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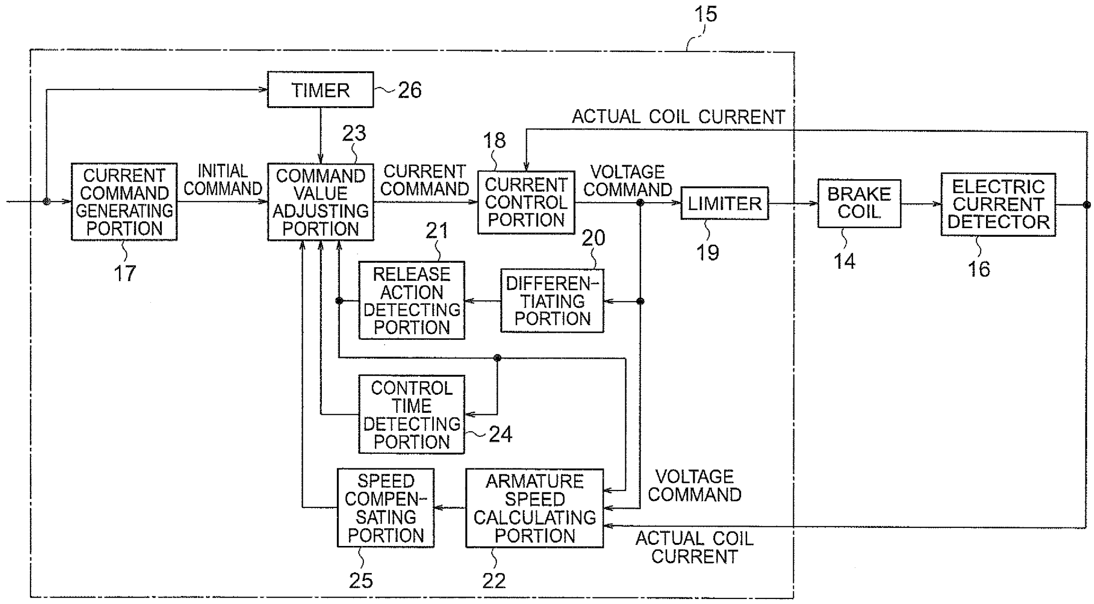
(54) **SOLENOID BRAKE CONTROL DEVICE**

(57) In an electromagnetic brake control apparatus, a control apparatus main body releases an electromagnetic braking apparatus by exciting a brake coil to attract an armature to the brake coil. The control apparatus main body can detect commencement of a release action of the armature by attraction by the brake coil and can ascertain a speed of the armature during the release action, and changes an attractive force that arises in the brake coil while making the speed of the armature track a preset target speed when commencement of the release action is detected.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present invention relates to an electromagnetic brake control apparatus that controls an excitation state of a brake coil in an electromagnetic braking apparatus such as an elevator braking apparatus, for example.

BACKGROUND ART

[0002] In conventional electromagnetic braking apparatuses, attempts have been made to reduce collision noise that arises when an armature collides with an electromagnetic field during brake release using an excitation current command means that increases a brake coil excitation current command gradually until a preset value is reached (see Patent Literature 1, for example),

[Patent Literature 1]

[0003] Japanese Patent Laid-Open No. HEI 9-267982 (Gazette)

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004] However, in conventional electromagnetic braking apparatuses such as that described above, since the brake coil excitation current is merely increased gradually, release action time becomes quite long if electromagnets are used that have a large time constant. Since irregularities in gaps between the electromagnets and the armature, irregularities in spring forces from braking springs, irregularities in electromagnetic characteristics, and age-related changes therein, etc., have also not been taken into consideration, it has not been possible to achieve stable reductions in collision noise.

[0005] The present invention aims to solve the above problems and an object of the present invention is to provide an electromagnetic brake control apparatus that can reduce collision noise stably during brake release while suppressing lengthening of brake release action time, and can perform a brake release action more reliably.

MEANS FOR SOLVING THE PROBLEM

[0006] In order to achieve the above object, according to one aspect of the present invention, there is provided an electromagnetic brake control apparatus that includes a control apparatus main body that releases an electromagnetic braking apparatus by exciting a brake coil to attract an armature to the brake coil, the electromagnetic brake control apparatus being **characterized in that:** the control apparatus main body can detect commencement of a release action of the armature by attraction by the brake coil and can ascertain a speed of the armature during the release action, and changes an attractive force that arises in the brake coil while making the speed of the armature track a preset target speed when commencement of the release action is detected.

EFFECTS OF THE INVENTION

[0007] In an electromagnetic brake control apparatus of this kind, because commencement of the release action of the armature due to attraction by the brake coil is detectable, and the speed of the armature during the release action is ascertainable, and the attractive force that arises in the brake coil can be reduced while tracking the speed of the armature to a preset target speed when commencement of the release action is detected, collision noise can be reduced stably during brake release in any electromagnetic braking apparatus while suppressing lengthening of brake release action time. By making the speed of the armature track the target speed, the brake release action can also be performed more reliably.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Figure 1 is a schematic structural diagram that shows an elevator apparatus according to Embodiment 1 of the present invention;
Figure 2 is a block diagram that shows a configuration of a control apparatus main body from Figure 1;
Figure 3 is a flowchart that shows action of the control apparatus main body from Figure 1 during brake release;
Figure 4 is a block diagram that shows a control apparatus main body of an elevator apparatus according to Embodiment 2 of the present invention; and
Figure 5 is a flowchart that shows action of the control apparatus main body from Figure 4 during brake release.

BEST MODE FOR CARRYING OUT THE INVENTION

[0009] Preferred embodiments of the present invention will now be explained with reference to the drawings.

Embodiment 1

[0010] Figure 1 is a schematic structural diagram that shows an elevator apparatus according to Embodiment 1 of the present invention. In the figure, a car 1 and a counterweight 2 are suspended inside a hoistway by a main rope 3, and are raised and lowered inside the hoistway by a driving force from a hoisting machine 4.

[0011] A hoisting machine 4 has: a drive sheave 5 onto which a main rope 3 is wound; a motor 6 that rotates the drive sheave 5; a brake drum 7 that functions as a brake rotating body that is rotated together with the drive sheave 5 together with motion of the car 1; and an electromagnetic braking apparatus 8 that brakes rotation of the first drive sheave 5.

[0012] The electromagnetic braking apparatus 8 has: a brake shoe 9 that can be placed in contact with and separated from the brake drum 7; an armature 10 that is connected to the brake shoe 9; a braking spring 11 that presses the brake shoe 9 against the brake drum 7; an electromagnet 12 that is disposed so as to face the armature 10 and that generates electromagnetic attraction that acts against the braking spring 11 and separates the brake shoe 9 from the brake drum 7; and a release detecting switch 13 that detects if the armature 10 has been displaced to a fully released position. A brake coil 14 is disposed on the electromagnet 12.

[0013] An excitation state of the brake coil 14 is controlled by a control apparatus main body 15. A detection signal from an electric current detector 16 for detecting an electric current value (an actual current value) that is passed to the brake coil 14 is input into the control apparatus main body 15.

[0014] Figure 2 is a block diagram that shows a configuration of the control apparatus main body 15 from Figure 1. In the figure, a current command generating portion 17 generates a current command for flowing a current to the brake coil 14 as an initial command in response to a brake release command. The current command from the current command generating portion 17 and the detection signal from the electric current detector 16 are input into a current control portion 18. The current control portion 18 generates a voltage command for applying a voltage to the brake coil 14 such that the actual current value in the brake coil 14 matches the value of the current command.

[0015] The voltage command from the current control portion 18 is input into the brake coil 14 by means of a limiter 19. The value of the voltage command from the current control portion 18 is differentiated by a differentiating portion 20, and is input into a release action detecting portion 21. In addition, the voltage command from the current control portion 18 and the detection signal from the electric current detector 16 are input into an armature speed calculating portion 22.

[0016] The release action detecting portion 21 detects commencement of a release action (displacement) of the armature 10 by comparing output from the differentiating portion 20 with a preset threshold value. Specifically, the release action detecting portion 21 detects the release action of the armature 10 based on time variations in the value of the voltage command.

[0017] When the release action of the armature 10 is detected, that information is input into the armature speed calculating portion 22, a command value adjusting portion 23, and a control time detecting portion 24 from the release action detecting portion 21.

[0018] The armature speed calculating portion 22 calculates a value for speed of the armature 10 after the release action based on information from each of the release action detecting portion 21, the current control portion 18, and the electric current detector 16 and sends it to a speed compensating portion 25. Specifically, the armature speed calculating portion 22 calculates the value of the speed of the armature 10 based on both the value of the voltage command and the actual current value of the brake coil 14 when commencement of the release action is detected by the release action detecting portion 21.

[0019] The speed compensating portion 25 sends a signal to the command value adjusting portion 23 that corresponds to a difference between output from the armature speed calculating portion 22 and a preset target speed. The target speed is set so as to reduce the speed immediately before the armature 10 contacts the electromagnet 12.

[0020] Based on information from both the release action detecting portion 21 and the speed compensating portion 25, the command value adjusting portion 23 changes the value of the current command (the initial command) that the current command generating portion 17 has generated and sends it to the current control portion 18. Specifically, the command value adjusting portion 23 changes the value of the current command (the initial command) such that output from the speed compensating portion 25 is reduced when commencement of the release action is detected by the release action detecting portion 21. In other words, when commencement of the release action is detected, the command value adjusting portion 23 changes the attractive force that is generated in the brake coil 14 while making the speed of the armature 10 track the target speed. In this example, when commencement of the release action is detected, the attractive force that is generated in the brake coil 14 is reduced more than before commencement of the release action.

[0021] The control time detecting portion 24 counts time from the commencement of the release action of the armature 10 (control time). A timer 26 also counts time from when excitation of the brake coil 14 is commenced in response to a brake release command.

[0022] The control apparatus main body 15 stops adjustment of the current command by the command value adjusting portion 23 and generates a pre-reduction attractive force in the brake coil 14 when a preset time T_{end} elapses from the commencement of excitation of the brake coil 14. The control apparatus main body 15 also stops adjustment of the current command by the command value adjusting portion 23 and generates a pre-reduction attractive force in the brake coil 14 when a preset time T_{cend} elapses from commencement of the release action of the armature 10.

[0023] The control apparatus main body 15 is disposed on an elevator control apparatus that controls running of the car 1. The elevator control apparatus includes a control board (not shown) that has: a data processing portion (CPU); a storage portion (ROM, RAM, hard disk, etc.); and a signal input-output portion. The functions of the control apparatus main body 15 are implemented by this control board. For that purpose, programs for implementing the above functions are stored in the storage portion of the control board.

[0024] Next, action will be explained. Figure 3 is a flowchart that shows action of the control apparatus main body 15 from Figure 1 during brake release. When doors of the car 1 are closed and preparation for the commencement of raising or lowering is completed, a brake release command is input into the control apparatus main body 15. An initial command I_0 is thereby sent from the current command generating portion 17 to the command value adjusting portion 23 as a current command. Then, when the initial command I_0 is input into the command value adjusting portion 23, the value of the initial command I_0 is output without modification from the command value adjusting portion 23 as a value I_p of the current command (Step S1). The timer 26 is reset simultaneously, and counting of time T from the commencement of excitation is commenced (Step S2).

[0025] Next, a voltage command is generated by the current control portion 18 such that the actual current value I of the brake coil 14 matches the value I_p of the current command (Step S3). Here, if we let proportional gain be K_p, and integrated gain be K_i, then the value u of the voltage command can be obtained from the following expression, for example:

[0026]

$$u = K_p \cdot (I_p - I) + K_i \cdot \int (I_p - I)dt \quad \ldots \quad (1)$$

[0027] Here, for circuit protection, the voltage command that is input into the brake coil 14 is limited to less than an upper limit U_{max} in the limiter 19 ($0 < u < u_{max}$). When the voltage command is input into the brake coil 14, the actual current I to the coil is increased at a certain time constant, and the value u of the voltage command is gradually reduced in accordance with Expression (1).

[0028] Then, when the actual current to the coil is increased and the attractive force that is generated in the brake coil 14 subsequently overcomes the spring force from the braking spring 11, the release action of the armature 10 is commenced. At this point, an inductive electromotive force is generated in a direction that impedes flux change (in this case, in a direction in which the voltage command increases). Consequently, during commencement of the release action of the armature 10, the differentiated value that is output from the differentiating portion 20 shifts from negative to positive.

[0029] The differentiated value that is found by the differentiating portion 20 is compared with a preset threshold value a (> 0) by the release action detecting portion 21 (Step S4). When the differentiated value exceeds the threshold value a, a release action commencement detection signal is output by the release action detecting portion 21. The control time detecting portion 24 is thereby reset, and counting of time T_c from the commencement of the release action of the armature 10 is commenced (Step S5). Moreover, at that point, time T from the commencement of excitation is $T + \delta T$.

[0030] When the armature speed calculating portion 22 receives the release action commencement detection signal, speed V_{est} of the armature 10 is calculated by the armature speed calculating portion 22 based on the value u of the voltage command and the actual current value I of the brake coil 14 (Step S6). Here, if we let an inductance model value be L, a coil resistance value be R, and a correction factor be K_n, then the speed V_{est} of the armature 10 can be obtained from the following expression, for example:

[0031]

$$V_{est} = K_n\{u - R \cdot I - L \cdot dI/dt\} \quad \ldots \quad (2)$$

[0032] The output from the armature speed calculating portion 22 is sent to the speed compensating portion 25. A corrected current δ_i, which is a signal that corresponds to a difference between the speed V_{est} of the armature 10 and a preset target speed value V_0, is thereby output by the speed compensating portion 25 (Step S7). Here, if we let a feedback coefficient be K_i, then the corrected current δ_i can be obtained from the following expression, for example:

[0033]

$$\delta_i = K_I(V_0 - V_{est}) \quad \ldots \quad (3)$$

[0034] When the command value adjusting portion 23 subsequently receives the corrected current δ_i, the value I_p of the current command is revised from the initial command value I_0 by the command value adjusting portion 23 so as to be smaller than the corrected current δ_i (Step S8). Here, the value I_p of the current command after revision can be obtained from the following expression, for example:

[0035]

$$I_p = I_0 - \delta_i \quad \ldots \quad (4)$$

[0036] When the value I_p of the current command is revised, the value u of the voltage command is revised in response to the value I_p of the current command by the current control portion 18 (Step S9). The electric current value is thereby reduced in such a way that the speed V_{est} of the armature 10 tracks the preset target speed V_0 after commencement of the release action of the armature 10. Consequently, impact force and collision noise are reduced when the armature 10 collides with the electromagnet 12. In contrast to that, the time until commencement of the release action is minimized by flowing current at a performance limit of the power source and the brake coil 14 until the armature 10 commences the release action. Moreover, for circuit protection, the voltage command that is input into the brake coil 14 is also limited here to less than an upper limit U_{max} in the limiter 19 ($0 < U < U_{max}$).

[0037] After the value u of the voltage command has been revised in response to the reduction in the value I_p of the current command, time T from the commencement of excitation is monitored to see whether it has reached T_{end} (Step S10), and time T_c from the commencement of the release action is monitored to see whether it has reached T_{cend} (Step S11). If either of the conditions $T > T_{end}$ or $T_c > T_{cend}$ is satisfied, then the value I_p of the current command is returned to the initial command value I_0 regardless of the state of the release action (Step S12).

[0038] The release detecting switch 13 is subsequently monitored to see whether it is switched on. When the release detecting switch 13 is switched on, it is deemed that the armature 10 has displaced to the released position and the release action has been completed, and the value I_p of the current command is switched to a holding current command value.

[0039] In an electromagnetic brake control apparatus of this kind, because commencement of the release action of the armature 10 due to attraction by the brake coil 14 is detectable, and the speed of the armature 10 during the release action is ascertainable, and the attractive force that arises in the brake coil 14 can be changed while tracking the speed of the armature 10 to a preset target speed when commencement of the release action is detected, collision noise can be reduced stably during brake release in any electromagnetic braking apparatus while suppressing lengthening of brake release action time. By making the speed of the armature 10 track the target speed, the brake release action can also be performed more reliably.

[0040] Because the control apparatus main body 15 has: an armature speed calculating portion 22 that calculates the speed of the armature 10 based on both the actual current value of the brake coil 14 and the value of the voltage command from the current control portion 18; and a speed compensating portion 25 that generates a corrected current that corresponds to a difference between the speed of the armature 10 and the preset target speed, the speed of the armature 10 can be ascertained easily. The speed of the armature 10 can also be made to track the target speed easily by controlling the value of the voltage command so as to reduce the corrected current.

[0041] Because the control apparatus main body 15 also has: a current command generating portion 17 that generates a current command in response to a brake release command; a current control portion 18 that generates a voltage command in such a way that the actual current value of the brake coil 14 matches the value of the current command; and a release action detecting portion 21 that detects the release action of the armature 10 based on changes in the value of the voltage command, commencement of the release action of the armature 10 can be detected more reliably and easily.

[0042] Because the value of the voltage command from the current control portion 18 is differentiated by the differentiating portion 20, and commencement of the release action is detected in the release action detecting portion 21 by comparing output from the differentiating portion 20 with a preset threshold value, commencement of the release action can be detected more reliably and easily. Moreover, detection of the release action of the armature 10 may also be performed by a sensor that can continuously detect action (displacement) of the armature 10.

[0043] Because the control apparatus main body 15 generates a pre-reduction attractive force in the brake coil 14 when a preset time T_{end} elapses from the commencement of excitation of the brake coil 14, the brake release action can be performed even more reliably even if an abnormality arises in the control that reduces the attractive force, enabling reliability to be improved further.

[0044] Because the control apparatus main body 15 generates a pre-reduction attractive force in the brake coil 14 when a preset time T_{cend} elapses from the commencement of the release action of the armature 10, the release action can thereby also be performed even more reliably, enabling reliability to be improved further.

Embodiment 2

[0045] Next, Figure 4 is a block diagram that shows a control apparatus main body of an elevator apparatus according to Embodiment 2 of the present invention. In Embodiment 1, the attractive force in the brake coil 14 was controlled by generating a current command, but in Embodiment 2, an attractive force in a brake coil 14 is controlled by generating a voltage command.

[0046] In the figure, a voltage command generating portion 31 generates a voltage command for applying a voltage to the brake coil 14 as an initial command in response to a brake release command. The voltage command is input into the brake coil 14 by means of a command value adjusting portion 36 and a limiter 19. A coil actual current value that is detected by an electric current detector 16 is differentiated by a differentiating portion 32 and input into a release action detecting portion 33. The voltage command from the command value adjusting portion 36 and the coil actual current value from the electric current detector 16 are input into an armature speed calculating portion 34.

[0047] The release action detecting portion 33 detects commencement of a release action of the armature 10 by comparing output from the differentiating portion 32 with a preset threshold value. Specifically, the release action detecting portion 33 detects the release action of the armature 10 based on time variations in the coil actual current value.

[0048] When the release action of the armature 10 is detected, that information is input into the armature speed calculating portion 34, the command value adjusting portion 36, and a control time detecting portion 24 from the release action detecting portion 33.

[0049] The armature speed calculating portion 34 calculates a value for speed of the armature 10 after the release action based on information from each of the release action detecting portion 33, the command value adjusting portion 36, and the electric current detector 16 and sends it to a speed compensating portion 35. Specifically, the armature speed calculating portion 34 calculates the value of the speed of the armature 10 based on both the value of the voltage command and the actual current value of the brake coil 14 when commencement of the release action is detected by the release action detecting portion 33. The speed compensating portion 35 sends a signal to the command value adjusting portion 36 that corresponds to a difference between output from the armature speed calculating portion 34 and a preset target speed.

[0050] Based on information from both the release action detecting portion 33 and the speed compensating portion 35, the command value adjusting portion 36 changes the value of the voltage command (the initial command) that the voltage command generating portion 31 has generated and sends it to the limiter 19. Specifically, the command value adjusting portion 36 changes the value of the voltage command (the initial command) such that output from the speed compensating portion 35 is reduced when commencement of the release action is detected by the release action detecting portion 33. In other words, when commencement of the release action is detected, the command value adjusting portion 36 changes the attractive force that is generated in the brake coil 14 while making the speed of the armature 10 track the target speed. In this example, when commencement of the release action is detected, the attractive force that is generated in the brake coil 14 is reduced more than before commencement of the release action.

[0051] The control time detecting portion 24 counts time from the commencement of the release action of the armature 10 (control time). A timer 26 also counts time from when excitation of the brake coil 14 is commenced in response to a brake release command.

[0052] The control apparatus main body 15 stops adjustment of the voltage command by the command value adjusting portion 36 and generates a pre-reduction attractive force in the brake coil 14 when a preset time T_{end} elapses from the commencement of excitation of the brake coil 14. The control apparatus main body 15 also stops adjustment of the voltage command by the command value adjusting portion 36 and generates a pre-reduction attractive force in the brake coil 14 when a preset time T_{cend} elapses from commencement of the release action of the armature 10.

Moreover, the overall configuration of the elevator apparatus is similar to that of Embodiment 1 (Figure 1).

[0053] Next, action will be explained. Figure 5 is a flowchart that shows action of the control apparatus main body 15 from Figure 4 during brake release. When doors of the car 1 are closed and preparation for the commencement of raising or lowering is completed, a brake release command is input into the control apparatus main body 15. An initial command u_0 is thereby sent from the voltage command generating portion 31 to the command value adjusting portion 36 as a voltage command. Then, when the initial command u_0 is input into the command value adjusting portion 36, the value of the initial command u_0 is output without modification from the command value adjusting portion 36 as a value u of the voltage command (Step S31). The timer 26 is reset simultaneously, and counting of time T from the commencement of excitation is commenced (Step S32).

[0054] For circuit protection, the voltage command that is input into the brake coil 14 is limited to less than an upper limit u_{max} in the limiter 19 ($0 < u < u_{max}$) (Step S33). When the voltage command is input into the brake coil 14, the actual current I to the coil is increased at a certain time constant.

[0055] Then, when the attractive force that is generated in the brake coil 14 subsequently overcomes the spring force from the braking spring 11, the release action of the armature 10 is commenced. At this point, an inductive electromotive force is generated in a direction that impedes flux change (in this case, in a direction in which the current value decreases). Consequently, during commencement of the release action of the armature 10, the differentiated value that is output from the differentiating portion 32 shifts from positive to negative.

[0056] The differentiated value that is found by the differentiating portion 32 is compared with a preset threshold value a (< 0) by the release action detecting portion 33 (Step S34). When the differentiated value becomes less than the threshold value a, a release action commencement detection signal is output by the release action detecting portion 33. The control time detecting portion 24 is thereby reset, and counting of time T_c from the commencement of the release action of the armature 10 is commenced (Step S35).

[0057] When the armature speed calculating portion 34 receives the release action commencement detection signal, speed V_{est} of the armature 10 is calculated by the armature speed calculating portion 34 based on the value u of the voltage command and the actual current value I of the brake coil 14 (Step S36). Here, if we let an inductance model value be L, a coil resistance value be R, and a correction factor be K_n, then the speed V_{est} of the armature 10 can be obtained from the following expression, for example:

[0058]

$$V_{est} = K_n\{u - R \bullet I - L \bullet dI/dt\} \quad \ldots \quad (5)$$

[0059] The output from the armature speed calculating portion 34 is sent to the speed compensating portion 35. A corrected voltage δ_u, which is a signal that corresponds to a difference between the speed V_{est} of the armature 10 and a preset target speed value V_0, is thereby output by the speed compensating portion 35 (Step S37). Here, if we let a feedback coefficient be K_I, then the corrected voltage δ_u can be obtained from the following expression, for example:

[0060]

$$\delta_u = K_I(V_0 - V_{est}) \quad \ldots \quad (6)$$

[0061] When the command value adjusting portion 36 subsequently receives the corrected voltage δ_u, the value u of the voltage command is revised from the initial command value U_0 by the command value adjusting portion 23 so as to be smaller than the corrected voltage δ_u (Step S38). Here, the value u of the voltage command after revision can be obtained from the following expression, for example:

[0062]

$$u = u_0 - \delta_u \quad \ldots \quad (7)$$

[0063] In other words, because the electric current value is reduced in such a way that the speed V_{est} of the armature 10 tracks the preset target speed V_0 after commencement of the release action of the armature 10, impact force and collision noise are reduced when the armature 10 collides with the electromagnet 12. In contrast to that, the time until commencement of the release action is minimized by applying a voltage at a performance limit of the power source and the brake coil 14 until the armature 10 commences the release action. Moreover, for circuit protection, the voltage command that is input into the brake coil 14 is also limited here to less than an upper limit U_{max} in the limiter 19 ($0 < U < U_{max}$) (Step S39).

[0064] After the value u of the voltage command has been revised, time T from the commencement of excitation is monitored to see whether it has reached T_{end} (Step S40), and time T_c from the commencement of the release action is monitored to see whether it has reached T_{cend} (Step S41). If either of the conditions $T > T_{end}$ or $T_c > T_{cend}$ is satisfied, then the value u of the voltage command is returned to the initial command value u_0 regardless of the state of the release action (Step S42).

[0065] The release detecting switch 13 is subsequently monitored to see whether it is switched on. When the release detecting switch 13 is switched on, it is deemed that the armature 10 has displaced to the released position and the release action has been completed, and the value u of the voltage command is switched to a holding voltage command value.

[0066] In an electromagnetic brake control apparatus of this kind, because commencement of the release action of the armature 10 due to attraction by the brake coil 14 is detectable, and the speed of the armature 10 during the release action is ascertainable, and the attractive force that arises in the brake coil 14 can be reduced while tracking the speed of the armature 10 to a preset target speed when commencement of the release action is detected, collision noise can be reduced stably during brake release in any electromagnetic braking apparatus while suppressing lengthening of brake release action time. By making the speed of the armature 10 track the target speed, the brake release action can also be performed more reliably.

[0067] Because the control apparatus main body 15 has: an armature speed calculating portion 34 that calculates the speed of the armature 10 based on both the actual current value of the brake coil 14 and the value of the voltage command from the command value adjusting portion 36; and a speed compensating portion 35 that generates a corrected voltage that corresponds to a difference between the speed of the armature 10 and the target speed, the speed of the armature 10 can be ascertained easily even using voltage control. The speed of the armature 10 can also be made to track the target speed easily by controlling the value of the voltage command so as to reduce the corrected voltage.

[0068] Because the control apparatus main body 15 also has: a voltage command generating portion 31 that generates a voltage command in response to a brake release command; and a release action detecting portion 33 that detects the release action of the armature 10 based on changes in the actual current value of the brake coil 14, commencement of the release action of the armature 10 can be detected more reliably and easily even using voltage control.

[0069] Because the value of the voltage command from the command value adjusting portion 36 is differentiated by the differentiating portion 32, and commencement of the release action is detected in the release action detecting portion 33 by comparing output from the differentiating portion 32 with a preset threshold value, commencement of the release action can be detected more reliably and easily.

[0070] Moreover, in each of the above embodiments, an electromagnetic brake control apparatus on an elevator apparatus has been explained, but the present invention can also be applied to electromagnetic brake control apparatuses that are disposed on other machinery.

In Figure 1, a type of electromagnetic braking apparatus is shown in which a brake shoe 9 presses against an outer circumferential surface of a brake drum 7, but may also be a type in which a brake shoe presses against an inner circumferential surface of a brake drum.

In addition, the brake rotating body may also be a brake disk. In other words, the present invention may also be applied to disc brakes.

The brake rotating body may also be integrated with a drive sheave.

Claims

1. An electromagnetic brake control apparatus that comprises a control apparatus main body that releases an electromagnetic braking apparatus by exciting a brake coil to attract an armature to the brake coil,
the electromagnetic brake control apparatus being **characterized in that**:

the control apparatus main body can detect commencement of a release action of the armature by attraction by the brake coil and can ascertain a speed of the armature during the release action, and changes an attractive force that arises in the brake coil while making the speed of the armature track a preset target speed when commencement of the release action is detected.

2. An electromagnetic brake control apparatus according to Claim 1, **characterized in that** the control apparatus main body comprises:

a current command generating portion that generates a current command for flowing an electric current to the brake coil in response to a brake release command;
a current control portion that generates a voltage command for applying a voltage to the brake coil such that an actual current value of the brake coil matches a value of the current command;
a release action detecting portion that detects the release action of the armature based on a change in a value of the voltage command;
an armature speed calculating portion that calculates the speed of the armature based on both the actual current value of the brake coil and the value of the voltage command;
a speed compensating portion that generates a signal that corresponds to a difference between the speed of the armature that has been calculated by the armature speed calculating portion and the target speed; and
a command value adjusting portion that changes the value of the current command based on information from both the release action detecting portion and the speed compensating portion.

3. An electromagnetic brake control apparatus according to Claim 2, **characterized in that:**

the control apparatus main body further comprises a differentiating portion that differentiates the value of the voltage command; and
the release action detecting portion detects commencement of the release action by comparing output from the differentiating portion with a preset threshold value.

4. An electromagnetic brake control apparatus according to Claim 1, **characterized in that** the control apparatus main body comprises:

a voltage command generating portion that generates a voltage command for applying a voltage to the brake coil in response to a brake release command;
a release action detecting portion that detects the release action of the armature based on a change in an actual current value of the brake coil;
an armature speed calculating portion that calculates the speed of the armature based on both the actual current value of the brake coil and the value of the voltage command;
a speed compensating portion that generates a signal that corresponds to a difference between the speed of the armature that has been calculated by the armature speed calculating portion and the target speed; and
a command value adjusting portion that changes the value of the voltage command based on information from both the release action detecting portion and the speed compensating portion.

5. An electromagnetic brake control apparatus according to Claim 4, **characterized in that:**

the control apparatus main body further comprises a differentiating portion that differentiates the actual current value of the brake coil; and
the release action detecting portion detects commencement of the release action by comparing output from the differentiating portion with a preset threshold value.

6. An electromagnetic brake control apparatus according to Claim 1, **characterized in that** the control apparatus main body generates a pre-reduction attractive force in the brake coil when a preset time elapses from commencement of excitation of the brake coil.

7. An electromagnetic brake control apparatus according to Claim 1, **characterized in that** the control apparatus main body generates a pre-reduction attractive force in the brake coil when a preset time elapses from commencement of the release action of the armature.

FIG. 1

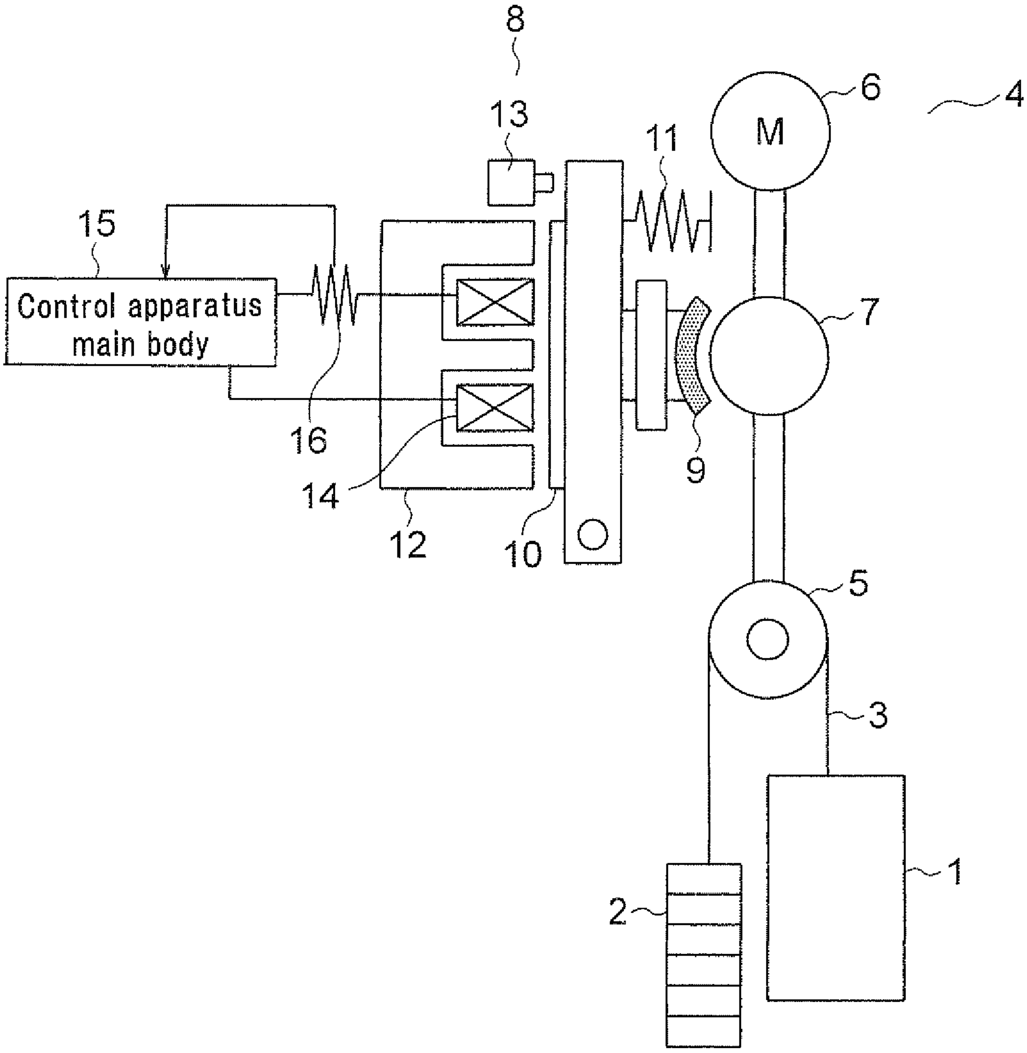


FIG. 2

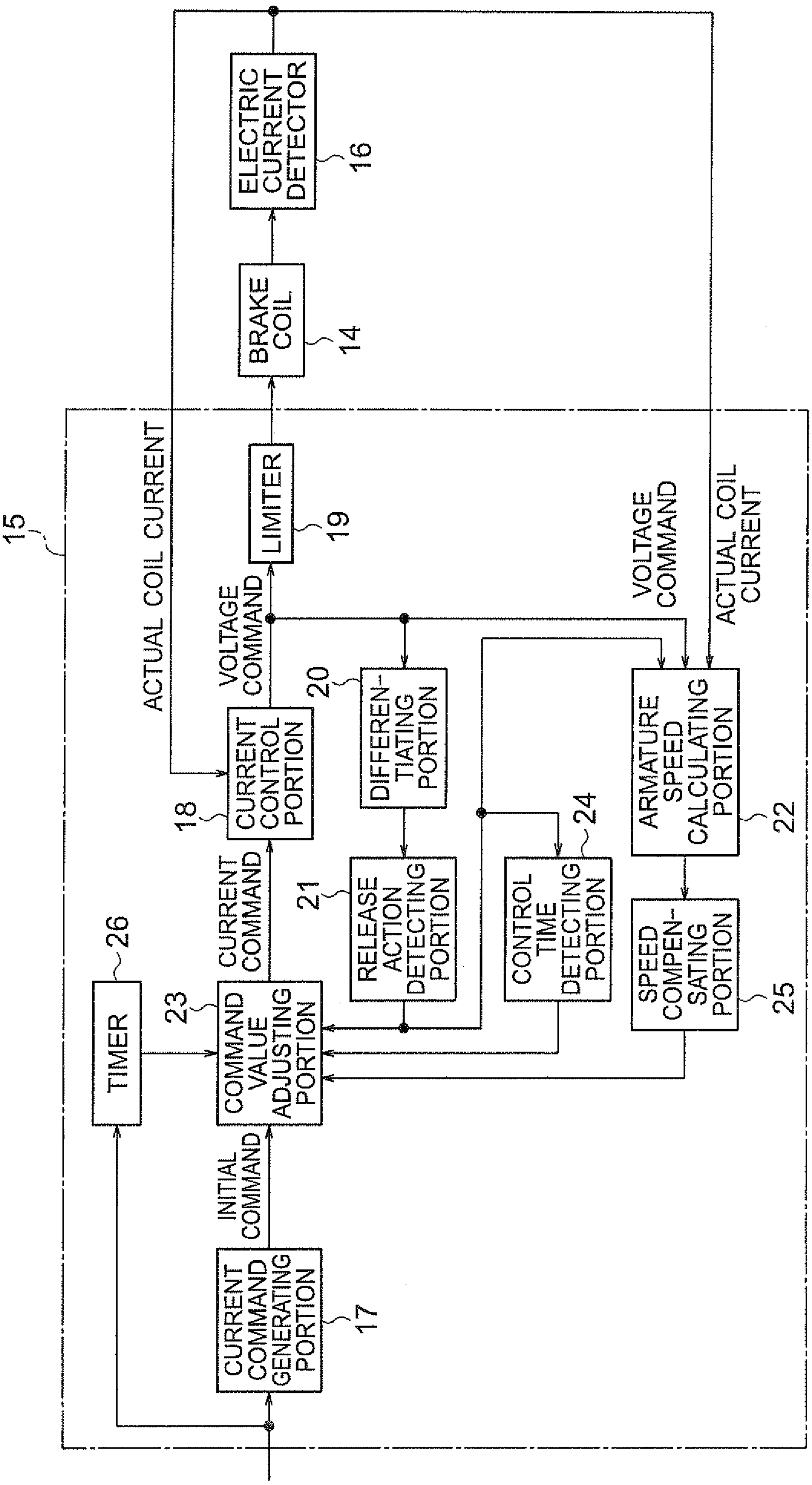

15
ACTUAL COIL CURRENT
VOLTAGE COMMAND
LIMITER
19
BRAKE COIL
14
ELECTRIC CURRENT DETECTOR
16
CURRENT COMMAND GENERATING PORTION
17
INITIAL COMMAND
TIMER
26
COMMAND VALUE ADJUSTING PORTION
23
CURRENT COMMAND
CURRENT CONTROL PORTION
18
DIFFEREN-TIATING PORTION
20
RELEASE ACTION DETECTING PORTION
21
CONTROL TIME DETECTING PORTION
24
VOLTAGE COMMAND
ACTUAL COIL CURRENT
ARMATURE SPEED CALCULATING PORTION
22
SPEED COMPEN-SATING PORTION
25

FIG. 3

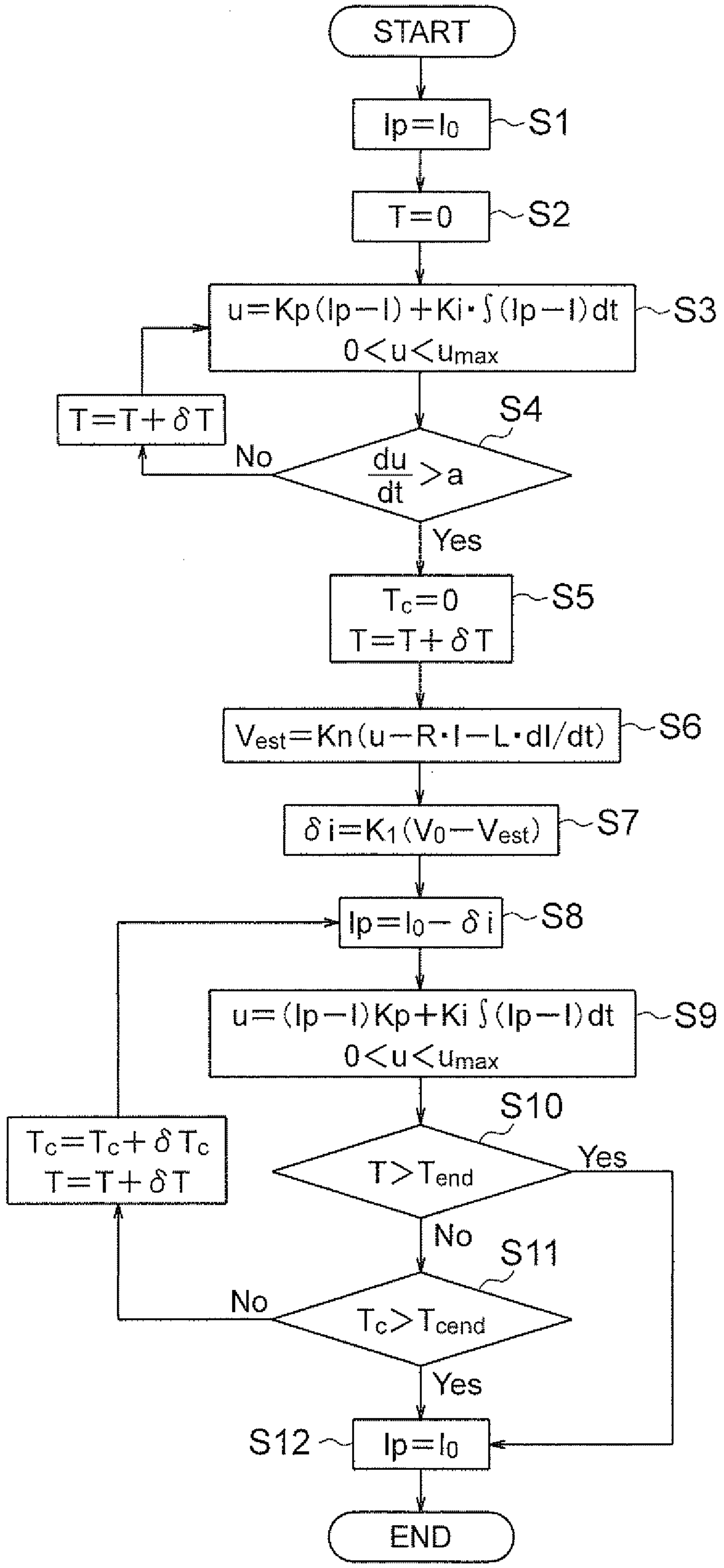

START
Ip=I0
S1
T=0
S2
u=Kp(Ip−I)+Ki·∫(Ip−I)dt
0<u<umax
S3
T=T+δT
S4
du/dt>a
No
Yes
Tc=0
T=T+δT
S5
Vest=Kn(u−R·I−L·dI/dt)
S6
δi=K1(V0−Vest)
S7
Ip=I0−δi
S8
u=(Ip−I)Kp+Ki∫(Ip−I)dt
0<u<umax
S9
S10
Tc=Tc+δTc
T=T+δT
T>Tend
Yes
No
S11
No
Tc>Tcend
Yes
S12
Ip=I0
END

FIG. 4

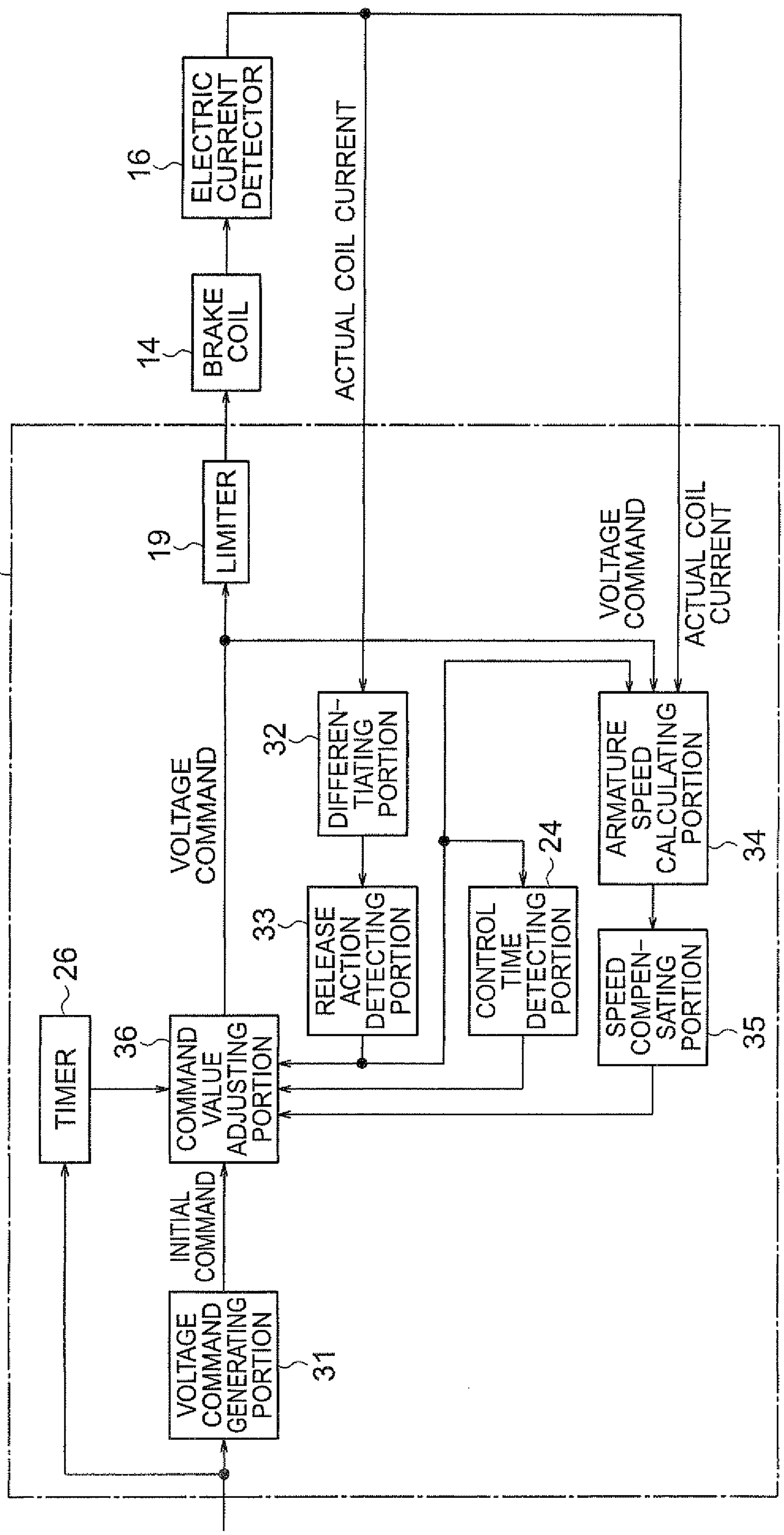
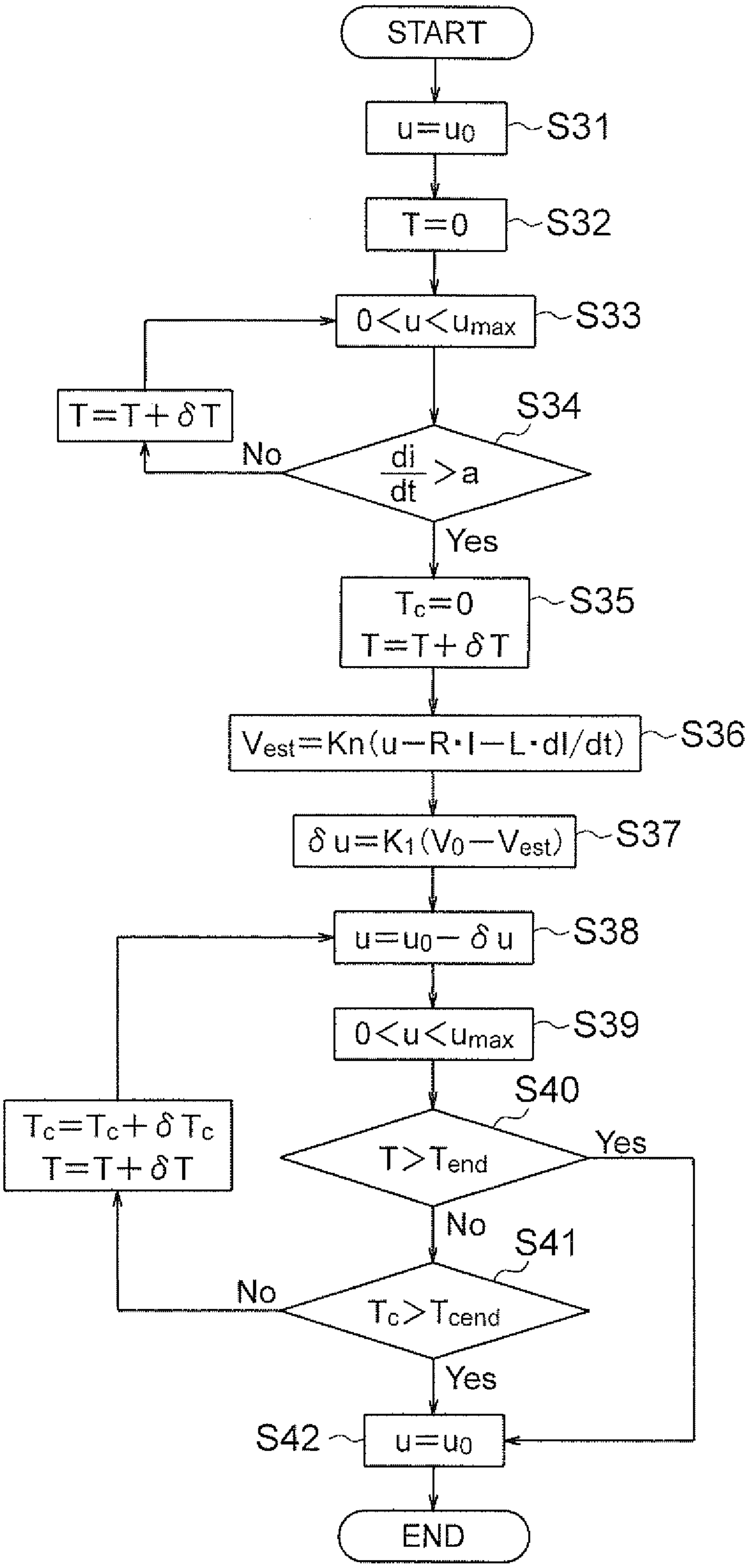

15
16
ELECTRIC CURRENT DETECTOR
14
BRAKE COIL
ACTUAL COIL CURRENT
19
LIMITER
VOLTAGE COMMAND
VOLTAGE COMMAND
ACTUAL COIL CURRENT
32
DIFFEREN-TIATING PORTION
ARMATURE SPEED CALCULATING PORTION
34
24
33
RELEASE ACTION DETECTING PORTION
CONTROL TIME DETECTING PORTION
SPEED COMPEN-SATING PORTION
35
26
TIMER
36
COMMAND VALUE ADJUSTING PORTION
INITIAL COMMAND
VOLTAGE COMMAND GENERATING PORTION
31

FIG. 5


START
u=u0
S31
T=0
S32
0<u<umax
S33
T=T+δT
No
S34
di/dt>a
Yes
Tc=0
T=T+δT
S35
Vest=Kn(u−R·I−L·dI/dt)
S36
δu=K1(V0−Vest)
S37
u=u0−δu
S38
0<u<umax
S39
S40
Tc=Tc+δTc
T=T+δT
T>Tend
Yes
No
S41
No
Tc>Tcend
Yes
S42
u=u0
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/325355

A. CLASSIFICATION OF SUBJECT MATTER
B66B1/32(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)
B66B1/00-B66B1/52

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	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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 7-80650 B2 (Japan Otis Elevator Co.), 30 August, 1995 (30.08.95), Page 3, left column, line 33 to page 4, right column, line 2; Figs. 1 to 5 (Family: none)	1-5 6-7
Y A	WO 2004/28945 A1 (Mitsubishi Electric Corp.), 08 April, 2004 (08.04.04), Description, page 3, line 1 to page 6, line 1; Figs. 1 to 4 & EP 1544148 A1	1-5 6-7

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 08 August, 2007 (08.08.07)	Date of mailing of the international search report 21 August, 2007 (21.08.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP HEI9267982 B **[0003]**