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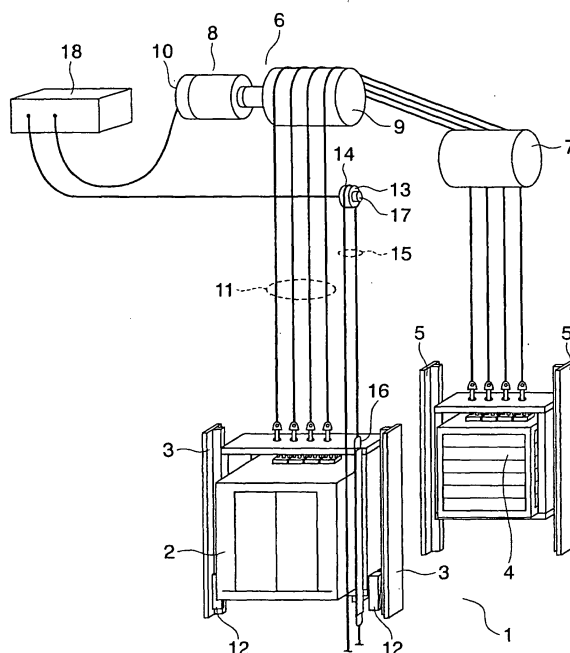
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(54) **ELEVATOR DEVICE**

(57) A shock absorber for a car is provided at a bottom within a hoistway. A hoisting machine is provided with a hoisting machine brake device for braking a movement of the car. A safety device controls an operation of the hoisting machine brake device when there is an abnormality in a speed of the car such that the speed of the car becomes equal to or lower than an allowable collision speed of a shock absorber before the car reaches a position of the shock absorber. The safety device starts the

operation of the hoisting machine brake device when the speed of the car exceeds an overspeed detection level. A value of the overspeed detection level in a predetermined interval from the position of the shock absorber is set in accordance with a position of the car such that the speed of the car becomes equal to the allowable collision speed of the shock absorber at the position of the shock absorber through braking of the car by the hoisting machine brake device.

FIG. 1



Description

Technical Field

5 **[0001]** The present invention relates to an elevator apparatus provided with a shock absorber for absorbing a shock caused to a car at a bottom within a hoistway.

Background Art

10 **[0002]** Conventionally, there has been proposed an elevator apparatus structured to actuate a brake of a hoisting machine when the speed of a car exceeds a first overspeed detection level and actuate an emergency stop device when the speed of the car exceeds a second overspeed detection level. In the conventional elevator apparatus thus structured, with a view to reducing a dimension of a hoistway in a height direction thereof, the values of the first overspeed detection level and the second overspeed detection level are so set as to decrease continuously as the distance from each end of the hoistway decreases. The first overspeed detection level and the second overspeed detection level are created on the basis of a running speed pattern according to which the car is caused to run during normal operation of an elevator (e.g., see Patent Document 1).

[0003] Patent Document 1: JP 2000-110868 A

20 Disclosure of the Invention

Problem to be solved by the Invention

25 **[0004]** Conventionally, however, the first overspeed detection level and the second overspeed detection level are created on the basis of the running speed pattern of the car, so the speed at which the car collides with a shock absorber installed at a bottom of the hoistway differs depending on the position of the car at the time when the brake of the hoisting machine or the emergency stop device is actuated. Accordingly, the allowable collision speed of the shock absorber needs to be set to a maximum value of the speed at which the car collides with the shock absorber, so the shock absorber is enlarged in size. Thus, the hoistway cannot be reduced in size.

30 **[0005]** The present invention has been made to solve the above-mentioned problem, and it is therefore an object of the present invention to provide an elevator apparatus enabling a reduction in size.

Means for solving the Problem

35 **[0006]** An elevator apparatus according to the present invention includes: a car that is raised and lowered within a hoistway; a shock absorber for the car which is provided at a bottom within the hoistway; a braking device for braking a movement of the car; and a safety device for operating the braking device when there is an abnormality in a speed of the car so that the speed of the car becomes equal to or lower than an allowable collision speed of the shock absorber before the car reaches a position of the shock absorber. The safety device has an overspeed detection level set therein beforehand in accordance with a position of the car. The safety device starts an operation of the braking device when the speed of the car exceeds the overspeed detection level. The overspeed detection level has a value that is set such that the speed of the car becomes equal to a predetermined value at the position of the shock absorber through braking of the car by the braking device, in a predetermined interval from the position of the shock absorber.

45 Brief Description of the Drawings

[0007]

50 Fig. 1 is a schematic diagram showing an elevator apparatus according to Embodiment 1 of the present invention. Fig. 2 is a graph showing a relationship between the braking torque applied to the drive sheave and time after detection of a first overspeed of the car by the safety device of Fig. 1.

Fig. 3 is a graph showing a relationship between a speed of the car and a time which has been calculated based on the relationship between the braking torque and the time of Fig. 2.

55 Fig. 4 is a graph showing the relationship between braking torque and time of Fig. 2 and the relationship for approximation between braking torque and time together.

Fig. 5 is a graph showing a relationship between the speed of the car and time, which has been calculated based on the relationship for approximation between braking torque and time of Fig. 4.

Fig. 6 is a graph showing a relationship between the acceleration of the car and time, which has been calculated

based on the relationship for approximation between braking torque and time of Fig. 4.

Fig. 7 is a graph showing a relationship between the first overspeed detection level and the position of the car, which has been calculated based on the relationship for approximation between braking torque and time of Fig. 4.

Fig. 8 is a schematic diagram showing an elevator apparatus according to Embodiment 2 of the present invention.

Fig. 9 is a graph showing a relationship between the braking force applied to the car and time after detection of the second overspeed by the safety device.

Fig. 10 is a graph showing a relationship between the speed of the car and time, which has been calculated based on the relationship between braking force and time of Fig. 9.

Fig. 11 is a graph showing the relationship between braking force and time in Fig. 9 and the relationship for approximation between braking force and time together.

Fig. 12 is a graph showing a relationship between the speed of the car and time, which has been calculated based on the relationship for approximation between braking force and time of Fig. 11.

Fig. 13 is a graph showing a relationship between the acceleration of the car and time, which has been calculated based on the relationship for approximation between braking force and time of Fig. 11.

Fig. 14 is a graph showing a relationship between the second overspeed detection level and the position of the car, which has been calculated based on the relationship for approximation between braking force and time of Fig. 11.

Best Modes for carrying out the Invention

[0008] Preferred embodiments of the present invention will be described hereinafter with reference to the drawings.

Embodiment 1

[0009] Fig. 1 is a schematic diagram showing an elevator apparatus according to Embodiment 1 of the present invention. Referring to Fig. 1, a pair of car guide rails 3 for guiding a car 2 and a pair of counterweight guide rails 5 for guiding a counterweight 4 are installed within a hoistway 1. A hoisting machine (drive device) 6 for raising/lowering the car 2 and the counterweight 4 within the hoistway 1 and a deflector pulley 7 disposed in the vicinity of the hoisting machine 6 are provided in an upper portion of the hoistway 1.

[0010] The hoisting machine 6 has a hoisting machine body 8 including a motor, and a drive sheave 9 that is rotated by the hoisting machine body 8. The hoisting machine body 8 is provided with a hoisting machine brake device (braking device) 10 for braking rotation of the drive sheave 9.

[0011] A plurality of main ropes 11 are looped around the drive sheave 9 and the deflector pulley 7. The car 2 and the counterweight 4 are suspended within the hoistway 1 by means of the respective main ropes 11. The car 2 and the counterweight 4 are raised/lowered within the hoistway 1 through rotation of the drive sheave 9.

[0012] The car 2 is mounted with a pair of emergency stop devices (braking devices) 12 disposed facing the car guide rails 3, respectively. The emergency stop devices 12 have wedges (braking members) respectively, which can move into contact with and away from the car guide rails 3, respectively. The car 2 is forcibly braked through contact of the respective wedges with the car guide rails 3.

[0013] A car shock absorber (not shown) for preventing the car 2 from directly colliding with a bottom within the hoistway 1 to absorb a shock caused to the car 2, and a counterweight shock absorber (not shown) for preventing the counterweight 4 from directly colliding with the bottom within the hoistway 1 to absorb a shock caused to the counterweight 4 are installed at the bottom within the hoistway 1. A maximum value of the speed at which the car 2 is allowed to run at the time of a collision is set as an allowable collision speed in the car shock absorber, and a maximum value of the speed at which the counterweight 4 is allowed to run at the time of a collision is set as an allowable collision speed in the counterweight shock absorber.

[0014] A speed governor 14 including a speed governor sheave 13 is provided in the upper portion of the hoistway 1. A tension pulley (not shown) is provided in a lower portion of the hoistway 1. A speed governor rope 15 is looped between the speed governor sheave 13 and the tension pulley. The speed governor rope 15 is connected at one end thereof and the other end thereof to one of the emergency stop devices 12 via a connecting rod 16. Thus, the speed governor rope 15 is moved as the car 2 is moved, so the speed governor sheave 13 is rotated in accordance with the speed of the car 2.

[0015] The speed governor 14 is provided with a speed detector (e.g., rotary encoder) 17 for generating a signal corresponding to rotation of the speed governor sheave 13. Information from the speed detector 17 is transmitted to a safety device 18 of an elevator.

[0016] The safety device 18 calculates a speed of the car 2 based on the information from the speed detector 17. A first overspeed detection level for detecting a first overspeed of the car 2 and a second overspeed detection level for detecting a second overspeed of the car 2 are set beforehand in the safety device 18 in accordance with the position of the car 2. The second overspeed detection level is set higher than the first overspeed detection level. The safety device 18 outputs an actuation signal to the hoisting machine brake device 10 when the speed of the car 2 exceeds the first

overspeed detection level, and outputs an actuation signal to the speed governor 14 when the speed of the car 2 exceeds the second overspeed detection level.

[0017] The hoisting machine brake device 10 performs a braking operation upon receiving the actuation signal from the safety device 18. Rotation of the drive sheave 9 is controlled through the braking operation of the hoisting machine brake device 10.

[0018] The speed governor 14 performs an operation of gripping the speed governor rope 15 upon receiving the actuation signal from the safety device 18. The connecting rod 16 is pulled upward with respect to the car 2 through the gripping of the speed governor rope 15 by the speed governor 14, so braking operations of the respective emergency stop devices 12 are performed. The wedges come into contact with the car guide rails 3 respectively through the braking operations of the respective emergency stop devices 12, so the car 2 is stopped forcibly.

[0019] Due to at least either the braking of the drive sheave 9 by the hoisting machine brake device 10 or the braking of the car 2 by the respective emergency stop devices 12, the speed of the car 2 becomes equal to or lower than the allowable collision speed thereof before the car 2 reaches the position of the car shock absorber. That is, the safety device 18 controls the hoisting machine brake device 10 and the speed governor 14 respectively such that the speed of the car 2 becomes, in the event of an abnormality thereof, equal to or lower than the allowable collision speed set in the car shock absorber before the car 2 reaches the position of the car shock absorber.

[0020] Next, an operation will be described. During operation of the elevator, the speed of the car 2 is constantly detected by the speed detector 17. When the speed of the car 2 exceeds the first overspeed detection level, the braking operation of the hoisting machine brake device 10 is performed through the control performed by the safety device 18. Thus, rotation of the drive sheave 9 is braked.

[0021] When the speed of the car 2 further rises and exceeds the second overspeed detection level after having exceeded the first overspeed detection level, the speed governor rope 15 is gripped by the speed governor 14 through the control performed by the safety device 18. Thus, the connecting rod 16 is pulled upward and the braking operations of the respective emergency stop devices 12 are performed. Thus, the car 2 is stopped forcibly.

[0022] Next, a method of deriving the value of the first overspeed detection level will be described. Fig. 2 is a graph showing a relationship between the braking torque applied to the drive sheave 9 and time (i.e., changes in braking torque with time) after detection of a first overspeed of the car 2 by the safety device 18 of Fig. 1. As shown in Fig. 2, when the safety device 18 detects the first overspeed of the car 2, the braking operation of the hoisting machine brake device 10 is started. After that, no braking torque is generated before a time point T_1 following the lapse of an operation delay time period t_1 . A braking torque is generated at the time point T_1 and then rises continuously with the lapse of time. After that, the braking torque reaches a maximum value at a time point T_2 . The braking torque is held unchanged after having reached the maximum value.

[0023] Fig. 3 is a graph showing a relationship between a speed of the car 2 and a time (i.e., changes in the speed of car 2 with time) which has been calculated based on the relationship between the braking torque and the time of Fig. 2. As shown in Fig. 3, after the safety device 18 has detected the first overspeed of the car 2, no braking torque is generated to be applied to the drive sheave 9 before the time point T_1 , so the speed of the car 2 continues to rise. A braking torque is generated to be applied to the drive sheave 9 after the time point T_1 , so the car 2 starts decelerating.

[0024] In this case, before the time point T_2 at which the braking torque reaches the maximum value, the braking torque applied to the drive sheave 9 rises continuously with the lapse of time, so the deceleration of the car 2 also increases continuously. After the time point T_2 , the braking torque is held at the maximum value, so the deceleration of the car 2 is constant. At a time point T_3 , the car 2 is stopped from moving.

[0025] To derive the first overspeed detection level, changes in braking torque with time as shown in Fig. 2 are first calculated from mechanical specifications of the hoisting machine brake device 10 and the car 2 such as the weights thereof. In this case, the changes in braking torque with time are calculated under a load condition of the car 2 where the car 2 is most unlikely to be decelerated. After that, a simplified relationship for approximation between braking torque and time (i.e., changes for approximation in braking torque with time) is calculated according to a preset method, based on the calculated changes in braking torque with time.

[0026] Fig. 4 is a graph showing the relationship between braking torque and time of Fig. 2 and the relationship for approximation between braking torque and time together. As shown in Fig. 4, in the relationship for approximation between braking torque and time, the braking torque is 0 from a time point when the safety device 18 detects the first overspeed of the car 2 to a time point T_4 following the lapse of an operation delay time period t_1 , rises instantaneously from 0 to a maximum value at the time point T_4 , and is held at the maximum value after the time point T_4 (as indicated by broken lines in Fig. 4). That is, the relationship for approximation between braking torque and time, according to which the braking torque is raised instantaneously from 0 to the maximum value at the time point T_4 following the lapse of the operation delay time t_1 , is calculated. The method of calculating the relationship for approximation between braking torque and time is not limited to the method indicated by the broken lines of Fig. 4. For example, the braking torque may be raised instantaneously in a plurality of stages in the course of changing from 0 to the maximum value.

[0027] After that, a speed of the car 2 and an acceleration of the car 2 are calculated in relation to time, based on the

relationship for approximation between braking torque and time. Fig. 5 is a graph showing a relationship between the speed of the car 2 and time, which has been calculated based on the relationship for approximation between braking torque and time of Fig. 4. Fig. 6 is a graph showing a relationship between the acceleration of the car 2 and time, which has been calculated based on the relationship for approximation between braking torque and time of Fig. 4. As shown in Figs. 5 and 6, the speed of the car 2 rises linearly at a constant acceleration a_1 from the time point when the safety device 18 detects the first overspeed of the car 2 to the time point T_4 following the lapse of the operation delay time period t_1 , and falls linearly at a constant acceleration a_2 after the time point T_4 . After that, the car 2 is stopped at the time point T_3 following the lapse of a time period t_2 .

[0028] After the relationship between the speed of the car 2 and time and the relationship between the acceleration of the car 2 and time have been calculated, a first overspeed detection level v_0 is calculated as a function of a position x_0 of the car 2 such that the speed at which the car 2 runs upon reaching the position of the car shock absorber becomes equal to an allowable collision speed (predetermined value) v_t of the car shock absorber.

[0029] More specifically, two cases are taken into account separately. In the first case, the car 2 collides with the car shock absorber between the time point when the safety device 18 detects the first overspeed of the car 2 and a time point when a braking torque is generated to be applied to the drive sheave 9. In the second case, the car 2 collides with the car shock absorber after the braking torque has been generated to be applied to the drive sheave 9.

[0030] In the case where the car 2 collides with the car shock absorber before the braking torque is generated to be applied to the drive sheave 9, the car 2 collides with the car shock absorber without being braked. Accordingly, a relationship expressed by a formula (1) is established given that (x_{01}, v_{01}) denotes a position and a speed of the car 2 at the time point when the safety device 18 detects the first overspeed of the car 2 and that t_1 denotes a time period from the time point when the safety device 18 detects the first overspeed of the car 2 to a time point when the car 2 collides with the car shock absorber.

[0031]

$$(x_{01} - (v_{01} \cdot t_1' + 1/2 \cdot a_1 \cdot t_1'^2), v_{01} + a_1 \cdot t_1') = (0, v_t) \dots (1)$$

[0032] When t_1 in the formula (1) is eliminated to calculate v_{01} as a function of x_{01} , a formula (2) is established.

[0033]

$$v_{01}(x_{01}) = (-2 \cdot a_1 \cdot x_{01} + v_t^2)^{0.5} \dots (2)$$

[0034] In the case where the car 2 collides with the car shock absorber after the braking torque has been generated to be applied to the drive sheave 9, a relationship expressed by a formula (3) is established given that t_2 denotes a time period from a time point when the braking torque is generated to the time point when the car 2 collides with the car shock absorber.

[0035]

$$(x_1 - (v_1 \cdot t_2' + 1/2 \cdot a_2 \cdot t_2'^2), v_1 + a_2 \cdot t_2') = (0, v_t) \dots (3)$$

[0036] A relationship expressed by a formula (4) is established given that (x_{02}, v_{02}) denotes a position and a speed of the car 2 at the time point when the safety device 18 detects the first overspeed of the car 2 and that (x_1, v_1) denotes a position and a speed of the car 2 at the time point when the braking torque is generated.

[0037]

$$(x_1, v_1) = (x_{02} - (v_{02} \cdot t_1 + 1/2 \cdot a_1 \cdot t_1^2), v_{02} + a_1 \cdot t_1) \dots (4)$$

[0038] When t_2 and (x_1, v_1) in the formulae (3) and (4) are eliminated to calculate v_{02} as a function of x_{02} , a formula (5) is established.

[0039]

$$v_{02}(x_{02}) = (a_2^2 \cdot t_1^2 - 2 \cdot a_2 \cdot x_{02} - a_2 \cdot a_1 \cdot t_1^2 + v_t^2)^{0.5} + a_2 \cdot t_1 - a_1 \cdot t_1 \dots$$

(5)

[0040] The first overspeed detection level v_0 is calculated as a function of the position x_0 of the car 2 through the foregoing procedure, as expressed by a formula (6) shown below.

[0041]

$$v_0(x_0) = \text{Max}\{v_{01}(x_0), v_{02}(x_0)\} \dots \quad (6)$$

[0042] It should be noted that the formula (6) means the larger one of the values $v_{01}(x_0)$ and $v_{02}(x_0)$.

[0043] In a case where a difference between a normal speed pattern of the car 2 running normally toward a car stop position at a lowest floor and the first overspeed detection level v_0 calculated according to the aforementioned method is small and the hoisting machine brake device 10 may be actuated erroneously due to, for example, a rise in speed resulting from the wobbling of the car 2, a detection error in the speed detector 17, a predetermined additional value is added to the first overspeed detection level v_0 to calculate the first overspeed detection level as a final value, with a view to preventing the hoisting machine brake device 10 from being actuated erroneously.

[0044] Fig. 7 is a graph showing a relationship between the first overspeed detection level and the position of the car 2, which has been calculated based on the relationship for approximation between braking torque and time of Fig. 4. As shown in Fig. 7, a variable overspeed detection value interval (predetermined interval) in which the value of a first overspeed detection level 30 decreases as the car 2 approaches the position of the car shock absorber, and a constant overspeed detection value interval in which the value of the first overspeed detection level 30 is held constant regardless of the position of the car 2 are set within the hoistway 1. The constant overspeed detection value interval is adjacent to the variable overspeed detection value interval.

[0045] The value of the first overspeed detection level 30 in the variable overspeed detection value interval is calculated according to the aforementioned method. Curves 20 to 23 represent changes in the speed of the car 2 in the cases where the speed of the car 2 exceeds the first overspeed detection level 30 at four different positions in the variable overspeed detection value interval, respectively. Each of all the curves 20 to 23 indicates the allowable car collision speed of the car shock absorber at the position of the car shock absorber. Accordingly, the speed of the car 2 is equal to the allowable car collision speed of the car shock absorber when the car 2 reaches the position of the car shock absorber.

[0046] In the elevator apparatus structured as described above, the first overspeed detection level for starting the braking operation of the hoisting machine brake device 10 is set beforehand in the safety device 18 in accordance with the position of the car 2, and the value of the first overspeed detection level in the predetermined interval from the car shock absorber is set such that the speed of the car 2 becomes equal to the allowable car collision speed at the position of the car shock absorber. Therefore, the speed at which the car 2 runs at the time of a collision with the car shock absorber can be prevented from being dispersed. Accordingly, the performance of the car shock absorber can be brought out efficiently, and the allowable car collision speed of the car shock absorber can be set low. Thus, the car shock absorber can be reduced in size, so the hoistway 1 can be reduced in size.

[0047] The car 2 is braked through the braking operation of the hoisting machine brake device 10. Therefore, the speed of the car 2 can be reduced to the allowable collision speed of the car shock absorber at the position of the car shock absorber, through the braking of the car 2 by the existing braking device.

[0048] The car 2 is braked through the braking operations of the emergency stop devices 12. Therefore, even in the case where, for example, the main ropes 11 for suspending the car 2 have been ruptured, the car 2 can be stopped more reliably.

Embodiment 2

[0049] Fig. 8 is a schematic diagram showing an elevator apparatus according to Embodiment 2 of the present invention. Referring to Fig. 8, the car 2 is provided with a speed detector (e.g., a linear encoder) 31 for detecting a speed of the car 2. Information (an electric signal) from the speed detector 31 is transmitted to the safety device 18.

[0050] The safety device 18 calculates the speed of the car 2 based on the information from the speed detector 31. A first overspeed detection level calculated in the same manner as in Embodiment 1 of the present invention and a second overspeed detection level higher than the first overspeed detection level are set beforehand in the safety device 18 in accordance with the position of the car 2. In addition, the safety device 18 outputs an actuation signal to the hoisting

machine brake device (first braking device) 10 when the speed of the car 2 exceeds the first overspeed detection level, and outputs an actuation signal to each of the emergency stop devices (second braking devices) 12 when the speed of the car 2 exceeds the second overspeed detection level.

[0051] The hoisting machine brake device 10 performs a braking operation upon receiving the actuation signal from the safety device 18. Rotation of the drive sheave 9 is braked through the braking operation of the hoisting machine brake device 10. Each of the emergency stop devices 12 performs a braking operation upon receiving the actuation signal from the safety device 18. Each of the wedges comes into contact with a corresponding one of the car guide rails 3 through the braking operation of a corresponding one of the emergency stop devices 12, so the car 2 is stopped forcibly. That is, the hoisting machine brake device 10 and each of the emergency stop devices 12 start the braking operations at the different overspeed detection levels respectively, so the car 2 is braked according to different methods. Embodiment 2 of the present invention is identical to Embodiment 1 of the present invention in other configurational details and other operational details.

[0052] Next, a method of deriving the value of the second overspeed detection level will be described. Fig. 9 is a graph showing a relationship between the braking force applied to the car 2 and time (i.e., changes in the braking force applied to car 2 with time) after detection of the second overspeed by the safety device 18. As shown in Fig. 9, when the safety device 18 detects the second overspeed of the car 2, the braking operation of the hoisting machine brake device 10 is started. After that, no braking force is generated before a time point T_{11} following the lapse of an operation delay time period t_{10} . A braking force is generated at the time point T_{11} and rises continuously with the lapse of time. After that, the braking force reaches a maximum value at a time point T_{12} . The braking force is held unchanged after having reached the maximum value.

[0053] Fig. 10 is a graph showing a relationship between the speed of the car 2 and time (i.e., changes in the speed of car 2 with time), which has been calculated based on the relationship between braking force and time of Fig. 9. As shown in Fig. 10, after the safety device 18 has detected the second overspeed of the car 2, no braking force is generated to be applied to the car 2 before the time point T_{11} , so the speed of the car 2 continues to rise. After the time point T_{11} , a braking force is generated to be applied to the car 2, so the car 2 starts decelerating abruptly.

[0054] In this case, before the time point T_{12} , the braking force applied to the car 2 rises continuously with the lapse of time, so the deceleration of the car 2 also increases continuously. After the time point T_{12} , the braking force is held at the maximum value, so the deceleration of the car 2 is constant. At a time point T_{13} , the car 2 is stopped from being moved.

[0055] To derive the second overspeed detection level, changes in braking force with time as shown in Fig. 9 are first calculated from mechanical specifications of the respective emergency stop devices 12 and the car 2 such as the weights thereof. In this case, the changes in braking force with time are calculated under a load condition of the car 2 where the car 2 is most unlikely to be decelerated. After that, a simplified relationship for approximation between braking force and time (i.e., changes for approximation in braking force with time) is calculated according to a preset method, based on the calculated changes in braking force with time.

[0056] Fig. 11 is a graph showing the relationship between braking force and time in Fig. 9 and the relationship for approximation between braking force and time together. As shown in Fig. 11, in the relationship for approximation between braking force and time, the braking force is 0 from a time point when the braking operations of the respective emergency stop devices 12 are started to a time point T_{14} following the lapse of an operation delay time period t_{11} , rises instantaneously from 0 to a maximum value at the time point T_{14} , and is held at the maximum value after the time point T_{14} (as indicated by broken lines in Fig. 11). That is, the relationship for approximation between braking force and time, according to which the braking force is raised instantaneously from 0 to the maximum value at the time point T_{14} following the lapse of the operation delay time period t_{11} , is calculated. The method of calculating the relationship for approximation between braking force and time is not limited to the method indicated by the broken lines of Fig. 11. For example, the braking force may be raised instantaneously in a plurality of stages in the course of changing from 0 to the maximum value.

[0057] After that, a speed of the car 2 and an acceleration of the car 2 are calculated in relation to time, based on the relationship for approximation between braking force and time. Fig. 12 is a graph showing a relationship between the speed of the car 2 and time, which has been calculated based on the relationship for approximation between braking force and time of Fig. 11. Fig. 13 is a graph showing a relationship between the acceleration of the car 2 and time, which has been calculated based on the relationship for approximation between braking force and time of Fig. 11. As shown in Figs. 12 and 13, the speed of the car 2 rises linearly at a constant acceleration a_{11} from the time point when the safety device 18 detects the second overspeed of the car 2 to the time point T_{14} following the lapse of the operation delay time period t_{11} , and falls linearly at a constant acceleration a_{12} after the time point T_{14} . After that, the car 2 is stopped at the time point T_{13} following the lapse of a time period t_{12} .

[0058] After the relationship between the speed of the car 2 and time and the relationship between the acceleration of the car 2 and time have been calculated, a second overspeed detection level v_{10} is calculated as a function of a position x_{10} of the car 2 such that the speed at which the car 2 runs upon reaching the position of the car shock absorber becomes equal to the allowable car collision speed (predetermined value) v_L .

[0059] More specifically, two cases are taken into account separately. In the first case, the car 2 collides with the car shock absorber between the time point when the safety device 18 detects the second overspeed of the car 2 and a time point when a braking force is generated to be applied to the car 2. In the second case, the car 2 collides with the car shock absorber after the braking force has been generated to be applied to the car 2.

[0060] In the case where the car 2 collides with the car shock absorber before the braking force is generated to be applied to the car 2, the car 2 collides with the car shock absorber without being braked. Accordingly, a relationship expressed by a formula (7) is established given that (x_{011}, v_{011}) denotes a position and a speed of the car 2 at the time point when the braking operations of the respective emergency stop devices 12 are started and that t_{11} denotes a time period from the time point when the braking operations of the respective emergency stop devices 12 are started to a time point when the car 2 collides with the car shock absorber.

[0061]

$$(x_{011} - (v_{011} \cdot t_{11}' + 1/2 \cdot a_{11} \cdot t_{11}'^2), v_{011} + a_{11} \cdot t_{11}') = (0, v_t) \dots$$

(7)

[0062] When t_{11} in the formula (7) is eliminated to calculate v_{011} as a function of x_{011} , a formula (8) is established.

[0063]

$$v_{011}(x_{011}) = (-2 \cdot a_{11} \cdot x_{011} + v_t^2)^{0.5} \dots (8)$$

[0064] In the case where the car 2 collides with the car shock absorber after the braking force has been generated to be applied to the car 2, a relationship expressed by a formula (9) is established given that t_{12} denotes a time period from a time point when the braking force is generated to the time point when the car 2 collides with the car shock absorber.

[0065]

$$(x_{11} - (v_{11} \cdot t_{12}' + 1/2 \cdot a_{12} \cdot t_{12}'^2), v_{11} + a_{12} \cdot t_{12}') = (0, v_t) \dots$$

(9)

[0066] A relationship expressed by a formula (10) is established given that (x_{012}, v_{012}) denotes a position and a speed of the car 2 at the time point when the safety device 18 detects the second overspeed of the car 2 and that (x_{11}, v_{11}) denotes a position and a speed of the car 2 at the time point when the braking force is generated.

[0067]

$$(x_{11}, v_{11}) = (x_{012} - (v_{012} \cdot t_{11} + 1/2 \cdot a_{11} \cdot t_{11}^2), v_{012} + a_{11} \cdot t_{11}) \dots$$

(10)

[0068] When t_{12} and (x_{11}, v_{11}) in the formulae (9) and (10) are eliminated to calculate v_{012} as a function of x_{012} , a formula (11) is established.

[0069]

$$v_{012}(x_{012}) =$$

$$(a_{12}^2 \cdot t_{11}^2 - 2 \cdot a_{12} \cdot x_{012} - a_{12} \cdot a_{11} \cdot t_{11}^2 + v_t^2)^{0.5} + a_{12} \cdot t_{11} - a_{11} \cdot t_{11} \dots (11)$$

[0070] The first overspeed detection level v_{10} is calculated as a function of the position x_{10} of the car 2 through the foregoing procedure, as expressed by a formula (12) shown below.

[0071]

$$v_{10}(x_{10}) = \text{Max}\{v_{011}(x_{10}), v_{012}(x_{10})\} \dots (12)$$

[0072] It should be noted that the formula (12) means the larger one of the values $v_{011}(x_{10})$ and $v_{012}(x_{10})$.

[0073] In a case where a difference between a first overspeed set pattern and the second overspeed detection level v_{10} calculated according to the aforementioned method is small and the respective emergency stop devices 12 may be actuated erroneously due to, for example, a rise in speed resulting from the wobbling of the car 2, a detection error in the speed detector 31, a predetermined additional value is added to the second overspeed detection level v_{10} to calculate the second overspeed detection level as a final value, with a view to preventing the respective emergency stop devices 12 from being actuated erroneously.

[0074] Fig. 14 is a graph showing a relationship between the second overspeed detection level and the position of the car 2, which has been calculated based on the relationship for approximation between braking force and time of Fig. 11. As shown in Fig. 14, a variable overspeed detection value interval (predetermined interval) in which the value of a second overspeed detection level 40 decreases as the car 2 approaches the position of the car shock absorber, and a constant overspeed detection value interval in which the value of the second overspeed detection level 40 is held constant regardless of the position of the car 2 are set within the hoistway 1. The constant overspeed detection value interval is adjacent to the variable overspeed detection value interval.

[0075] The value of the second overspeed detection level 40 in the variable overspeed detection value interval is calculated according to the aforementioned method. Curves 50 to 53 represent changes in the speed of the car 2 in the cases where the speed of the car 2 has exceeded the second overspeed detection level 40 at four different positions in the variable overspeed detection value interval, respectively. Each of all the curves 50 to 53 indicates the allowable car collision speed of the car shock absorber at the position of the car shock absorber. Accordingly, the speed of the car 2 is equal to the allowable car collision speed of the car shock absorber when the car 2 reaches the position of the car shock absorber. That is, the speed of the car 2 collides with the car shock absorber at the allowable car collision speed regardless of the position of the car 2 at the time point when the braking operations of the respective emergency stop devices 12 are started.

[0076] In the elevator apparatus structured as described above, the first overspeed detection level and the second overspeed detection level are set beforehand in the safety device 18, and the hoisting machine brake device 10 for starting the braking operation when the speed of the car 2 exceeds the first overspeed detection level and the emergency stop devices 12 for starting the braking operations when the speed of the car 2 exceeds the second overspeed detection level brake the car 2 according to different methods, respectively. Therefore, the car 2 can be braked according to different braking methods in accordance with the level of an abnormality in the speed of the car 2. As a result, the car 2 can be braked more reliably.

[0077] The car 2 is braked by the hoisting machine brake device 10 and the emergency stop devices 12, so the car 2 can be braked by the existing braking devices. As a result, the speed of the car 2 can be easily held equal to or lower than the allowable car collision speed at the position of the car shock absorber.

Claims

1. An elevator apparatus, comprising:

a car that is raised and lowered within a hoistway;
 a shock absorber for the car which is provided at a bottom within the hoistway;
 a braking device for braking a movement of the car; and
 a safety device for operating the braking device when there is an abnormality in a speed of the car so that the speed of the car becomes equal to or lower than an allowable collision speed of the shock absorber before the car reaches a position of the shock absorber, and wherein:

the safety device has an overspeed detection level set therein beforehand in accordance with a position of the car;

the safety device starts an operation of the braking device when the speed of the car exceeds the overspeed detection level; and

the overspeed detection level has a value that is set such that the speed of the car becomes equal to a predetermined value at the position of the shock absorber through braking of the car by the braking device,

in a predetermined interval from the position of the shock absorber.

5 2. An elevator apparatus according to Claim 1, further comprising
a hoisting machine having a drive sheave around which a main rope for suspending the car is looped, for raising
and lowering the car through rotation of the drive sheave, and wherein
the braking device is a hoisting machine brake device for braking rotation of the drive sheave.

10 3. An elevator apparatus according to Claim 1, wherein the braking device is an emergency stop device mounted on
the car to brake the movement of the car through contact of a braking member with a guide rail for guiding the car.

15 4. An elevator apparatus according to Claim 1, wherein:

the braking device has a first braking device and a second braking device for braking the car according to
mutually different methods;

the overspeed detection level is composed of a first overspeed detection level and a second overspeed detection
level set higher than the first overspeed detection level; and

the safety device starts an operation of the first braking device when the speed of the car exceeds the first
overspeed detection level, and starts an operation of the second braking device when the speed of the car
exceeds the second overspeed detection level.

20 5. An elevator apparatus according to Claim 4, further comprising
a hoisting machine having a drive sheave around which a main rope for suspending the car is looped, for raising
and lowering the car through rotation of the drive sheave, and wherein:

25 the first braking device is a hoisting machine brake device for braking rotation of the drive sheave; and
the second braking device is an emergency stop device mounted on the car to brake the movement of the car
through contact of a braking member with a guide rail for guiding the car.

FIG. 1

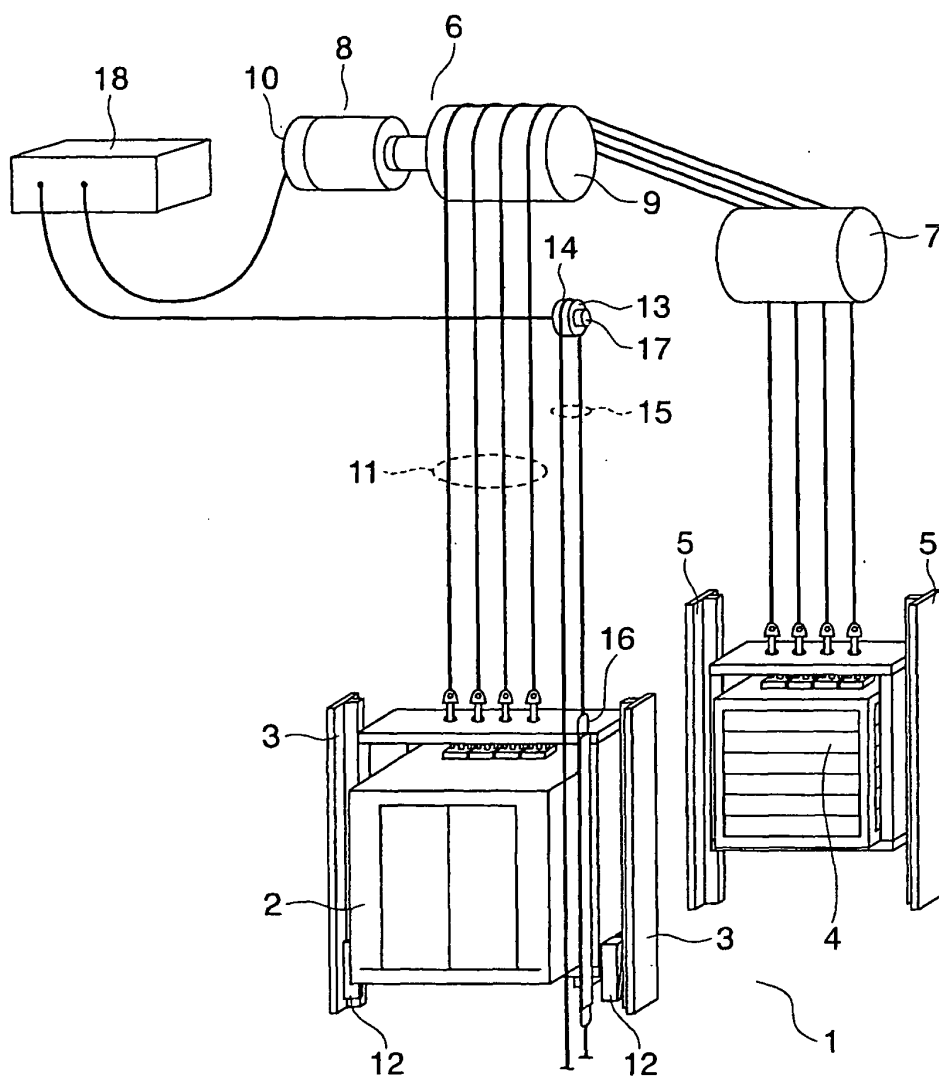


FIG. 2

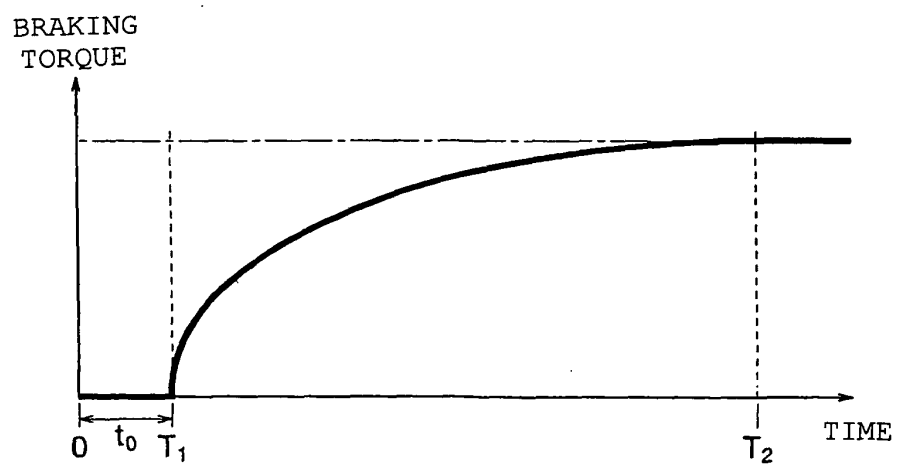


FIG. 3

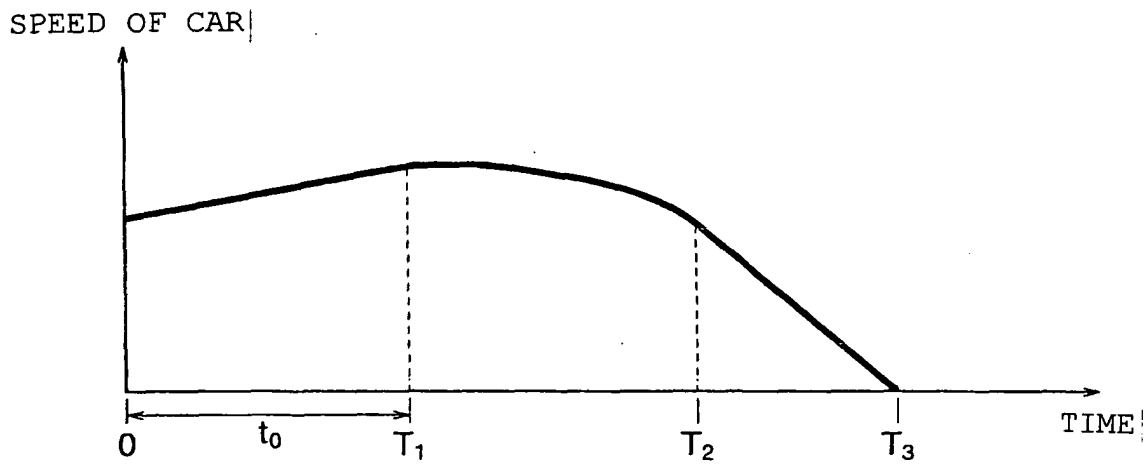


FIG. 4

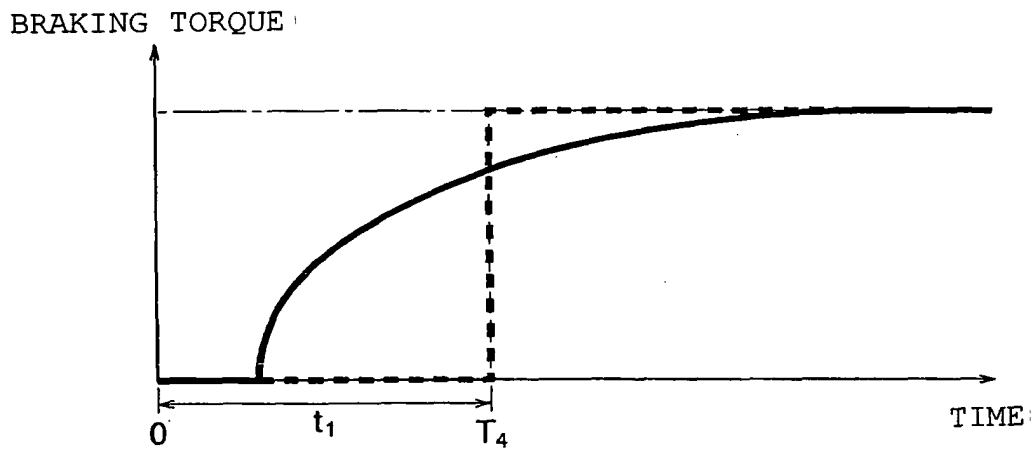


FIG. 5

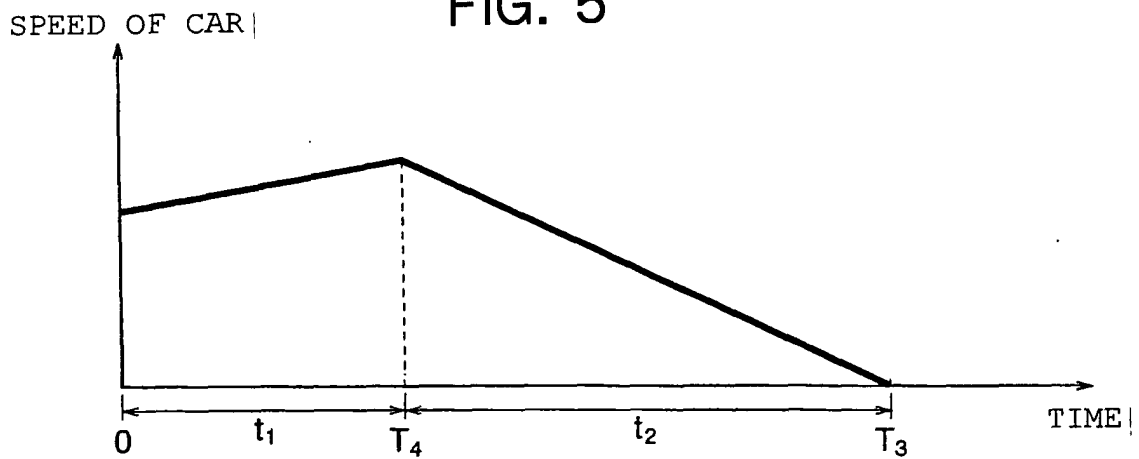


FIG. 6

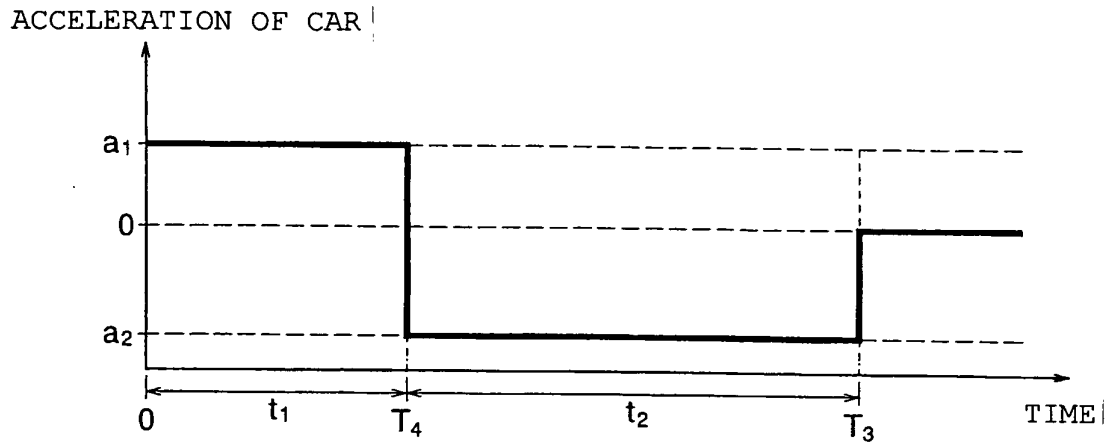


FIG. 7

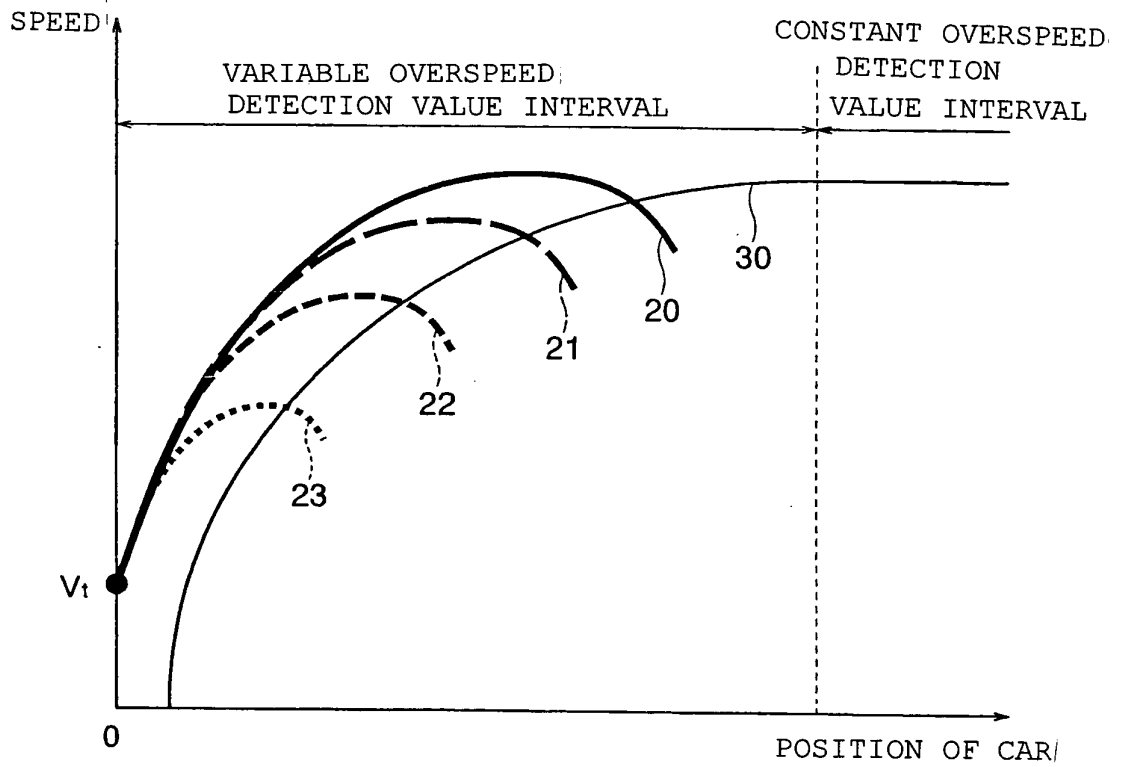


FIG. 8

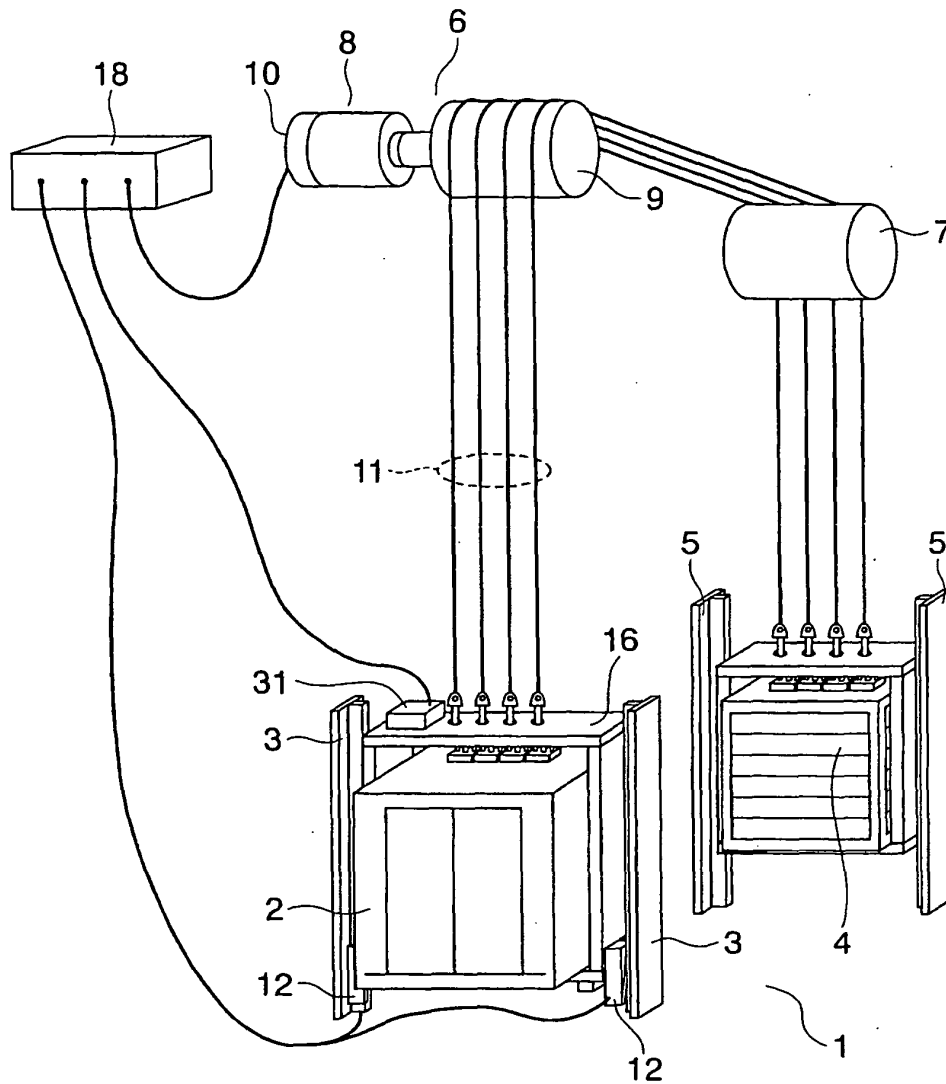


FIG. 9

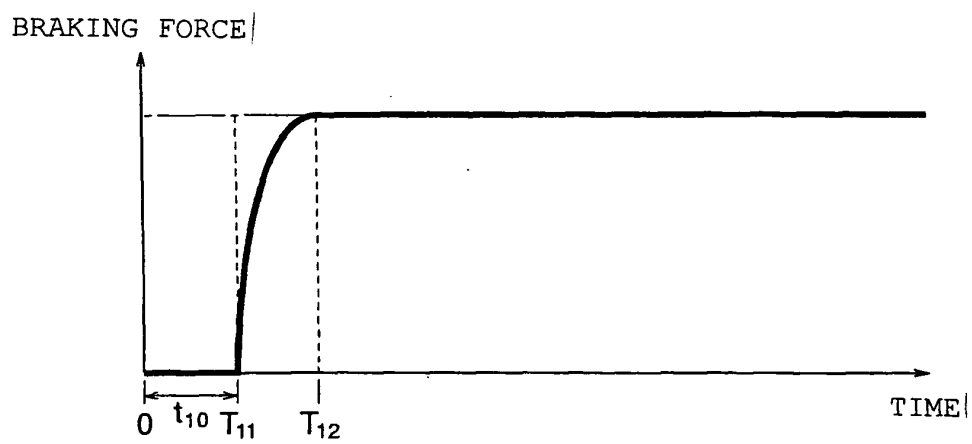


FIG. 10

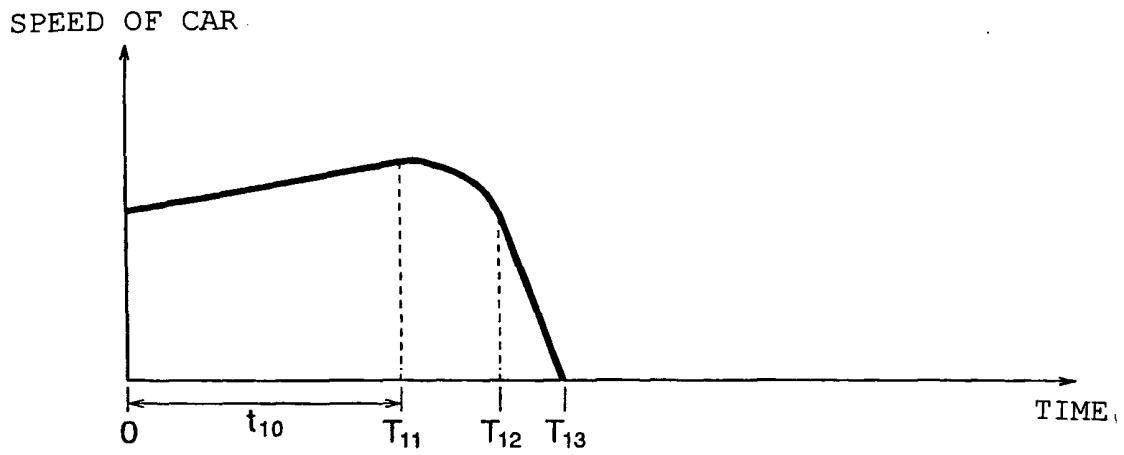


FIG. 11

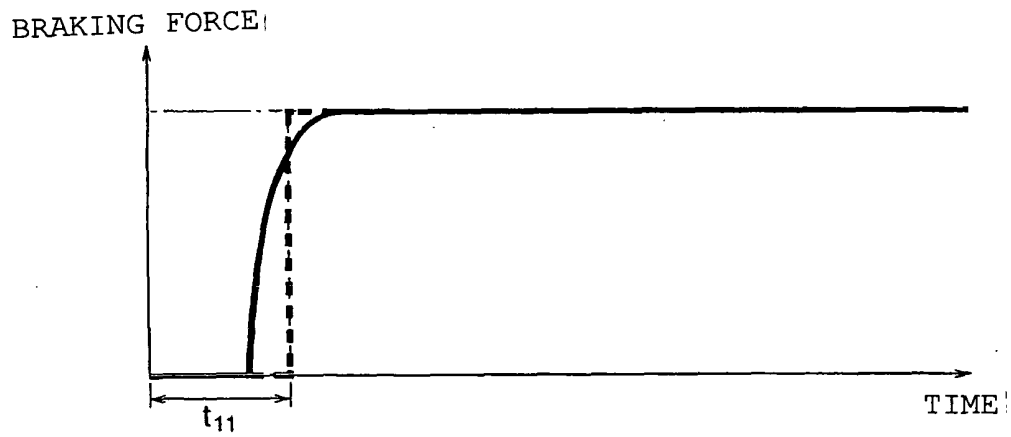


FIG. 12

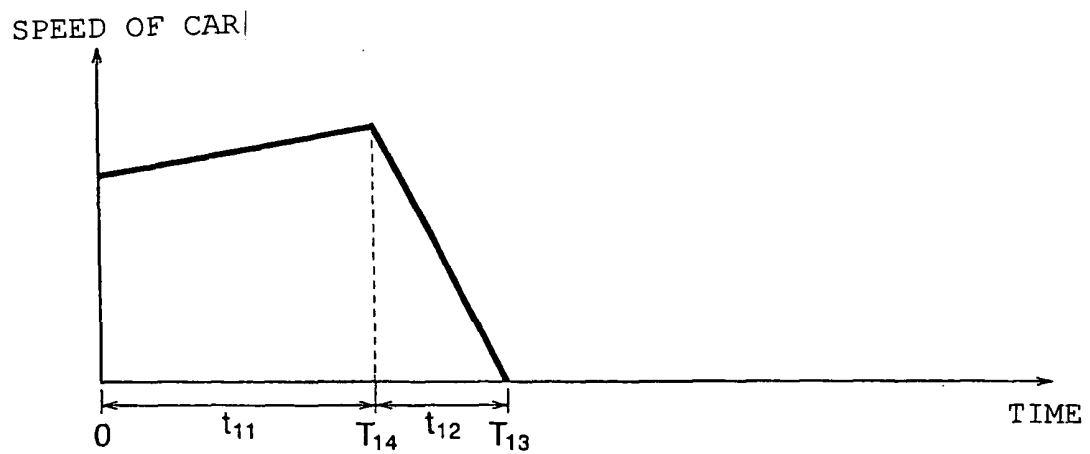


FIG. 13

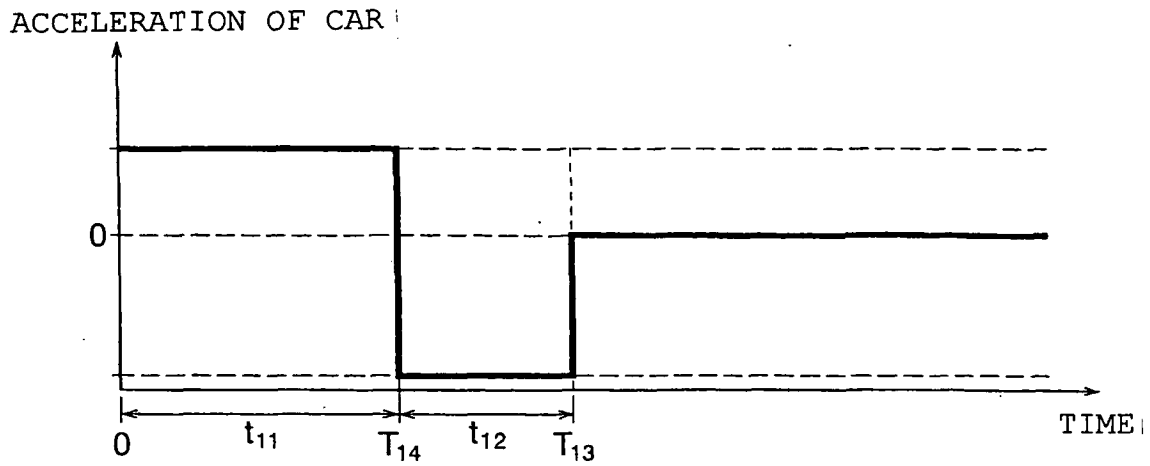
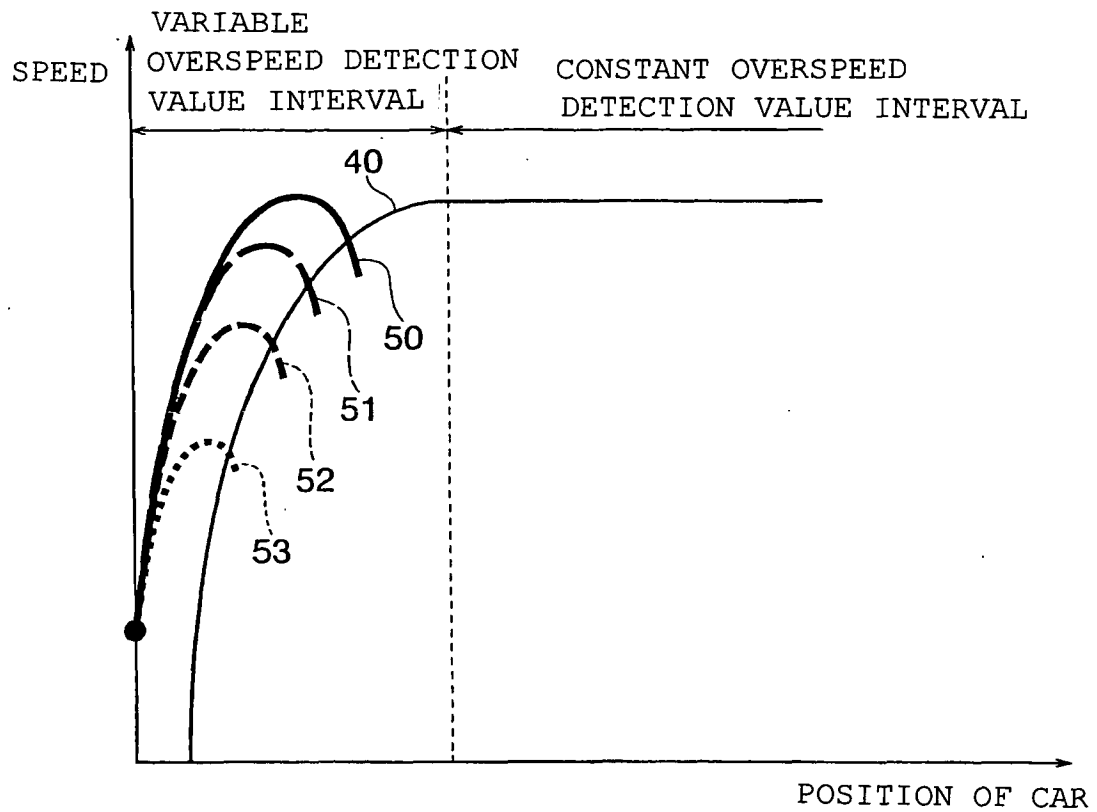


FIG. 14



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/307085

A. CLASSIFICATION OF SUBJECT MATTER

B66B5/06 (2006.01), **B66B1/32** (2006.01)

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)

B66B1/00 (2006.01) - **B66B5/28** (2006.01)

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

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Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006

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.
X	WO 2004/031064 A1 (Hitachi, Ltd.), 15 April, 2004 (15.04.04), Pay attention to Claims (Family: none)	1-5
X Y	JP 2004-137055 A (Toshiba Elevator and Building Systems Corp.), 13 May, 2004 (13.05.04), Pay attention to Prior Art (Family: none)	1-2 3-5
Y	WO 2004/083091 A1 (Mitsubishi Electric Corp.), 30 September, 2004 (30.09.04), Pay attention to Mode for carrying out the invention 2 (Family: none)	3-5

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

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"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
13 July, 2006 (13.07.06)Date of mailing of the international search report
25 July, 2006 (25.07.06)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

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REFERENCES CITED IN THE DESCRIPTION

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