes a car perform an emergency stop in response to an activating signal. A slippage monitoring apparatus computes a slippage extent value that is a value that relates to extent of slippage of a suspending body relative to a driving sheave based on the signals from first and second speed detectors. The slippage monitoring apparatus stops the car at a predetermined floor using a hoisting machine if the slippage extent value exceeds a first threshold value, and activates the safety gear using the activating signal if the slippage extent value exceeds a second threshold value.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to an elevator apparatus in which slippage of a suspending body relative to a driving sheave can be detected and a car can be stopped.

BACKGROUND ART

[0002] In conventional elevator protective devices, slippage of a traction rope relative to a sheave is detected based on rotational speed of a pulley that is rotated together with running of a car and a command running speed in a speed command generating device, and the sheave is made to perform an emergency stop if a slippage speed exceeds a set value (see Patent Literature 1, for example).

[0003] In conventional elevator safety braking devices, an activating signal is generated by a safety control device if a car speed that is detected by a speed sensor exceeds a threshold value. When the activating signal is generated, a friction brake is pressed against a guide rail to brake the car (see Patent Literature 2, for example).

[Patent Literature 1]

[0004] Japanese Patent Laid-Open No. SHO 59-230981 (Gazette)

[Patent Literature 2]

[0005] Japanese Patent Publication No. 2002-532366 (Gazette)

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006] In conventional elevator protective devices and safety braking devices such as those described above, low-speed rope slippage cannot be detected, and there has been a risk that rope service life may be reduced due to cumulative friction with the sheaves or that rope breakage may occur.

[0007] The present invention aims to solve the above problems and an object of the present invention is to provide an elevator apparatus that can suppress damage to a suspending body due to excessive slippage of the suspending body relative to a driving sheave, and that can also prevent cumulative damage to a suspending body due to minute slippage of the suspending body.

MEANS FOR SOLVING THE PROBLEM

[0008] In order to achieve the above object, according to one aspect of the present invention, there is provided an elevator apparatus including: a hoisting machine that has a driving sheave; a suspending body that is wound around the driving sheave; a car that is suspended by the suspending body, and that is raised and lowered by the hoisting machine; a safety gear that is mounted to the car, and that makes the car perform an emergency stop in response to an activating signal; a first speed detector that generates a signal that corresponds to a rotational speed of the hoisting machine; a second speed detector that generates a signal that corresponds to a running speed of the car; and a slippage monitoring apparatus that computes a slippage extent value that is a value that relates to extent of slippage of the suspending body relative to the driving sheave based on the signals from the first and second speed detectors, and stops the car at a predetermined floor using the hoisting machine if the slippage extent value exceeds a first threshold value, and activates the safety gear by the activating signal if the slippage extent value exceeds a second threshold value that corresponds to a slippage extent that is greater than the first threshold value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Figure 1 is a structural diagram that shows an elevator apparatus according to Embodiment 1 of the present invention;
Figure 2 is a block diagram that shows part of the elevator apparatus from Figure 1;
Figure 3 is a flowchart that shows operation of a slippage determining portion from Figure 2;
Figure 4 is a block diagram that shows part of an elevator apparatus according to Embodiment 2 of the present invention;
Figure 5 is a flowchart that shows operation of a slippage determining portion from Figure 4;
Figure 6 is a block diagram that shows part of an elevator apparatus according to Embodiment 3 of the present invention; and
Figure 7 is a flowchart that shows operation of a slippage determining portion from Figure 6.

BEST MODE FOR CARRYING OUT THE INVENTION

[0010] Preferred embodiments of the present invention will now be explained with reference to the drawing.

Embodiment 1

[0011] Figure 1 is a structural diagram that shows an elevator apparatus according to Embodiment 1 of the present invention. In the figure, a hoisting machine 1 is disposed in an upper portion of a hoistway. The hoisting machine 1 has: an electric motor 2; a driving sheave 3 that is rotated by the electric motor 2; and a hoisting machine brake 4 that brakes rotation of the driving sheave

3. In this example, the driving sheave 3 is linked directly to a rotating shaft of the electric motor 2, and is rotated together with the rotor of the electric motor 2. During normal operation, the hoisting machine brake 4 holds the electric motor 2 and the driving sheave 3 in a stopped state when rotation thereof is stopped (static holding).

[0012] A first speed detector 5 that generates a signal that corresponds to rotational speed of the hoisting machine 1, i.e., rotational speed of the driving sheave 3, is disposed on the hoisting machine 1. An encoder that is disposed on the rotating shaft of the electric motor 2 (a hoisting machine encoder), for example, can be used as the first speed detector 5.

[0013] A deflecting sheave 6 is disposed in a vicinity of the hoisting machine 1.
A suspending body 7 is wound around the driving sheave 3 and the deflecting sheave 6. The suspending body 7 includes a plurality of main ropes. Ropes that have circular cross sections, or a belt that has a flat cross section, for example, can be used as the main ropes.

[0014] A car 8 is connected to a first end portion of the suspending body 7. A counterweight 9 is connected to a second end portion of the suspending body 7. In other words, the car 8 and the counterweight 9 are suspended inside the hoistway by the suspending body 7, and are raised and lowered by the hoisting machine 1. A pair of car guide rails 10 that guide raising and lowering of the car 8 and a pair of counterweight guide rails that guide raising and lowering of the counterweight 9 (not shown) are installed in the hoistway.

[0015] A safety gear 11 that makes the car 8 perform an emergency stop by engaging with the car guide rails 10 is mounted to a lower portion of the car 8. The safety gear 11 has an emergency stopper driving portion 11 a for activating the safety gear 11 in response to an electric activating signal. An electromagnetic actuator, for example, can be used as the emergency stopper driving portion 11a.

[0016] A speed governor 12 is disposed in an upper portion of the hoistway.
The speed governor 12 has a speed governor sheave 13 and a rope gripping apparatus 14. A speed governor rope 15 is wound around the speed governor sheave 13. Two end portions of the speed governor rope 15 are coupled to the safety gear 11 by means of a coupling rod 16. A lower end portion of the speed governor rope 15 is wound around a tension sheave 17 that is disposed in a lower portion of the hoistway.

[0017] The speed governor rope 15 is cycled together with the raising and lowering of the car 8. The speed governor sheave 13 is thereby rotated at a speed that corresponds to the running speed of the car 8. If the running speed of the car 8 reaches a preset first overspeed, this is detected by the speed governor 12, and the car 8 is urgently stopped by the hoisting machine 1. At that point, passage of electric current to the electric motor 2 is interrupted and rotation of the electric motor 2 and the driving sheave 3 is also braked by friction from the hoisting machine brake 4.

[0018] If the running speed of the car 8 reaches a preset second overspeed (the second overspeed is greater than the first overspeed), this is detected by the speed governor 12, and the speed governor rope 15 is gripped by the rope gripping apparatus 14, stopping circulation of the speed governor rope 15. The safety gear 11 is thereby operated mechanically by means of the coupling rod 16 such that the car 8 is made to perform an emergency stop by the safety gear 11.

[0019] A second speed detector 18 that generates a signal that corresponds to rotational speed of the speed governor sheave 13, i.e., a signal that corresponds to the running speed of the car 8, is disposed on the speed governor 12. An encoder that is disposed on the rotating shaft of the speed governor sheave 13 (a speed governor encoder), for example, can be used as the second speed detector 18.

[0020] The signals from the first and second speed detectors 5 and 18 are input into a safety gear actuating command apparatus 19 that constitutes a slippage monitoring apparatus. Based on the signals from the first and second speed detectors 5 and 18, the safety gear actuating command apparatus 19 computes a slippage extent value that is a value that relates to an extent of slippage of the suspending body 7 relative to the driving sheave 3. In Embodiment 1, the safety gear actuating command apparatus 19 computes slippage speed of the suspending body 7 relative to the driving sheave 3 as the slippage extent value.

[0021] The safety gear actuating command apparatus 19 stops the car 8 at a predetermined floor using the hoisting machine 1 if the slippage speed of the suspending body 7 exceeds a first speed threshold value (a first threshold value). In addition, the safety gear actuating command apparatus 19 outputs an activating signal to the emergency stopper driving portion 11 a if the slippage speed of the suspending body 7 exceeds a second speed threshold value (a second threshold value) that is greater than the first speed threshold value.

[0022] Figure 2 is a block diagram that shows part of the elevator apparatus from Figure 1. The safety gear actuating command apparatus 19 has a slippage speed computing portion 20 and a slippage determining portion 21. The slippage speed computing portion 20 computes the slippage speed of the suspending body 7 relative to the driving sheave 3 based on the signals from the first and second speed detectors 5 and 18. Specifically, if V1 is the speed detected by the first speed detector 5 and V2 is the speed detected by the second speed detector 18, then slippage speed δV can be found using $\delta V = |V1 - V2|$.

[0023] The result calculated by the slippage speed computing portion 20 and information that relates to elevator operating conditions are input into the slippage determining portion 21. The information that relates to the elevator operating conditions includes information regarding whether or not an emergency stop signal has been issued, i.e., information regarding whether or not the hoisting machine brake 4 is performing an emergency braking operation. The slippage determining portion 21 compares the slippage speed that has been found by the slippage speed computing portion 20 with the first and second speed threshold values, and outputs commands to various kinds of safety system actuating portions 22 in response to the compared results and elevator operating conditions.

[0024] Here, the safety gear actuating command apparatus 19 includes a microcomputer, for example. Functions of the slippage speed computing portion 20 and the slippage determining portion 21 are implemented by the microcomputer. Programs for implementing the functions of the slippage speed computing portion 20 and the slippage determining portion 21 are stored in a storage portion of the microcomputer.

[0025] Figure 3 is a flowchart that shows operation of a slippage determining portion from Figure 2. The slippage determining portion 21 first determines presence or absence of an emergency stop signal (Step S1). If an emergency stop signal has not been issued, determine whether or not the slippage speed exceeds the first speed threshold value Va (Step S2). If the slippage speed is less than or equal to the first speed threshold value Va, continue normal operation.

[0026] If the slippage speed exceeds the first speed threshold value Va, increment by 1 the cumulative count C1 by which the first speed threshold value Va has been exceeded (Step S3), and issue a designated floor stop command (Step S4). When the designated floor stop command is issued, the car 8 is moved to a predetermined floor and stopped. The floor at which the car 8 is stopped may be a preset floor such as a lobby floor, etc., or the nearest floor, for example.

[0027] After the designated floor stop command has been output, the slippage determining portion 21 determines whether or not the slippage speed exceeds the second speed threshold value Vb (Step S5). If the slippage speed exceeds the second speed threshold value Vb, issue a hoisting machine emergency stop command and a safety gear activating command (an activating signal) in order to suppress damage to the suspending body 7 (Step S6). When the hoisting machine emergency stop command is issued, passage of electric current to the electric motor 2 is interrupted, and rotation of the driving sheave 3 is braked by the hoisting machine brake 4. When the safety gear activating command is issued, the safety gear 11 is activated by the emergency stopper driving portion 11 a to brake.

[0028] If, on the other hand, the slippage speed has not exceeded the second speed threshold value Vb, determine whether or not the cumulative count C1 has exceeded a preset specified value α (Step S7). If C1 is less than or equal to α, then operation of the car 8 is returned to normal operation after the car 8 is stopped at the designated floor. If C1 exceeds α, it is deemed that damage to the suspending body 7 may have accumulated, and a safety gear activating command is issued after the car 8 is stopped at the designated floor (Step S8) to await maintenance inspection by a maintenance worker.

[0029] The above represents operation when an emergency stop signal has not been issued, but even in a case in which an emergency stop signal has been issued, first determine whether or not the slippage speed exceeds the first speed threshold value Va (Step S9). If the slippage speed is less than or equal to the first speed threshold value Va, determine whether or not the slippage speed exceeds the second speed threshold value Vb (Step S11).

[0030] If the slippage speed exceeds the first speed threshold value Va, increment the cumulative count C1 by 1 (Step S10), and then determine whether or not the slippage speed exceeds the second speed threshold value Vb (Step S11).

[0031] If the slippage speed exceeds the second speed threshold value Vb, issue a safety gear activating command in order to suppress damage to the suspending body 7 (Step S12). If the slippage speed has not exceeded the second speed threshold value Vb, determine whether or not the cumulative count C1 has exceeded the preset specified value α (Step S13). If C1 is less than or equal to α, await restoration of an emergency stop state by an emergency stop signal without activating the safety gear 11. If C1 exceeds α, it is deemed that damage to the suspending body 7 may have accumulated, and a safety gear activating command is issued after the emergency stop by the hoisting machine 1 (Step S14) to await maintenance inspection by a maintenance worker.

[0032] The safety gear actuating command apparatus 19 executes determining operations such as those described above periodically at a predetermined period.

[0033] In an elevator apparatus of this kind, because slippage speed of a suspending body 7 relative to a driving sheave 3 is computed based on the signals from the first and second speed detectors 5 and 18, and a car 8 is stopped at a designated floor by a hoisting machine 1 if the slippage speed exceeds a first speed threshold value Va, and an activating signal is output to an emergency stopper driving portion 11a to activate a safety gear 11 if the slippage speed exceeds a second speed threshold value Vb, damage to the suspending body 7 due to excessive slippage of the suspending body 7 relative to the driving sheave 3 can be suppressed, and cumulative damage to the suspending body 7 due to minute slippage of the suspending body 7 can also be prevented.

[0034] Because an emergency braking operation by the hoisting machine brake 4 is given priority over a designated floor stopping operation if the slippage speed exceeds the first speed threshold value Va during the emergency braking operation by the hoisting machine brake 4, reliability can be improved.

In addition, because the car 8 is stopped at a predetermined floor and then the safety gear 11 is activated if the count C1 by which the slippage speed has exceeded the first speed threshold value Va exceeds a preset specified value α, cumulative damage to the suspending body 7 that results from minute slippage can be detected early, enabling deterioration in the service of the elevator apparatus to be prevented.

[0035] Moreover, the count C1 by which the slippage speed has exceeded the first speed threshold value Va is a numerical value that expresses cumulative slippage, and may also be a cumulative value of slippage speeds δV, for example. In that case, the car 8 is stopped at a predetermined floor and the safety gear 11 is activated if the cumulative value of slippage speeds δV that have exceeded the first speed threshold value Va exceeds a preset specified value, for example.

Embodiment 2

[0036] Next, Figure 4 is a block diagram that shows part of an elevator apparatus according to Embodiment 2 of the present invention. In Embodiment 2, a safety gear actuating command apparatus 19 computes slippage distance of a suspending body 7 relative to a driving sheave 3 as a slippage extent value. The safety gear actuating command apparatus 19 stops a car 8 at a predetermined floor using a hoisting machine 1 if the slippage distance of the suspending body 7 exceeds a first distance threshold value (a first threshold value). In addition, the safety gear actuating command apparatus 19 outputs an activating signal to an emergency stopper driving portion 11a if the slippage distance of the suspending body 7 exceeds a second distance threshold value (a second threshold value) that is greater than the first distance threshold value.

[0037] The safety gear actuating command apparatus 19 has a slippage distance computing portion 23 and a slippage determining portion 21. The slippage distance computing portion 23 computes the slippage distance of the suspending body 7 relative to the driving sheave 3 based on signals from first and second speed detectors 5 and 18.

[0038] Specifically, if V1 is the speed detected by the first speed detector 5, V2 is the speed detected by the second speed detector 18, and Δt is the time taken to travel a prescribed distance, then slippage distance δX can be found using $\delta X = \int |V1 - V2| dt$, or $\delta X = \int |V1 - V2| \Delta t$.

[0039] The slippage distance computing portion 23 returns the slippage distance δX to an initial value each time the car 8 is started. Here, the slippage distance computing portion 23 performs a resetting of the slippage distance δX that is output immediately before the car 8 commences running from a normal stopped state. Malfunctions that accompany error accumulation are thereby prevented.

[0040] The slippage determining portion 21 compares the slippage distance that has been found by the slippage distance computing portion 23 with the first and second distance threshold values, and outputs commands to various kinds of safety system actuating portions 22 in response to the compared results and elevator operating conditions.

[0041] Here, the safety gear actuating command apparatus 19 includes a microcomputer, for example. Functions of the slippage distance computing portion 23 and the slippage determining portion 21 are implemented by the microcomputer. Programs for implementing the functions of the slippage distance computing portion 23 and the slippage determining portion 21 are stored in a storage portion of the microcomputer. The rest of the configuration is similar to that of Embodiment 1.

[0042] Figure 5 is a flowchart that shows operation of a slippage determining portion from Figure 4. The slippage determining portion 21 first determines presence or absence of an emergency stop signal (Step S21). If an emergency stop signal has not been issued, determine whether or not the slippage distance exceeds the first distance threshold value Xa (Step S22). If the slippage distance is less than or equal to the first distance threshold value Xa, continue normal operation.

[0043] If the slippage distance exceeds the first distance threshold value Xa, increment by 1 the cumulative count C2 by which the first distance threshold value Xa has been exceeded (Step S23), and issue a designated floor stop command (Step S24). When the designated floor stop command is issued, the car 8 is moved to a predetermined floor and stopped. The floor at which the car 8 is stopped may be a preset floor such as a lobby floor, etc., or the nearest floor, for example.

[0044] After the designated floor stop command has been output, the slippage determining portion 21 determines whether or not the slippage distance exceeds the second distance threshold value Xb (Step S25). If the slippage distance exceeds the second distance threshold value Xb, issue a hoisting machine emergency stop command and a safety gear activating command (an activating signal) in order to suppress damage to the suspending body 7 (Step S26). When the hoisting machine emergency stop command is issued, passage of electric current to the electric motor 2 is interrupted, and rotation of the driving sheave 3 is braked by the hoisting machine brake 4. When the safety gear activating command is issued, the safety gear 11 is activated by the emergency stopper driving portion 11 a to brake.

[0045] If, on the other hand, the slippage distance has not exceeded the second distance threshold value Xb, determine whether or not the cumulative count C2 has exceeded a preset specified value β (Step S27). If C2 is less than or equal to β, then operation of the car 8 is returned to normal operation after the car 8 is stopped at the designated floor. If C2 exceeds β, it is deemed that damage to the suspending body 7 may have accumulated, and a safety gear activating command is issued after the car 8 is stopped at the designated floor (Step S28) to await maintenance inspection by a maintenance worker.

[0046] The above represents operation when an emergency stop signal has not been issued, but even in a case in which an emergency stop signal has been issued, first determine whether or not the slippage distance exceeds the first distance threshold value Xa (Step S29). If the slippage distance is less than or equal to the first distance threshold value Xa, determine whether or not the slippage distance exceeds the second distance threshold value Xb (Step S31).

[0047] If the slippage distance exceeds the first distance threshold value Xa, increment the cumulative count C2 by 1 (Step S30), and then determine whether or not the slippage distance exceeds the second distance threshold value Xb (Step S31).

[0048] If the slippage distance exceeds the second distance threshold value Xb, issue a safety gear activating command in order to suppress damage to the suspending body 7 (Step S32). If the slippage distance has not exceeded the second distance threshold value Xb, determine whether or not the cumulative count C2 has exceeded the preset specified value β (Step S33). If C2 is less than or equal to β, await restoration of an emergency stop state by an emergency stop signal without activating the safety gear 11. If C2 exceeds β, it is deemed that damage to the suspending body 7 may have accumulated, and a safety gear activating command is issued after the emergency stop by the hoisting machine 1 (Step S34) to await maintenance inspection by a maintenance worker.

[0049] The safety gear actuating command apparatus 19 executes determining operations such as those described above periodically at predetermined period.

[0050] In an elevator apparatus of this kind, because slippage distance of a suspending body 7 relative to a driving sheave 3 is computed based on the signals from the first and second speed detectors 5 and 18, and a car 8 is stopped at a designated floor by a hoisting machine 1 if the slippage distance exceeds a first distance threshold value Xa, and an activating signal is output to an emergency stopper driving portion 11a to activate a safety gear 11 if the slippage distance exceeds a second distance threshold value Xb, damage to the suspending body 7 due to excessive slippage of the suspending body 7 relative to the driving sheave 3 can be suppressed, and cumulative damage to the suspending body 7 due to minute slippage of the suspending body 7 can also be prevented.

[0051] Because an emergency braking operation by the hoisting machine brake 4 is given priority over a designated floor stopping operation if the slippage distance exceeds the first distance threshold value Xa during the emergency braking operation by the hoisting machine brake 4, reliability can be improved.

In addition, because the car 8 is stopped at a predetermined floor and then the safety gear 11 is activated if the count C2 by which the slippage distance has exceeded the first distance threshold value Xa exceeds a preset specified value β, cumulative damage to the suspending body 7 that results from minute slippage can be detected early, enabling deterioration in the service of the elevator apparatus to be prevented.

[0052] Moreover, the count C2 by which the slippage distance has exceeded the first distance threshold value Xa is a numerical value that expresses cumulative slippage, and may also be a cumulative value of slippage distances δX, for example. In that case, the car 8 is stopped at a predetermined floor and the safety gear 11 is activated if the cumulative value of slippage distances δX that have exceeded the first distance threshold value Xa exceeds a preset specified value, for example.

Embodiment 3

[0053] Next, Figure 6 is a block diagram that shows part of an elevator apparatus according to Embodiment 3 of the present invention. In Embodiment 3, a safety gear actuating command apparatus 19 computes slippage distance and slippage speed of a suspending body 7 relative to a driving sheave 3 as a slippage extent value. The safety gear actuating command apparatus 19 stops a car 8 at a predetermined floor using a hoisting machine 1 if the slippage distance of the suspending body 7 exceeds a distance threshold value (a first threshold value). In addition, the safety gear actuating command apparatus 19 outputs an activating signal to an emergency stopper driving portion 11a if the slippage speed of the suspending body 7 exceeds a speed threshold value (a second threshold value).

[0054] Here, the speed threshold value is set so as to correspond to a slippage extent that is greater than the distance threshold value. Specifically, the speed threshold value is set so as to be greater than a value when the distance threshold value is divided by unit time (a prescribed time).

[0055] The safety gear actuating command apparatus 19 has a slippage speed computing portion 20, a slippage distance computing portion 23, and a slippage determining portion 21. The slippage speed computing portion 20 computes the slippage speed of the suspending body 7 in a similar manner to Embodiment 1. The slippage distance computing portion 23 computes the slippage distance of the suspending body 7 in a similar manner to Embodiment 2.

[0056] The slippage determining portion 21 compares the slippage distance that has been found by the slippage distance computing portion 23 with the distance threshold value, and also compares the slippage speed that has been found by the slippage speed computing portion 20 with the speed threshold value, and outputs commands to various kinds of safety system actuating portions 22 in response to the compared results and elevator operating conditions.

[0057] Here, the safety gear actuating command apparatus 19 includes a microcomputer, for example. Functions of the slippage speed computing portion 20, the slippage distance computing portion 23, and the slippage determining portion 21 are implemented by the microcomputer. Programs for implementing the functions of the slippage speed computing portion 20, the slippage distance computing portion 23, and the slippage determining portion 21 are stored in a storage portion of the microcomputer. The rest of the configuration is similar to that of Embodiment 1.

[0058] Figure 7 is a flowchart that shows operation of a slippage determining portion from Figure 6. The slippage determining portion 21 first determines presence or absence of an emergency stop signal (Step S41). If an emergency stop signal has not been issued, determine whether or not the slippage distance exceeds the distance threshold value Xc (Step S42). If the slippage distance is less than or equal to the distance threshold value Xc, continue normal operation.

[0059] If the slippage distance exceeds the distance threshold value Xc, increment by 1 the cumulative count C3 by which the distance threshold value Xc has been exceeded (Step S43), and issue a designated floor stop command (Step S44). When the designated floor stop command is issued, the car 8 is moved to a predetermined floor and stopped. The floor at which the car 8 is stopped may be a preset floor such as a lobby floor, etc., or the nearest floor, for example.

[0060] After the designated floor stop command has been output, the slippage determining portion 21 determines whether or not the slippage speed exceeds the speed threshold value Vc (Step S45). If the slippage speed exceeds the speed threshold value Vc, issue a hoisting machine emergency stop command and a safety gear activating command (an activating signal) in order to suppress damage to the suspending body 7 (Step S46). When the hoisting machine emergency stop command is issued, passage of electric current to the electric motor 2 is interrupted, and rotation of the driving sheave 3 is braked by the hoisting machine brake 4. When the safety gear activating command is issued, the safety gear 11 is activated by the emergency stopper driving portion 11 a to brake.

[0061] If, on the other hand, the slippage speed has not exceeded the speed threshold value Vc, determine whether or not the cumulative count C3 has exceeded a preset specified value Y (Step S47). If C3 is less than or equal to γ, then operation of the car 8 is returned to normal operation after the car 8 is stopped at the designated floor. If C3 exceeds γ, it is deemed that damage to the suspending body 7 may have accumulated, and a safety gear activating command is issued after the car 8 is stopped at the designated floor (Step S48) to await maintenance inspection by a maintenance worker.

[0062] The above represents operation when an emergency stop signal has not been issued, but even in a case in which an emergency stop signal has been issued, first determine whether or not the slippage distance exceeds the distance threshold value Xc (Step S49). If the slippage distance is less than or equal to the distance threshold value Xc, determine whether or not the slippage speed exceeds the speed threshold value Vc (Step S51).

[0063] If the slippage distance exceeds the distance threshold value Xc, increment the cumulative count C3 by 1 (Step S50), and then determine whether or not the slippage speed exceeds the speed threshold value Vc (Step S51).

[0064] If the slippage speed exceeds the speed threshold value Vc, issue a safety gear activating command in order to suppress damage to the suspending body 7 (Step S52). If the slippage speed has not exceeded the speed threshold value Vc, determine whether or not the cumulative count C3 has exceeded the preset specified value γ (Step S53). If C3 is less than or equal to γ, await restoration of an emergency stop state by an emergency stop signal without activating the safety gear 11. If C3 exceeds γ, it is deemed that damage to the suspending body 7 may have accumulated, and a safety gear activating command is issued after the emergency stop by the hoisting machine 1 (Step S54) to await maintenance inspection by a maintenance worker.

[0065] The safety gear actuating command apparatus 19 executes determining operations such as those described above periodically at predetermined period.

[0066] In an elevator apparatus of this kind, because slippage distance and slippage speed of a suspending body 7 relative to a driving sheave 3 is computed based on the signals from the first and second speed detectors 5 and 18, and a car 8 is stopped at a designated floor by a hoisting machine 1 if the slippage distance exceeds a distance threshold value Xc, and an activating signal is output to an emergency stopper driving portion 11a to activate a safety gear 11 if the slippage speed exceeds a speed threshold value Vc, damage to the suspending body 7 due to excessive slippage of the suspending body 7 relative to the driving sheave 3 can be suppressed, and cumulative damage to the suspending body 7 due to minute slippage of the suspending body 7 can also be prevented.

[0067] Because an emergency braking operation by the hoisting machine brake 4 is given priority over a designated floor stopping operation if the slippage distance exceeds the distance threshold value Xc during the emergency braking operation by the hoisting machine brake 4, reliability can be improved.

In addition, because the car 8 is stopped at a predetermined floor and then the safety gear 11 is activated if the count C3 by which the slippage distance has exceeded the distance threshold value Xc exceeds a preset specified value γ, cumulative damage to the suspending body 7 that results from minute slippage can be detected early, enabling deterioration in the service of the elevator apparatus to be prevented.

[0068] Moreover, in Figure 1, an elevator apparatus using a one-to-one (1:1) roping method is shown, but other roping methods may also be used.

The activating signal is not limited to an electrical signal, and may also be an optical signal, etc., for example.

In addition, the second speed detector is not limited to being a speed governor encoder, and a sensor that detects running speed of a car directly, or a sensor that detects traveling speed of a suspending body, etc., can also be used, for example.

Claims

1. An elevator apparatus comprising:

a hoisting machine that has a driving sheave;
a suspending body that is wound around the driving sheave;
a car that is suspended by the suspending body, and that is raised and lowered by the hoisting machine;
a safety gear that is mounted to the car, and that makes the car perform an emergency stop in response to an activating signal;
a first speed detector that generates a signal that corresponds to a rotational speed of the hoisting machine;
a second speed detector that generates a signal that corresponds to a running speed of the car; and
a slippage monitoring apparatus that computes a slippage extent value that is a value that relates to extent of slippage of the suspending body relative to the driving sheave based on the signals from the first and second speed detectors, and stops the car at a predetermined floor using the hoisting machine if the slippage extent value exceeds a first threshold value, and activates the safety gear by the activating signal if the slippage extent value exceeds a second threshold value that corresponds to a slippage extent that is greater than the first threshold value.

2. An elevator apparatus according to Claim 1, wherein the slippage monitoring apparatus computes a slippage speed of the suspending body relative to the driving sheave as the slippage extent value, and compares the slippage speed with a first speed threshold value that constitutes the first threshold value and a second speed threshold value that constitutes the second threshold value.

3. An elevator apparatus according to Claim 1, wherein the slippage monitoring apparatus computes a slippage distance of the suspending body relative to the driving sheave as the slippage extent value, and compares the slippage distance with a first distance threshold value that constitutes the first threshold value and a second distance threshold value that constitutes the second threshold value.

4. An elevator apparatus according to Claim 1, wherein the slippage monitoring apparatus computes a slippage speed and a slippage distance of the suspending body relative to the driving sheave as the slippage extent value, and compares the slippage distance with a distance threshold value that constitutes the first threshold value, and compares the slippage speed with a speed threshold value that constitutes the second threshold value.

5. An elevator apparatus according to either of Claims 3 or 4, wherein the slippage monitoring apparatus returns the slippage distance to an initial value each time the car is started.

6. An elevator apparatus according to Claim 1, wherein:

a hoisting machine brake that brakes rotation of the driving sheave is disposed on the hoisting machine; and
an emergency braking operation by the hoisting machine brake is given priority over an operation that stops the car at a predetermined floor if the slippage extent value exceeds the first threshold value during the emergency braking operation by the hoisting machine brake.

7. An elevator apparatus according to Claim 1, wherein the slippage monitoring apparatus stops the car at a predetermined floor and then activates the safety gear if a count by which the slippage extent value has exceeded the first threshold value exceeds a preset specified value.

8. An elevator apparatus according to Claim 1, wherein the slippage monitoring apparatus stops the car at a predetermined floor and then activates the safety gear if a cumulative value of slippage extent values that have exceeded the first threshold value exceeds a preset specified value.

Amended claims under Art. 19.1 PCT

1. (Amended)
An elevator apparatus comprising:

a hoisting machine that has a driving sheave;
a suspending body that is wound around the driving sheave;
a car that is suspended by the suspending body, and that is raised and lowered by the hoisting machine;
a safety gear that is mounted to the car, and that makes the car perform an emergency stop in response to an activating signal;
a first speed detector that generates a signal that corresponds to a rotational speed of the hoisting machine;
a second speed detector that generates a signal that corresponds to a running speed of the car; and
a slippage monitoring apparatus that computes

a slippage extent value that is a value that relates to extent of slippage of the suspending body relative to the driving sheave based on the signals from the first and second speed detectors, and stops the car at a predetermined floor using the hoisting machine if the slippage extent value exceeds a first threshold value, and activates the safety gear by the activating signal if the slippage extent value exceeds a second threshold value that corresponds to a slippage extent that is greater than the first threshold value,

wherein the slippage monitoring apparatus computes a slippage speed and a slippage distance of the suspending body relative to the driving sheave as the slippage extent value, and compares the slippage distance with a distance threshold value that constitutes the first threshold value and compares the slippage speed with a speed threshold value that constitutes the second threshold value.

2. (Canceled)

3. (Canceled)

4. (Canceled)

5. (Amended)
An elevator apparatus according to Claim 1, wherein the slippage monitoring apparatus returns the slippage distance to an initial value each time the car is started.

6. An elevator apparatus according to Claim 1, wherein:

a hoisting machine brake that brakes rotation of the driving sheave is disposed on the hoisting machine; and
an emergency braking operation by the hoisting machine brake is given priority over an operation that stops the car at a predetermined floor if the slippage extent value exceeds the first threshold value during the emergency braking operation by the hoisting machine brake.

7. An elevator apparatus according to Claim 1, wherein the slippage monitoring apparatus stops the car at a predetermined floor and then activates the safety gear if a count by which the slippage extent value has exceeded the first threshold value exceeds a preset specified value.

8. An elevator apparatus according to Claim 1, wherein the slippage monitoring apparatus stops the car at a predetermined floor and then activates the safety gear if a cumulative value of slippage extent values that have exceeded the first threshold value exceeds a preset specified value.

FIG. 1

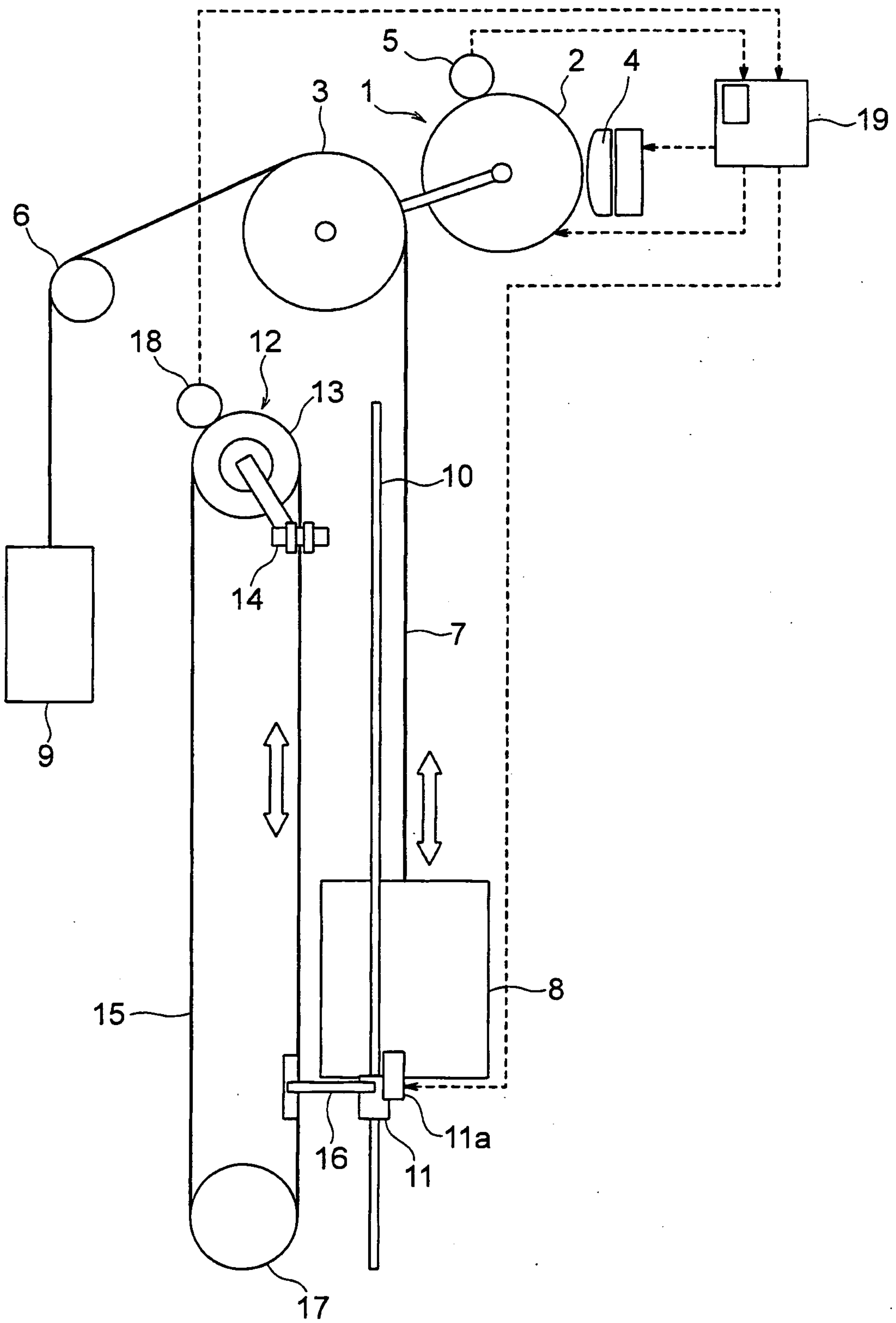


FIG. 2

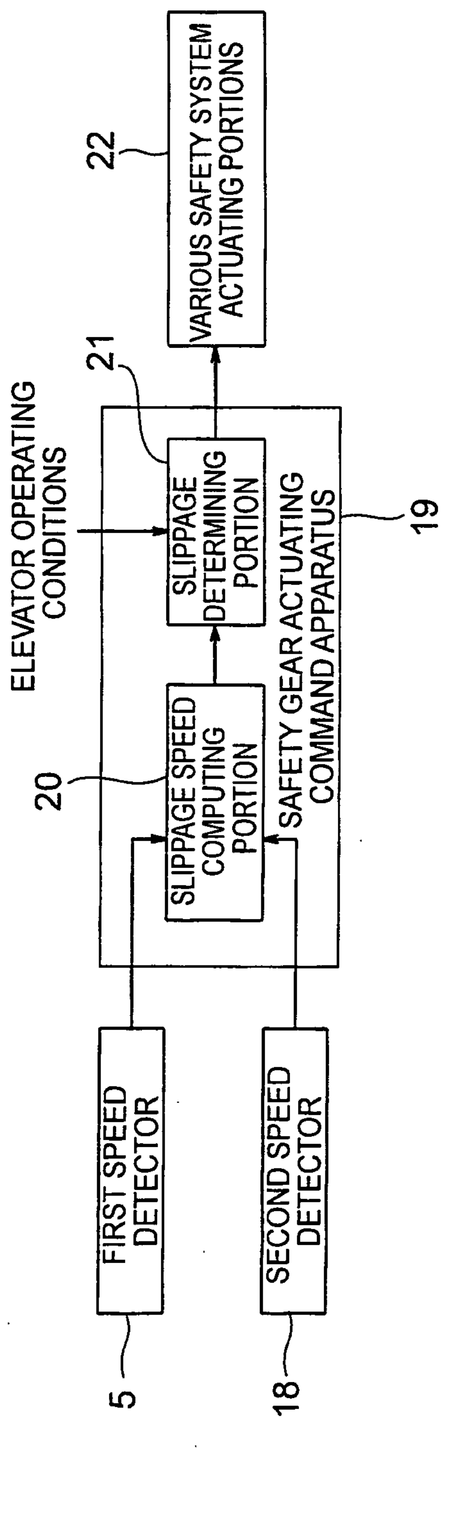

FIRST SPEED DETECTOR
5
SECOND SPEED DETECTOR
18
SLIPPAGE SPEED COMPUTING PORTION
20
ELEVATOR OPERATING CONDITIONS
SLIPPAGE DETERMINING PORTION
21
SAFETY GEAR ACTUATING COMMAND APPARATUS
19
VARIOUS SAFETY SYSTEM ACTUATING PORTIONS
22

FIG. 3

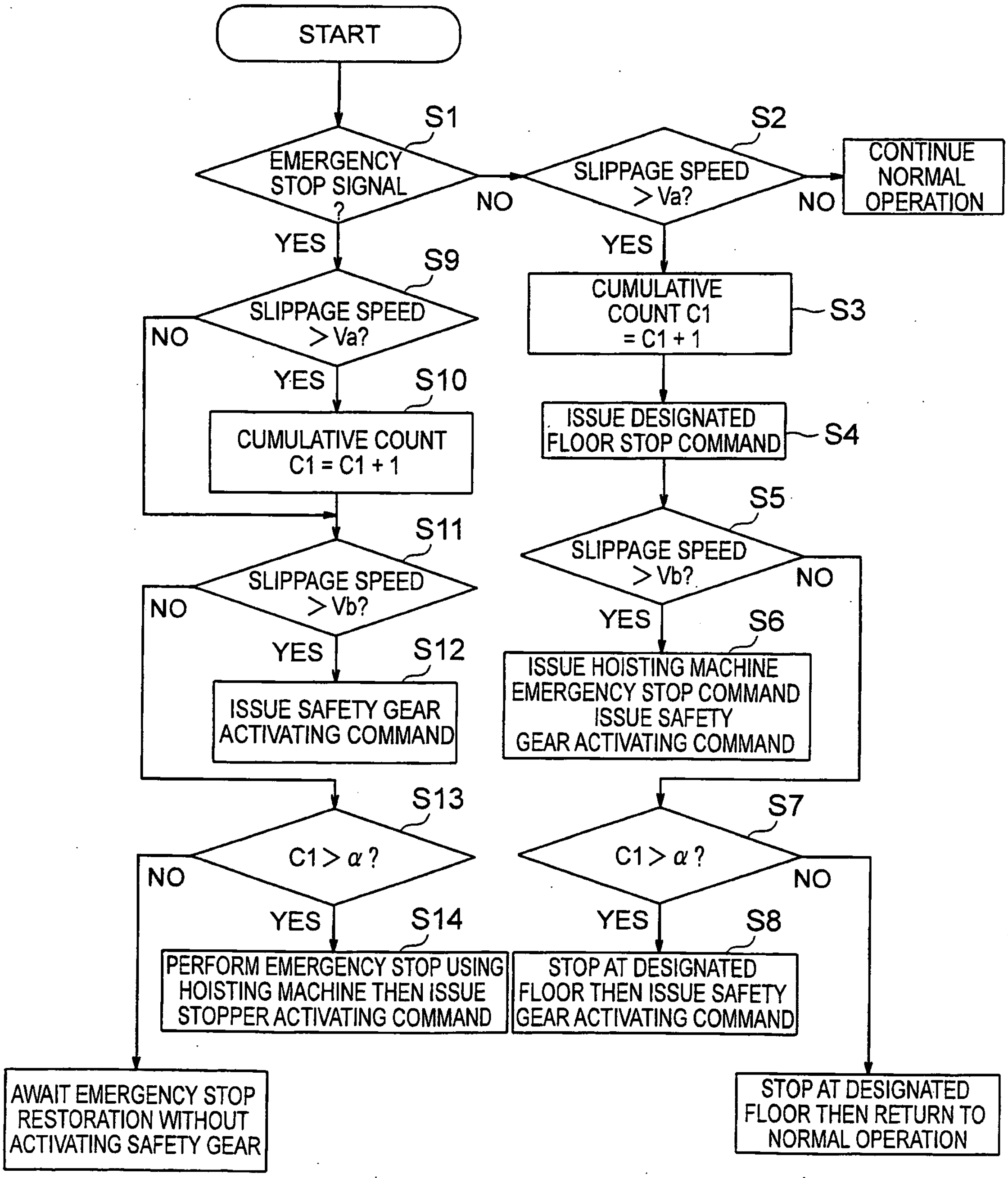

START
S1
EMERGENCY STOP SIGNAL ?
NO
YES
S2
SLIPPAGE SPEED > Va?
NO
CONTINUE NORMAL OPERATION
YES
CUMULATIVE COUNT C1 = C1 + 1
S3
ISSUE DESIGNATED FLOOR STOP COMMAND
S4
S5
SLIPPAGE SPEED > Vb?
NO
YES
S6
ISSUE HOISTING MACHINE EMERGENCY STOP COMMAND ISSUE SAFETY GEAR ACTIVATING COMMAND
S7
C1 > α ?
NO
YES
S8
STOP AT DESIGNATED FLOOR THEN ISSUE SAFETY GEAR ACTIVATING COMMAND
STOP AT DESIGNATED FLOOR THEN RETURN TO NORMAL OPERATION
S9
SLIPPAGE SPEED > Va?
NO
YES
S10
CUMULATIVE COUNT C1 = C1 + 1
S11
SLIPPAGE SPEED > Vb?
NO
YES
S12
ISSUE SAFETY GEAR ACTIVATING COMMAND
S13
C1 > α ?
NO
YES
S14
PERFORM EMERGENCY STOP USING HOISTING MACHINE THEN ISSUE STOPPER ACTIVATING COMMAND
AWAIT EMERGENCY STOP RESTORATION WITHOUT ACTIVATING SAFETY GEAR

FIG. 4

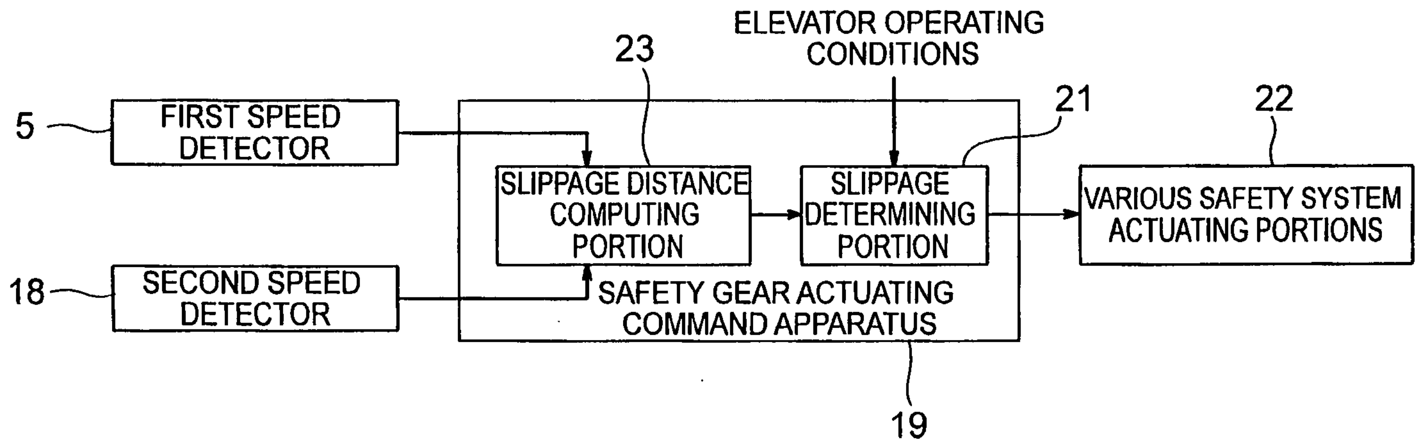

5
FIRST SPEED DETECTOR
18
SECOND SPEED DETECTOR
23
SLIPPAGE DISTANCE COMPUTING PORTION
ELEVATOR OPERATING CONDITIONS
21
SLIPPAGE DETERMINING PORTION
SAFETY GEAR ACTUATING COMMAND APPARATUS
19
22
VARIOUS SAFETY SYSTEM ACTUATING PORTIONS

FIG. 5

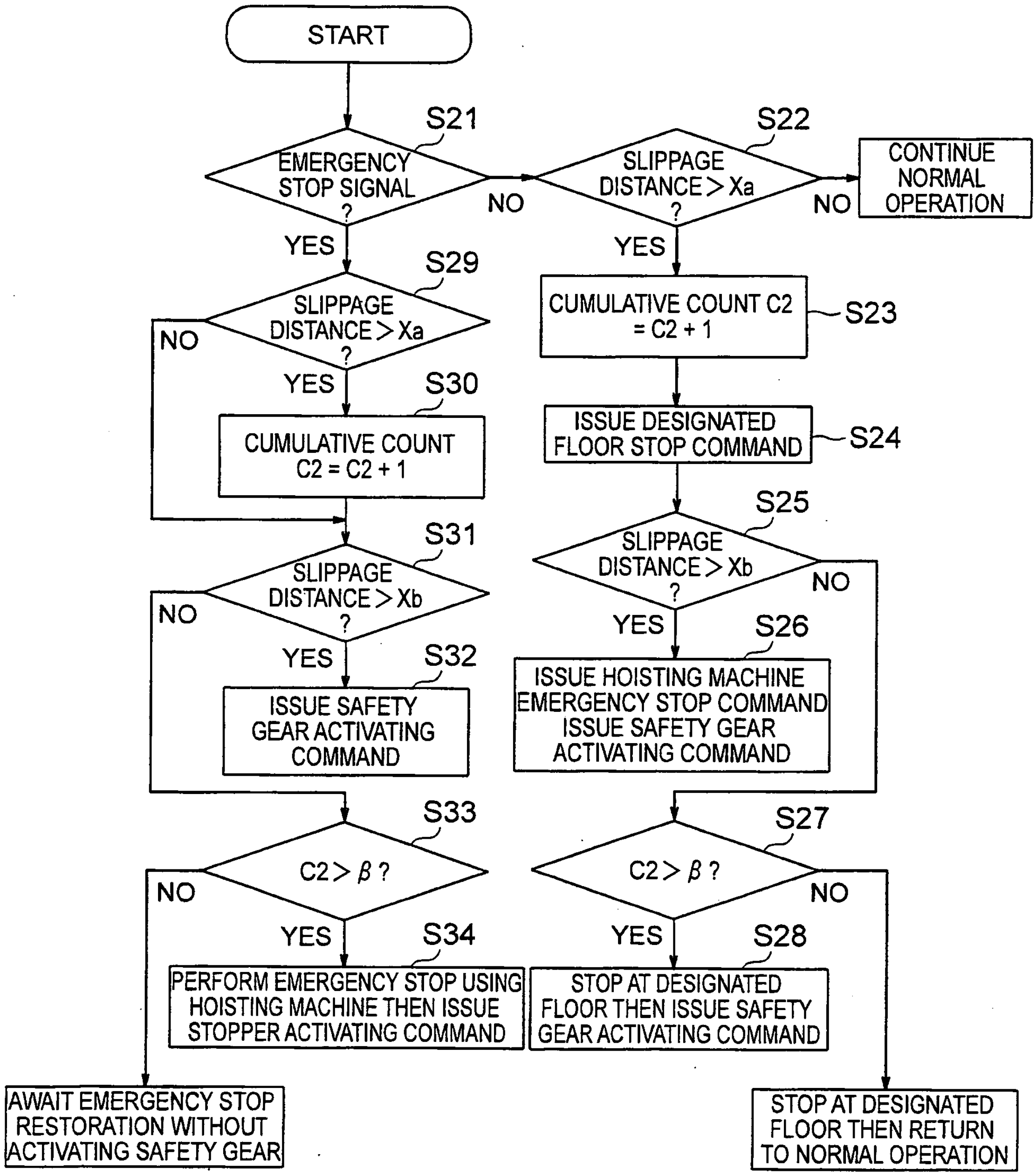

START
S21
EMERGENCY STOP SIGNAL ?
NO
YES
S22
SLIPPAGE DISTANCE > Xa ?
NO
CONTINUE NORMAL OPERATION
YES
S23
CUMULATIVE COUNT C2 = C2 + 1
S24
ISSUE DESIGNATED FLOOR STOP COMMAND
S25
SLIPPAGE DISTANCE > Xb ?
NO
YES
S26
ISSUE HOISTING MACHINE EMERGENCY STOP COMMAND ISSUE SAFETY GEAR ACTIVATING COMMAND
S27
C2 > β ?
NO
YES
S28
STOP AT DESIGNATED FLOOR THEN ISSUE SAFETY GEAR ACTIVATING COMMAND
STOP AT DESIGNATED FLOOR THEN RETURN TO NORMAL OPERATION
S29
SLIPPAGE DISTANCE > Xa ?
NO
YES
S30
CUMULATIVE COUNT C2 = C2 + 1
S31
SLIPPAGE DISTANCE > Xb ?
NO
YES
S32
ISSUE SAFETY GEAR ACTIVATING COMMAND
S33
C2 > β ?
NO
YES
S34
PERFORM EMERGENCY STOP USING HOISTING MACHINE THEN ISSUE STOPPER ACTIVATING COMMAND
AWAIT EMERGENCY STOP RESTORATION WITHOUT ACTIVATING SAFETY GEAR

FIG. 6

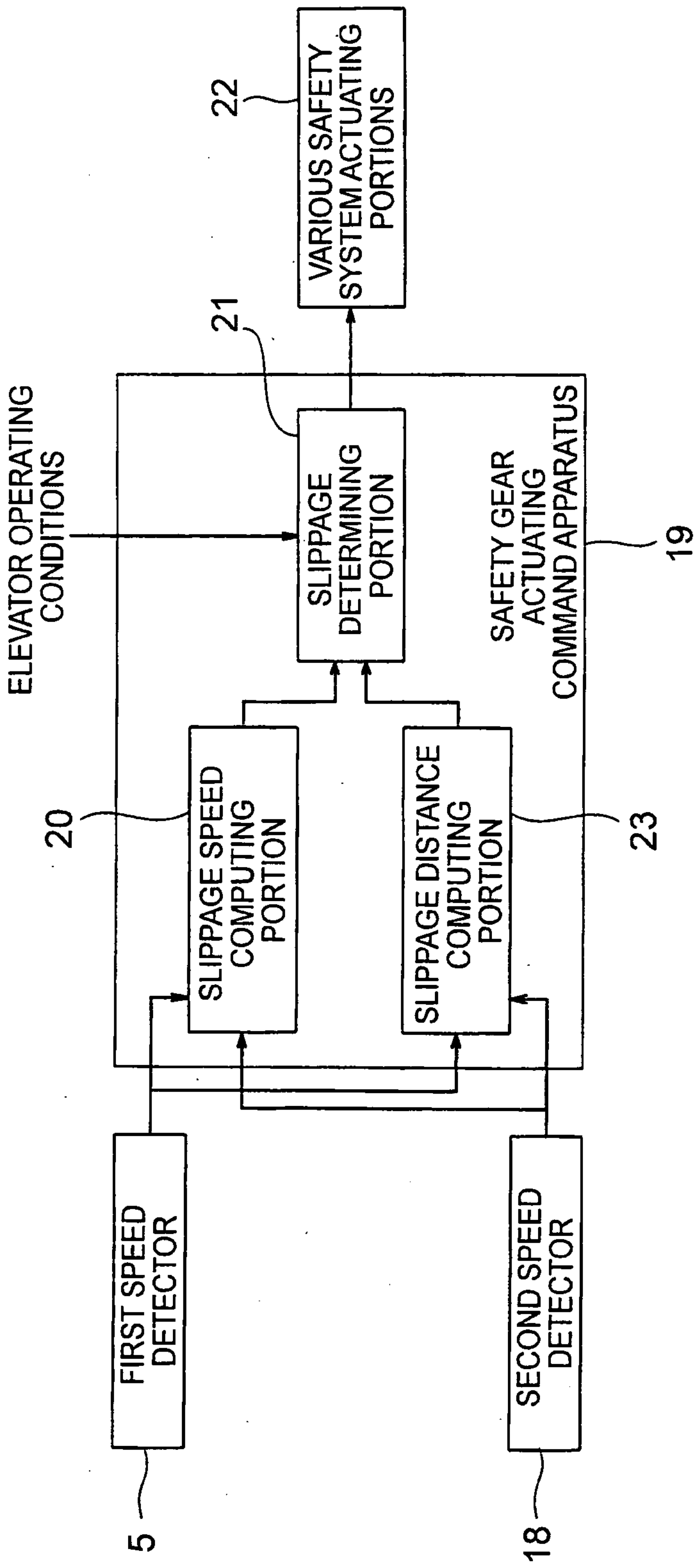
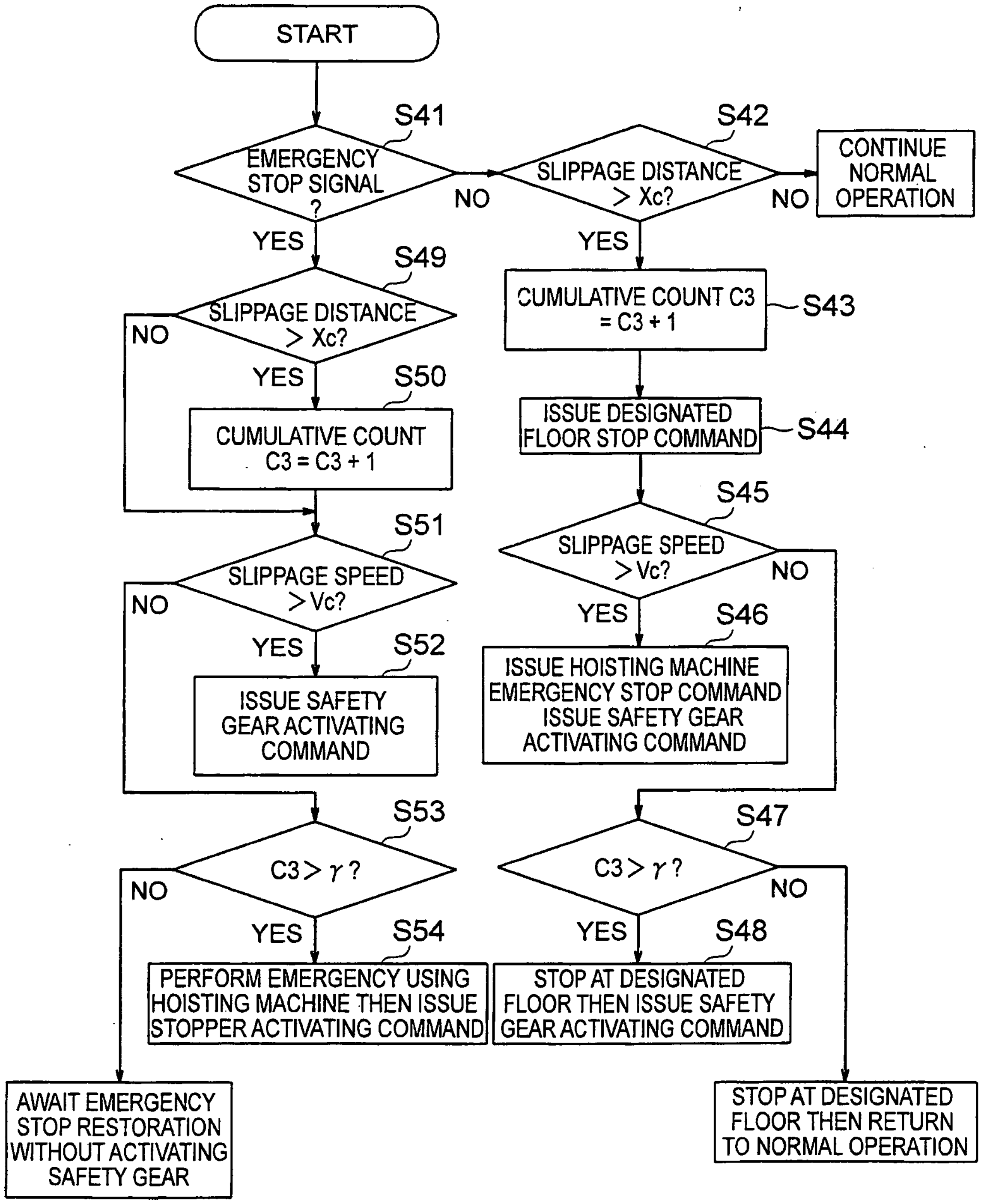

ELEVATOR OPERATING CONDITIONS
SLIPPAGE DETERMINING PORTION
VARIOUS SAFETY SYSTEM ACTUATING PORTIONS
SLIPPAGE SPEED COMPUTING PORTION
SLIPPAGE DISTANCE COMPUTING PORTION
SAFETY GEAR ACTUATING COMMAND APPARATUS
FIRST SPEED DETECTOR
SECOND SPEED DETECTOR
5
18
19
20
21
22
23

FIG. 7


START
S41
EMERGENCY STOP SIGNAL ?
NO
YES
S42
SLIPPAGE DISTANCE > Xc?
NO
CONTINUE NORMAL OPERATION
YES
S43
CUMULATIVE COUNT C3 = C3 + 1
S44
ISSUE DESIGNATED FLOOR STOP COMMAND
S45
SLIPPAGE SPEED > Vc?
NO
YES
S46
ISSUE HOISTING MACHINE EMERGENCY STOP COMMAND ISSUE SAFETY GEAR ACTIVATING COMMAND
S47
C3 > γ ?
NO
YES
S48
STOP AT DESIGNATED FLOOR THEN ISSUE SAFETY GEAR ACTIVATING COMMAND
STOP AT DESIGNATED FLOOR THEN RETURN TO NORMAL OPERATION
S49
SLIPPAGE DISTANCE > Xc?
NO
YES
S50
CUMULATIVE COUNT C3 = C3 + 1
S51
SLIPPAGE SPEED > Vc?
NO
YES
S52
ISSUE SAFETY GEAR ACTIVATING COMMAND
S53
C3 > γ ?
NO
YES
S54
PERFORM EMERGENCY USING HOISTING MACHINE THEN ISSUE STOPPER ACTIVATING COMMAND
AWAIT EMERGENCY STOP RESTORATION WITHOUT ACTIVATING SAFETY GEAR

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/074410

A. CLASSIFICATION OF SUBJECT MATTER
B66B5/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B66B5/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 06-144721 A (Mitsubishi Electric Corp.), 24 May, 1994 (24.05.94), Par. Nos. [0024] to [0030]; Figs. 1, 4 (Family: none)	1-3,5-6 4,7-8
Y A	JP 52-123052 A (Mitsubishi Electric Corp.), 15 October, 1977 (15.10.77), Column 6, line 17 to column 8, line 15; Figs. 1, 3 (Family: none)	1-3,5-6 4,7-8
Y	JP 09-040333 A (Meidensha Corp.), 10 February, 1997 (10.02.97), Claim 1 (Family: none)	2

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 September, 2008 (01.09.08)	09 September, 2008 (09.09.08)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/074410

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000-118903 A (Hitachi, Ltd.), 25 April, 2000 (25.04.00), Claim 2 (Family: none)	3,5
Y	JP 04-125273 A (Toshiba Corp.), 24 April, 1992 (24.04.92), Page 3, lower left column, lines 6 to 20 (Family: none)	5
Y	JP 2004-231355 A (Mitsubishi Electric Corp.), 19 August, 2004 (19.08.04), Claim 1 & CN 1519187 A	6
A	JP 01-172191 A (Mitsubishi Electric Corp.), 07 July, 1989 (07.07.89), Claims 1 to 2 & US 4817761 A	7-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP SHO59230981 B **[0004]**
- JP 2002532366 A **[0005]**