(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 544 148 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
17.10.2012 Bulletin 2012/42

(21) Application number: **03703305.7**

(22) Date of filing: **10.02.2003**

(51) Int Cl.:
B66B 1/32 *(2006.01)*

(86) International application number:
PCT/JP2003/001385

(87) International publication number:
WO 2004/028945 (08.04.2004 Gazette 2004/15)

(54) **BRAKE CONTROLLER OF ELEVATOR**

BREMSSTEUERUNG FÜR AUFZUG

COMMANDE DE FREIN D'ASCENSEUR

(84) Designated Contracting States:
DE FR

(30) Priority: **27.09.2002 JP 2002283672**

(43) Date of publication of application:
22.06.2005 Bulletin 2005/25

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Printed by Jouve, 75001 PARIS (FR)

Description

TECHNICAL FIELD

[0001] The present invention relates to a brake control apparatus for an elevator, and more specifically, to the reduction of brake operation noise generated when a brake shoe collides with a brake drum.

BACKGROUND ART

[0002] In a known brake control apparatus for an elevator, after an exciting current command to a brake coil (electromagnet) for driving a brake shoe has been increased gradually to a specified value, the exciting current command is rapidly decreased to reduce the brake operation noise generated (for example, see Japanese patent application JP-A-9267982.

[0003] However, such a known brake control apparatus for an elevator involves the following problem; that is, the timing and current value for brake falling (i.e., brake application) are uncertain or unknown, and hence these are varied greatly due to the setting of a gap (between a brake shoe and a brake drum) and individual differences of brakes. In addition, if the current value and duration for gradually increasing the current value deviate from their ideal conditions, the collision speed of the brake shoe against the brake drum might not be decreased to a sufficient extent. On the contrary, the attraction of a magnet might sometimes become too large, so the shoe is magnetically pulled back to the magnet, thus obstructing proper brake application. Thus, in order to reduce the collision sound or noise (i.e., generated upon collision between the shoe and the drum), a large amount of labor or effort is required for adjustments of the brake as well as control parameters, and besides there can hardly be expected the effect of reducing the collision noise in cases where there take place uncertain external disturbances such as temperature changes, aging or secular changes, etc.

[0004] The present invention is intended to solve the problems as referred to above, and has for its object to provide a brake control apparatus for an elevator which is easy to perform brake adjustment operation, and which is capable of reducing the falling or collision sound of a brake without being affected by external disturbances.

DISCLOSURE OF THE INVENTION

[0005] Bearing the above object in mind, the present invention reside in a brake control apparatus for an elevator which is characterized by including an electromotive force estimating section for estimating an electromotive force of an electromagnet resulting from a moving speed of an armature attracted to a brake coil of the electromagnet that drives a brake shoe of an elevator brake, and a compensating section for supplying to the electromagnet a voltage command that is compensated so as to match the electromotive force or an integrated value of the electromotive force to a target value, wherein a brake coil voltage is controlled so as to suppress the moving speed of the armature after the armature starts moving upon brake application.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

Fig. 1 is a schematic view showing the entire construction of a brake system of an elevator including a brake control apparatus according to the present invention;
Fig. 2 is a constructional view showing one example of the brake control apparatus according to a first embodiment of the present invention;
Fig. 3 is an explanatory view of the operation of the brake control apparatus according to the present invention;
Fig. 4 is another explanatory view of the operation of the brake control apparatus according to the present invention;
Fig. 5 is a constructional view showing one example of a brake control apparatus according to a second embodiment of the present invention;
Fig. 6 is a constructional view showing one example of a brake control apparatus according to a third embodiment of the present invention;
Fig. 7 is a constructional view showing one example of a brake control apparatus according to a fourth embodiment of the present invention;
Fig. 8 is a constructional view showing one example of a brake control apparatus according to a fifth embodiment of the present invention;
Fig. 9 is a constructional view showing one example of a compensating section according to the fifth embodiment of the present invention;

Fig. 10 is an explanatory view of the operation of the brake control apparatus according to the present invention;
Fig. 11 is a constructional view showing one example of a compensating section according to a sixth embodiment of the present invention;
Fig. 12 is a constructional view showing one example of a brake control apparatus according to a seventh embodiment of the present invention; and
Fig. 13 is a constructional view showing one example of a compensating section according to an eighth embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Embodiment 1.

[0007] Hereinafter, reference will be made to one example of a brake control apparatus according to a first embodiment of the present invention. Fig. 1 shows the construction of an entire brake system of an elevator including the brake control apparatus according to the present invention, and such a situation is similar in respective embodiments to be described later. A car 1 of the elevator is hung, together with a counter weight 4, by a main rope 3 wrapped around a sheave 2 of a winch in a well bucket fashion. A brake drum 6 adapted to be driven by a hoist motor 5 is generally installed on an axle that couples the hoist motor 5 and the sheave 2 with each other, and a brake shoe 8 is urged into engagement with the brake drum 6 under the action of the resilient force of a spring 7 thereby to provide a braking force due to the friction therebetween. Upon actuation of the elevator, electric current is supplied to a brake coil or electromagnet 10 (in the following description, the brake coil will be explained as being the same as the electromagnet) to energize it under the control of a control unit 9, whereby an armature 11 attached to the brake shoe 8 is attracted to the brake coil while overcoming the resilient force of the spring 7. At this time, a brake contact 12 is turned on by the armature to generate an output 12a, through which it is detected that the attraction of the brake shoe has been completed. In addition, upon brake application, the brake coil is de-energized similarly by the control unit 9, and at this time, the current supplied to the brake coil is decreased according to a time constant which is decided depending on the resistance and reactance of the coil, so that the attraction of the coil also decreases in accordance with the decreasing brake current. When the attraction of the brake coil becomes less than the force of the spring 7, the brake coil is separated from the armature 11 and caused to fall or move toward the brake drum under the pull of the spring force.

[0008] Fig. 2 is a constructional view that shows the brake control apparatus including the component parts 9, 10 and 13 of Fig. 1 according to the first embodiment of the present invention. The inventor focuses attention on the fact that the electromotive force of the brake coil of the electromagnet basically indicates the speed of the armature. The electromotive force of this coil is estimated from a current detector signal, based on which the speed of the armature is controlled and adjusted by controlling a voltage command to the brake coil of the electromagnet. In Fig. 2, the current detector 13 detects the electric current that flows through the brake coil (electromagnet). An electromotive force estimating section 30 estimates the electromotive force generated by the electromagnet from a coil application voltage command signal 20 to the electromagnet 10 and a current detector signal 21 from the current detector 13. A target value setting section (setting section) 22 provides a target value of the electromotive force. A difference calculating section 23a calculates a differential (difference) between the target value of the electromotive force and an estimated electromotive force signal. A compensating section 24 shapes the gain and phase of an output of the difference calculating section 23a, and outputs it to the electromagnet as the coil application voltage command signal 20. A nonlinear compensating section 32 compensates for the electric current flowing through the electromagnet 10. For example, it performs the compensation through an adding section 25a in such a manner that an output 21 a of the current detector 13 becomes in a proportional relation to the coil application voltage command signal 20 to the electromagnet. An inductance adjusting section 29 adjusts an inductance value 26 of the electromagnet in the electromotive force estimating section 30 in accordance with the current detector signal 21.

[0009] Moreover, in the electromotive force estimating section 30, a differentiating section 27 differentiates the current detector signal. The brake coil inductance value 26 is actually calculated by a multiplying section by multiplying the differentiation signal of differentiating section by the inductance of the brake coil. A brake coil resistance value 28 is actually calculated by the multiplying section by multiplying the current detector signal by the resistance value of the brake coil. An adding section 25b adds both of these multiplication signals to each other. A difference calculating section 23b subtracts an output of the adding section 25b from the voltage command signal 20 to the brake coil, and outputs it as an estimated electromotive force signal 31.

[0010] Now, reference will be made to the operation of the brake control apparatus according to the first embodiment of the present invention. Fig. 3 is an explanatory view of the operation of the brake control apparatus according to the first embodiment of the present invention. (a) in Fig. 3 shows a voltage given to the brake coil, (b) in Fig. 3 shows the displacement of the armature 11, and (c) in Fig. 3 shows the speed change of the armature 11. In Fig. 3, when the brake is released, an attraction voltage is applied to the brake coil , so that the electromagnet provided with the brake coil

attracts the armature 11 while overcoming the spring 7. When the brake contact 12 detects the attraction of the armature 11 at time point T2, a hold voltage is applied to the brake coil . The hold voltage is set to be a value which is lower than the attraction voltage, and at which the attraction of the electromagnet in its attracting state becomes slightly larger than the spring force. As a result, the heat generation of the brake coil during its attraction can be suppressed.

[0011] Then, when the brake is applied with the hold voltage being imposed on the brake coil , the imposed voltage of the brake coil 10 is made zero from the hold voltage at time point T4, as shown in (a) of Fig. 3, as a consequence of which the brake current starts decreasing. When the attraction of the brake coil due to the brake current becomes smaller than the spring force, the armature 11 starts falling or moving toward the brake drum, and the speed of the armature 11 is increasing, as shown in (c) of Fig. 3. When the start of movement of the armature 11 is detected by the electromotive force estimating section 30, the control unit 9 calculates a difference between an output value from a setting section 22 and the estimated electromotive force signal 31 output from the electromotive force estimating section 30 by means of the difference calculating section 23a. A differential signal from the difference calculating section, with its amplification factor and phase being controlled by the compensating section 24, is supplied to the brake coil as a control voltage command. In addition, a compensation voltage is added from the nonlinear compensating section 32 to the adding section 25a so that the electric current flowing through the brake coil 10 becomes in a proportional relation to the voltage command given to the brake coil . For example, the compensating section 32 feeds back a voltage which is in proportion to a coil current (current detector signal) of the brake coil detected by the current detector 13. Here, note that the control voltage command is given to the brake coil until a predetermined time point T6 is passed at which the armature 11 ends its falling operation, as shown in (a) of Fig. 3. Moreover, the amplification factor of the compensating section 24 is set to such a value at which the armature 11 can not be magnetically pulled back to the electromagnet.

[0012] Next, the operation of the electromotive force estimating section 30 will be described below. Assuming that the resistance value of the coil is represented by R and the inductance of the coil is represented by L, the relation between the voltage command E to the electromagnet, i.e., brake coil and the coil current i flowing through the brake coil is represented from electromagnetics by the following expression;

$$E = Ri + L(di/dt) + (\partial L/\partial t)i \qquad (1)$$

[0013] Further, assuming that the displacement of the armature is represented by x and the speed thereof is represented by v, the right-hand side third term of expression (1) above is represented by the following expression:

$$(\partial L/\partial t)i = (\partial L/\partial x)(dx/dt)i = (\partial L/\partial x)vi \qquad (2)$$

[0014] This is a voltage proportional to the speed v of the armature, and is an electromotive force resulting from the speed. The electromotive force estimating section 30 estimates the estimated electromotive force signal 31 by using the following expression obtained from the above relational expression:

$$(\partial L/\partial x)vi \fallingdotseq E - Ri - L(di/dt) \qquad (3)$$

That is, expression (3) above is calculated by the differentiating section 27, the brake coil resistance value 28 and the inductance adjusting section 29.

[0015] Then, the operation of the inductance adjusting section 29 will be described below. For example, as shown in Fig. 4, the brake coil current i and the inductance L are obtained beforehand, and the relation between the brake coil current i and the inductance L is tabulated. The control unit 9 calls or picks up the inductance L from this table based on the output signal of the current detector 13, and changes the inductance L in the electromotive force estimating section 30.

[0016] With the brake control apparatus as constructed above, after the start of falling or moving of the brake, the brake coil voltage is controlled so as to suppress the falling or moving speed of the brake, so that the falling or moving speed of the brake is slowed down below a prescribed value in comparison with a conventional speed change which is indicated by an alternate long and short dash line in (c) of Fig. 3. As a result, the brake operation noise generated upon collision of the brake shoe 8 with the brake drum 6 becomes small.

Embodiment 2.

[0017] Fig. 5 is a constructional view that shows a brake control apparatus according to a second embodiment of the present invention. In this embodiment, the same or corresponding parts as those of the above-mentioned first embodiment are identified by the same symbols (this is similar in the following embodiments). In Fig. 5, an electromotive force estimating section 30 includes a filter section 33b for subjecting a current detector signal to prescribed filtering with a zero point calculated from the inductance and resistance of the electromagnet, a filter section 33a for filtering a voltage command to the electromagnet, and a difference calculating section 23b for calculating a difference between output signals of both of the filter sections. Both of the filter sections have their time constants set to the same value.

[0018] Now, reference will be made to the operation of the brake control apparatus according to the second embodiment of the present invention. The operation of this embodiment is the same as that of the first embodiment excluding the operation of the electromotive force estimating section 30. The electromotive force estimating section 30 performs filtering on the relation of expression (3) above. Specifically, assuming that the Laplace transform of an electromotive force signal is represented by Ev(s) and the Laplace transforms of a coil voltage command E and a coil current are further represented by E(s) and i(s), respectively, the relation of the following expression is obtained by applying, for instance, filtering with a time constant τ to both sides of expression (3) above:

$$\{1/(\tau s + 1)\}Ev(s) \doteqdot \{1/(\tau s + 1)\}E(s) - \{(Ls + R)/(\tau s + 1)\}i(s) \qquad (4)$$

Accordingly, the electromotive force estimating section 30 operates in accordance with expression (4) above, and calculates an estimated electromotive force 31. With the brake control apparatus as constructed above, the current detector signal is not subjected to differentiating operation, and hence the brake control apparatus becomes robust with respect to external noise disturbances, so that the brake noise generated upon collision of the brake shoe 8 with the brake drum 6 can be further reduced.

Embodiment 3.

[0019] Fig. 6 is a constructional view that shows a brake control apparatus according to a third embodiment of the present invention. The brake control apparatus of Fig. 6 is different from the second embodiment shown in Fig. 2 in the following. That is, the brake control apparatus of this embodiment includes an integrating section 34 for integrating an electromotive force estimated by an electromotive force estimating section 30, an amplifying section 35b for amplifying an output of the integrating section 34, a setting section 22 for providing an integrated value of an electromotive force, i.e., a target value for a position to which the armature is to be displaced, a difference calculating section 23c for calculating a difference between an output signal of the setting section 22 and an output signal from the amplifying section 35b, an amplifying section 35a for amplifying an output signal of the electromotive force estimating section 30, and a difference calculating section 23d for calculating a difference between the output signal of the amplifying section 35a and an output signal of the difference calculating section 23c to output it as a voltage command to the electromagnet. Here, note that no provision is made for the compensating section 24.

[0020] Explaining the operation of this embodiment, an estimated electromotive force is integrated by the integrating section 34, and further amplified by the amplifying section 35b, and a difference between the output of the amplifying section 35b and an output signal of the setting section 22 is calculated by the difference calculating section 23c. In addition, the difference calculating section 23d calculates a difference between the output signal of the difference calculating section 23c and the estimated electromotive force amplified by the amplifying section 35a, and generates an output signal as a voltage command to the coil.

[0021] With the brake control apparatus as constructed above, the output signal of the difference calculating section 23c becomes a differential signal representative of a difference between an integrated value signal of the electromotive force that increases as the armature begins to move and a fixed value signal of the target value setting section or the setting section 22. Accordingly, the output signal of the difference calculating section 23c decreases gradually in accordance with the movement of the armature. Thus, the difference calculating section 23d sets, as a new target value, the output signal of the difference calculating section 23c that is decreasing gradually with the movement of the armature, and calculates a difference between this new target value and an estimated electromotive force signal amplified by the amplifying section 35a.

[0022] On the other hand, the electromotive force signal represented by expression (2) is proportional to the product of the armature speed v of and the coil current i. In order to control the armature speed v immediately before the collision of the brake shoe with the brake drum in a stable manner (at a fixed value) despite the fact that the coil current is decreasing gradually, it is more convenient to target the variable signal gradually decreasing with the movement of the

armature, as shown in this embodiment, than to target the fixed value signal of the setting section 22 as in the aforementioned first and second embodiments. By so doing, the brake sound or noise generated when the brake shoe 8 collides with the brake drum 6 can be further reduced. Incidentally, it is evident that a similar operation can be obtained even if the construction of the second embodiment is used for the electromotive force estimating section 30.

Embodiment 4.

[0023] (a) in Fig. 7 is a constructional view that shows a brake control apparatus according to a fourth embodiment of the present invention. In this embodiment, a compensator adjusting section 36 is further provided. As shown in (b) of Fig. 7, this compensator adjusting section 36 includes a latch circuit 37, a comparator 38 and a gain table 39.

[0024] Now, the operation of this embodiment will be described below. The operation of this embodiment is the same as that of the first embodiment excluding the operation of the compensator adjusting section 36. The operation of the compensator adjusting section 36 will be described below. The comparator 38 operates to determine the timing at which an electromotive force from the electromotive force estimating section 30 is generated (a reference voltage based on which the presence or absence of the generation of an electromotive force is determined from an estimated electromotive force signal is connected to a lower side terminal of the comparator). The latch circuit 37 operates to store an output signal of the current detector 13 at that timing. The gain table 39 is a table that serves to associate a current value generated by the electromotive force with an amplification factor in the compensating section 24. The compensator adjusting section 36 operates to adjust the amplification factor in the compensating section 24 by means of the gain table 39 in accordance with the coil current value (current detector power output) stored in the latch circuit 37 at each time. This has the following advantageous effect. That is, considering the fact that the coil current value, serving to make the armature start to move, is proportional to the urging force of the spring 7, increasing the urging force of the spring increases the amplification factor of the compensating section 24, whereas decreasing the urging force of the spring decreases the amplification factor of the compensating section 24. As a result, the stability in operation of the control system can be improved.

[0025] With the brake control apparatus as constructed above, even if the urging force of the spring 7 constituting the brake is changed according to a secular change or aging, the brake operation noise generated upon collision of the brake shoe 8 with the brake drum 6 can be reduced. Incidentally, it is evident that a similar operation can be obtained even if the construction of the second embodiment is used for the electromotive force estimating section 30.

Embodiment 5.

[0026] Fig. 8 is a constructional view that shows a brake control apparatus according to a fifth embodiment of the present invention. Similar to the third embodiment, this fifth embodiment performs control based on an integrated value of an electromotive force, i.e., a variable target value related to the displaced position of the armature. The armature operating current detecting section 18 detects a coil current value, at which the armature 11 of the electromagnet 10 starts to operate or move, based on a current detector signal 21. The target value setting section 22 provides a target value for an integral signal 310 of an estimated electromotive force signal 31 b amplified by the amplifying section 35. The difference calculating section 23c calculates a difference between the target value and the integral signal 310 of the estimated electromotive force signal. The compensating section 24 outputs a coil application voltage command signal 20 to the brake coil (electromagnet) based on the output signal of the difference calculating section 23c, the current detector signal 21, the estimated electromotive force signal 31a of the electromotive force estimating section, and an output signal 320 of the armature operating current detecting section 18. The inductance adjusting section 29 adjusts an inductance value 26 of the electromagnet in the electromotive force estimating section 30 in accordance with the current detector signal 21.

[0027] In addition, in the electromotive force estimating section 30, a difference calculating section 23b subtracts the output of the adding section 25b from the coil application voltage command signal 20 to the brake coil. Further, an output of the difference calculating section 23b is passed to a filter section 33 which then outputs estimated electromotive force signals 31 a, 31 b.

[0028] Fig. 9 is a constructional view that shows one example of the configuration of the compensating section 24. In the compensating section 24, the output signal 31 a of the electromotive force estimating section 30 is input to an electromotive force compensating section 40, and the output signal 320 of the armature operating current detecting section 18 is input to a spring force compensating section 41 and an electromagnetic force compensating section 42. The current detector signal 21 is input to the electromagnetic force compensating section 42, a differentiating section 27a and a counterbalance voltage compensating section 47, respectively. An output signal of the electromotive force compensating section 40, an output signal of the spring force compensating section 41 and an output signal of the electromagnetic force compensating section 42 are respectively input to a multiplying section 44. A difference calculating section 23d calculates a difference between an output signal of the multiplying section 44 and the output signal 17 of

the difference calculating section 23c as shown in Fig. 8, and its output difference is input to a switching section 45. An output signal of a zero signal source 48 is also input to the switching section 45. An output signal of the differentiating section 27a is input to the switching section 45, too. An output signal of the switching section 45 and an output signal of the counterbalance voltage compensating section 47 are added up to each other by an adding section 25c to provide a coil application voltage command signal 20.

[0029] Now, the operation of the fifth embodiment of the present invention will be described below. The basic operation of this embodiment is the same as that of the above-mentioned embodiments. When the brake is applied with a hold voltage being imposed on the brake coil , the imposed voltage of the brake coil is made zero from the hold voltage at time point T4, as shown in (a) of Fig. 3, whereby a brake current (current of the brake coil) starts decreasing. As a result, when the attraction of the brake coil due to the brake current becomes smaller than the spring force, the armature 11 starts falling or moving toward the brake drum, and the speed of the armature 11 is increasing, as shown in (c) of Fig. 3. When the start of movement of the armature 11 is detected by the electromotive force estimating section 30, the difference calculating section 23c in the control unit 9 calculates a difference between an output value from the setting section 22 and an estimated electromotive force signal 31 b, which is output from the electromotive force estimating section 30, integrated by the integrating section 34 and amplified by the amplifying section 35. The compensating section 24 outputs a coil application voltage command signal 20 to the brake coil (electromagnet) based on the output signal 17 of the difference calculating section 23c, the current detector signal 21, the output signal 31 a of the electromotive force estimating section, and the output signal 320 of the armature operating current detecting section 18.

[0030] The basic operations of the electromotive force estimating section 30, the inductance adjusting section 29 and the like are the same as those of the above-mentioned embodiments.

[0031] Now, the operation of the compensating section 24 will be described below. First of all, the electromotive force compensating section 40 operates to change the gain and phase of the electromotive force estimating signal 31 a by means of a controller having a transfer function represented by the following expression for instance, and generates an output signal which is input to the multiplying section 44.

$$C(s) = 250(K_d s + K_p)/(s + 250) \qquad (5)$$

where C(s) represents the transfer function between an input signal and an output signal, s represents a Laplacian operator, K_p represents a constant indicative of a proportional gain, and K_d represents a constant indicative of a differential gain.

[0032] The spring force compensating section 41 outputs a calculation value which is calculated from the output signal 320 of the armature operating current detecting section 18 by applying thereto a linear function represented by the following expression for instance:

$$y = a_s u + b_s \qquad (6)$$

$$c_s \leqq y \leqq d_s \qquad (7)$$

where a signal u represents the output signal 320 from the armature operating current detecting section 18, a signal y represents the output signal of the spring force compensating section 41, and c_s and d_s represent a lower limit and an upper limit, respectively, of the output signal y of the spring force compensating section. In addition, although expression (6) above is a linear equation in this example, it is needless to say that a multidimensional equation or a nonlinear equation, in which arithmetic expressions are classified and changed according to the magnitude of the signal u, may be used in place of this expression.

[0033] The electromagnetic force compensating section 42 outputs a calculation value which is calculated from the output signal 320 from the armature operating current detecting section 18 and the output signal 21 of the current detector by using a linear function such as, for example, the following expression:

$$r = a_m(i - u) + b_m \qquad (8)$$

$$c_m \leqq r \leqq d_m \qquad (9)$$

where a signal u represents the output signal 320 from the armature operating current detecting section 18, a signal i represents the output signal 21 of the current detector, a signal r represents the output signal of the electromagnetic force compensating section 42, and c_m and d_m represent a lower limit and an upper limit, respectively, of the output signal r of the electromagnetic force compensating section 42. Although expression (8) above is a linear equation in this example, it is needless to say that a multidimensional equation or a nonlinear equation, in which arithmetic expressions are classified and changed according to the magnitude of the signal i, may be used in place of this expression.

[0034] The multiplying section 44 operates to multiply the output signals of the electromotive force compensating section 40, the spring force compensating section 41 and the electromagnetic force compensating section 42 with one another. A difference between the output signal of the multiplying section 44 and the output signal 17 from the difference calculating section 23c is calculated by the difference calculating section 23d, and input therefrom to the switching section 45.

[0035] The switching section 45 operates to switch the output signal of the difference calculating section 23d and the output signal of the zero signal source 48 by the sign of a signal which is obtained by differentiating the coil current detector signal 21 with respect to time by means of the differentiating section 27a. For example, such an arithmetic calculation as shown by the following expression is carried out:

$$z = w \ (q \geqq 0)$$

$$z = 0 \ (q < 0) \qquad (10)$$

where q represents a signal which is obtained by differentiating the coil current detector signal 21 with respect to time by means of the differentiating section 27a, w represents the output signal of the difference calculating section 23d, and z represents the output signal of the switching section 45.

[0036] Further, the adding section 25c adds the output signal of the switching section 45 to an output signal, which is obtained by subjecting the coil current detector signal 21 to the counterbalance voltage compensating section 47, to provide a coil application voltage command signal 20. The counterbalance voltage compensating section 47 outputs a calculation value which is obtained by applying a linear function such as, for example, the following expression to the coil current detector signal 21:

$$e = Ri \qquad (11)$$

where a signal i represents the coil current detector signal 21, a signal e represents the output signal of the counterbalance voltage compensating section 47, and R represents the direct current resistance value of the brake coil 10, for instance.

[0037] The control operation of the brake control system is as follows. The output signal obtained by applying the counterbalance voltage compensating section 47 to the coil current detector signal 21 is constantly output to the coil application voltage command signal. In addition, only when the current detector signal 21 increases gradually with time, the output signal (negative feedback signal) of the difference calculating section 23d is added to the coil application voltage command signal 20.

[0038] (a) in Fig. 10 shows an example of the operation of the coil application voltage command signal 20 without control (broken line) and under the control of the control apparatus of the present invention (solid line) at the time of brake application; (b) in Fig. 10 shows an example of the operation of the armature displacement without control (broken line) and under the control of the control apparatus of the present invention (solid line); and (c) in Fig. 10 further shows an example of the operation of the armature speed without control (broken line) and under the control of the control apparatus of the present invention (solid line). When the speeds of the armature with and without control in (c) of Fig. 10 are compared with each other, a maximum value of the speed (solid line) under the control of the present control apparatus at a time point at which the brake shoe is expected to come in contact with the brake drum is smaller than that without control (broken line), so that the falling or actuation speed of the brake is slowed down below a prescribed value in comparison with a conventional speed change which is indicated by the alternate long and short dash line in

(c) of Fig. 3. As a result, the brake operation noise generated upon collision of the brake shoe 8 with the brake drum 6 becomes small.

[0039] The operation or movement of the armature is started at the instant when the balance of the electromagnetic force and the spring force is changed, and the magnitude of the coil current at this time is substantially proportional to the spring force. Accordingly, there is obtained an advantageous effect that by compensating for the coil application voltage command signal 20 by the output value of the armature operating current detecting section 18, the armature can operate stably even if there is a variation of the spring force.

[0040] In addition, as the armature is moving, the electromagnetic force of the coil is gradually decreasing in accordance with the travel or distance moved of the armature, so the electromagnetic force is not proportional to the voltage applied to the coil. Therefore, it is easier to control the armature speed by gradually increasing the voltage applied to the coil in accordance with the travel or moved distance of the armature. Thus, focusing attention on the fact that the coil current increases in accordance with the armature movement, the electromagnetic force compensating section 42 generates an output value which is proportional to the difference between the output value of the armature operating current detecting section 18 and the coil current detector signal 21. By multiplying this output value by the outputs of the electromotive force compensating section 40 and the spring force compensating section 41, respectively, the controllability of the speed of the armature can be improved, thereby making it possible to further reduce the brake operation noise generated upon collision of the brake shoe 8 with the brake drum 6 in a stable manner.

Embodiment 6.

[0041] Fig. 11 is a constructional view that shows a compensating section in a brake control apparatus according to a sixth embodiment of the present invention. In this embodiment, a compensating section 24 is provided with a timer section 43 and a gain changing section 50a.

[0042] Now, the operation of this embodiment will be described below. The operation of this embodiment is the same as that of the above-mentioned fifth embodiment excluding compensation adjusting operation. The timer section 43 counts or measures the time from a time point when the brake is released until brake operation is started. Here, let us assume the time counted or measured be Thold. Then, the operation of the gain changing section 50a will be described below. For example, the gain changing section 50a performs arithmetic calculations as shown by the following.

$$\text{If } Thold \leqq Thmax,$$

$$Kp = Kpini\{1 + (Kprate/Thmax)(Thold - Thmin)\}$$

$$\text{If } Thold > Thmax$$

$$Kp = Kpini*1.3 \qquad (12)$$

where Kpini represents an initial value of Kp, Kprate represents a gain change rate, Thmax represents a maximum brake release time, and Thmin represents a minimum brake release time. In this example, the gain is changed by a linear expression according to the time counted or measured.

[0043] With the brake control apparatus as constructed above, the armature is magnetized in accordance with the time during which the brake is being released (i.e., the time during which the armature is attracted to the electromagnet), so it becomes difficult for the armature to separate from the electromagnet even if the coil current gradually decreases upon brake application. Since the gain of the electromotive force compensating section is changed according to the brake release time, the brake operation noise generated upon collision of the brake shoe 8 with the brake drum 6 is reduced without regard to the period of time during which the brake is being released.

Embodiment 7.

[0044] Fig. 12 is a constructional view that shows a brake control apparatus according to a seventh embodiment of the present invention. This embodiment includes a resistance value estimating section 51.

[0045] Now, the operation of this embodiment will be described below. The operation of this embodiment is the same as that of the fifth embodiment excluding the operation of the resistance value estimating section 51. The resistance value estimating section 51 operates to estimate the resistance of the coil from the coil application voltage command signal 20 and the coil current detector signal 21. For example, the resistance is estimated by dividing the result of running average processing of the coil application voltage command signal 20 (an average thereof calculated in a prescribed period) within a certain fixed time during the brake release by the corresponding result of running average processing of the coil current detector signal 21. This estimated resistance value is set as a brake coil resistance value 28 of the electromotive force estimating section 30.

[0046] With the brake control apparatus as constructed above, the electromotive force estimation accuracy of the electromotive force estimating section 30 can be improved, so that the brake operation noise generated upon collision of the brake shoe 8 with the brake drum 6 can be reduced.

Embodiment 8.

[0047] Fig. 13 is a constructional view that shows the configuration of a compensating section in a brake control apparatus according to an eighth embodiment of the present invention. This embodiment includes a second gain changing section 50b in the compensating section 24.

[0048] Now, the operation of this embodiment will be described below. The operation of this embodiment is the same as that of the above embodiments excluding the operation of the second gain changing section 50b. The second gain changing section 50b operates to change the initial gain Kp of the first gain changing section 50a in accordance with the resistance value of the coil (see a broken line arrow in Fig. 12) estimated by a resistance value estimating section 51 (for example, the one in Fig. 12). For example, assuming that R* represents the resistance value estimated by the resistance value estimating section 51, the initial gain Kpini is classified and changed by the magnitude of the estimated resistance value as shown by the following.

$$R^* \leqq R_1 \qquad Kpini = K_1$$

$$R_1 \leqq R^* \leqq R_2 \qquad Kpini = K_2$$

$$R_2 \leqq R^* \qquad Kpini = K_3 \qquad (13)$$

[0049] With the brake control apparatus as constructed above, since the temperature of the coil is proportional to the resistance value thereof, the gain of the electromotive force compensating section 40 can be changed in proportion to an environmental temperature of the brake. As a result, there is obtained an advantageous effect that even if there is a variation in the environmental temperature, stable control can be achieved, so that the brake operation noise generated upon collision of the brake shoe 8 with the brake drum 6 can also be reduced.

[0050] As described in the foregoing, according to the present invention, provision is made for an estimating section for estimating the electromotive force of an electromagnet resulting from the moving speed of an armature (brake shoe), an electromotive force target value setting section, and a compensating section. With such a construction, a brake coil voltage is controlled so as to suppress the falling or moving speed of the brake after the brake starts falling or moving, as a result of which the falling or moving speed of the brake is slowed down in comparison with a conventional speed change, thereby reducing the brake operation noise generated upon collision of a brake shoe with a brake drum.

INDUSTRIAL APPLICABILITY

[0051] According to the present invention, the falling or moving speed of a brake is slowed down as compared with a conventional speed change, whereby the brake operation noise generated when a brake shoe collides with a brake drum can be reduced. As a result, an elevator can be used in a place where operation noise thereof gives rise to a problem, thus making it possible to utilize the elevator in much more places.

Claims

1. A brake control apparatus for an elevator, comprising:

- an electromotive force estimating section (30) for estimating an electromotive force of an electromagnet (10) as a brake coil resulting from a moving speed of an armature (11) attracted to the electromagnet (10) which armature (11) drives a brake shoe (8) of an elevator brake; and
- a compensating section (24) for supplying to the electromagnet (10) a voltage command that is compensated so as to match the electromotive force or an integrated value of the electromotive force to a target value;

wherein the voltage supplied to the electromagnet (10) is controlled so as to suppress the moving speed of the armature (11) at a time (T4) when the armature (11) starts moving away from its holding position attracted against the electromagnet (10).

2. The apparatus according to claim 1,
characterized by:

- a current detector (13) for detecting an electric current that flows through the electromagnet (10) as the brake coil;
- wherein the electromotive force estimating section (30) is adapted to estimate an electromotive force generated by the electromagnet (10) based on a voltage command to the electromagnet (10) and an output of the current detector (13);
- a target value setting section (22) for providing a target value for the electromotive force;
- a difference calculating section (23a, 23c) for calculating a difference between the electromotive force target value and the estimated electromotive force;
- wherein the compensating section (24) is adapted to shape the gain and phase of an output of the difference calculating section (23a, 23c) to provide the voltage command to the electromagnet (10);
- a nonlinear compensating section (32) for performing compensation so as to make the output of the current detector (13) and the voltage command to the electromagnet (10) to have a proportional relation with respect to each other; and
- a section for adjusting an inductance value of the electromagnet (10) in the electromotive force estimating section (30) in accordance with the output of the current detector (13).

3. The apparatus according to claim 1,
characterized by:

- a current detector (13) for detecting an electric current that flows through the electromagnet (10) as the brake coil;
- wherein the electromotive force estimating section (30) is adapted to estimate an electromotive force generated by the electromagnet (10) based on a voltage command to the electromagnet (10) and an output of the current detector (13);
- a section (34) for integrating the electromotive force estimated by the electromotive force estimating section (30);
- a target value setting section (22) for providing a target value for the electromotive force;
- a first difference calculating section (23c) for calculating a difference between an output of the target value setting section (22) and an output from the electromotive force integrating section (34);
- a second difference calculating section (23d) for calculating a difference between an output of the electromotive force estimating section (30) and an output of the first difference calculating section (23c) to provide a voltage command to the electromagnet (10);
- a nonlinear compensating section (32) for performing compensation so as to make the output of the current detector (13) and the voltage command to the electromagnet (10) to have a proportional relation with respect to each other; and
- a section for adjusting an inductance value of the electromagnet (10) in the electromotive force estimating section (30) in accordance with the output of the current detector (13).

4. The apparatus according to claim 2,
characterized by a compensator adjusting section (36) for changing the gain of the compensating section (24) in accordance with the output value of the current detector (13) when the electromotive force is generated, based on the output of the electromotive force estimating section (30) and the output of the current detector (13).

5. The apparatus according to claim 1,

characterized by:

- a current detector (13) for detecting an electric current that flows through the electromagnet (10) as the brake coil;
- wherein the electromotive force estimating section (30) is adapted to estimate an electromotive force generated by the electromagnet (10) based on a voltage command to the electromagnet (10) and an output of the current detector (13);
- a section (34) for integrating an electromotive force estimated by the electromotive force estimating section (30);
- a target value setting section (22) for providing a target value for an integrated value of the electromotive force;
- a difference calculating section (23c) for calculating a difference between an output of the target value setting section (22) and an output from the electromotive force integrating section (34);
- an armature operating current detecting section (18) for detecting a coil current value, at which the armature (11) of the electromagnet (10) starts to operate, based on the output of the current detector (13);
- wherein the compensating section (24) is adapted to supply a voltage command to the electromagnet (10) based on the outputs of the current detector (13), the electromotive force estimating section (30), the difference calculating section (23c), and the armature operating current detecting section (18); and
- a section for adjusting an inductance value of the electromagnet (10) in the electromotive force estimating section (30) in accordance with the output of the current detector (13).

6. The apparatus according to any of claims 2, 3 and 5,
characterized in that the electromotive force estimating section (30) comprises:

- a section for differentiating the output of the current detector (13);
- a section for multiplying the differentiated signal by the inductance of the electromagnet (10);
- a section for multiplying the output of the current detector (13) by a resistance value of the electromagnet (10);
- an adding section (25b) in the estimating section for adding both of multiplication signals; and
- a difference calculating section (23b) in the estimating section for subtracting an output of the adding section (25b) from the voltage command to the electromagnet (10).

7. The apparatus according to any of claims 2, 3 and 5,
characterized in that the electromotive force estimating section (30) comprises:

- a first filter section (3 3b) for applying to the output of the current detector (13) a prescribed filtering with a zero point calculated from the inductance and resistance of the electromagnet (10);
- a second filter section (33a) for filtering the voltage command to the electromagnet (10); and
- a difference calculating section (23b) in the estimating section for calculating a difference between outputs of both of the filter sections (33a, 33b);
- wherein both of the filter sections (33a, 33b) have their time constants set to the same value.

8. The apparatus according to claim 5,
characterized in that the compensation section (24) comprises:

- an electromotive force compensating section (40) for compensating for the gain and phase of the output of the electromotive force estimating section (30);
- a spring force compensating section (41) operable to change its output value in accordance with the output of the armature operating current detecting section (18);
- an electromagnetic force compensating section (42) operable to change its output value to based on the output of the armature operating current detecting section (18) and the output of the current detector (13);
- a multiplying section (44) in the compensating section (24) for multiplying outputs of the electromotive force compensating section (40), the spring force compensating section (41) and the electromagnetic force compensating section (42) with one another;
- a difference calculating section (23d) in the compensating section (24) for calculating a difference between an output of the difference calculating section (23c) and an output of the multiplying section (44) in the compensating section (24);
- a differentiating section (27a) in the compensating section (24) for differentiating the output of the current detector (13);
- a switching section (45) for switching between an output of the difference calculating section (23d) in the compensating section (24) and a zero signal by means of an output of the differentiating section (27a) in the compensating section (24);

- a counterbalance voltage compensating section (47) for outputting a voltage signal so as to make the electromagnetic force balance with a force of a spring (7) in accordance with the output of the current detector (13); and
- an adding section (25c) in the compensating section (24) for adding an output of the switching section (45) and an output of the counterbalance voltage compensating section (47).

9. The apparatus according to claim 8,
characterized by:

- a timer section (43) for counting a period of time during which the electromagnet (10) is attracting the armature (11) thereby to release the brake; and
- a section (50a) for changing the gain of the electromotive force compensating section (40) based on an output of the timer section (43).

10. The apparatus according to claim 8,
characterized by:

a resistance value estimating section (51) for estimating a resistance value of the electromagnet (10) based on the voltage command to the electromagnet (10) and
the output of the current detector (13) when the electromagnet (10) is attracting the armature (11) thereby to release the brake, the resistance value estimating section (51) being operable to change the resistance value in the electromotive force estimating section (30) into this estimated value.

11. The apparatus according to claim 10,
characterized by a section (50b) for changing the gain in the compensating section (24) in accordance with an output of the resistance value estimating section (51).

Patentansprüche

1. Bremssteuervorrichtung für einen Aufzug, die folgendes aufweist:

- eine Schätzeinheit (30) für eine elektromotorische Kraft, um eine elektromotorische Kraft eines Elektromagneten (10) als Bremsspule zu schätzen, die aus einer Bewegungsgeschwindigkeit eines Ankers (11) resultiert, der von dem Elektromagneten (10) angezogen wird, wobei der Anker (11) eine Bremsbacke (8) einer Aufzugsbremse antriebsmäßig bewegt; und
- eine Kompensationseinheit (24), um dem Elektromagneten (10) einen Spannungsbefehl zuzuführen, der derart kompensiert ist, daß die elektromotorische Kraft oder ein integrierter Wert der elektromotorischen Kraft einem Zielwert entspricht;

wobei die dem Elektromagneten (10) zugeführte Spannung derart gesteuert wird, daß die Bewegungsgeschwindigkeit des Ankers (11) zu einem Zeitpunkt (T4) unterdrückt wird, in dem der Anker (11) beginnt, sich aus seiner an den Elektromagneten (10) angezogenen Halteposition wegzubewegen.

2. Vorrichtung nach Anspruch 1,
gekennzeichnet durch:

- einen Stromdetektor (13) zum Detektieren eines elektrischen Stroms, der durch den Elektromagneten (10) als Bremsspule fließt;
- wobei die Schätzeinheit (30) für elektromotorische Kraft dazu ausgebildet ist, eine von dem Elektromagneten (10) erzeugte elektromotorische Kraft auf der Basis eines Spannungsbefehls an den Elektromagneten (10) und eines Ausgangssignals des Stromdetektors (13) zu schätzen;
- eine Zielwert-Vorgabeeinheit (22) zum Bereitstellen eines Zielwertes für die elektromotorische Kraft;
- eine Differenzberechnungseinheit (23a, 23c) zum Berechnen einer Differenz zwischen dem Zielwert der elektromotorischen Kraft und der geschätzten elektromotorischen Kraft;
- wobei die Kompensationseinheit (24) dazu ausgebildet ist, die Verstärkung und die Phase eines Ausgangssignals der Differenzberechnungseinheit (23a, 23b) zu formen, um den Spannungsbefehl an den Elektromagneten (10) bereitzustellen;
- eine nichtlineare Kompensationseinheit (32) zum Durchführen einer Kompensation in einer derartigen Weise,

daß das Ausgangssignal des Stromdetektors (13) und der Spannungsbefehl an den Elektromagneten (10) eine proportionale Beziehung relativ zueinander aufweisen; und
- eine Einheit zum Einstellen eines Induktivitätswertes des Elektromagneten (10) in der Schätzeinheit (30) für elektromotorische Kraft in Abhängigkeit von dem Ausgangssignal des Stromdetektors (13).

3. Vorrichtung nach Anspruch 1,
gekennzeichnet durch:

- einen Stromdetektor (13) zum Detektieren eines elektrischen Stroms, der durch den Elektromagneten (10) als Bremsspule fließt;
- wobei die Schätzeinheit (30) für elektromotorische Kraft dazu ausgebildet ist, eine von dem Elektromagneten (10) erzeugte elektromotorische Kraft auf der Basis eines Spannungsbefehls an den Elektromagneten (10) und eines Ausgangssignals des Stromdetektors (13) zu schätzen;
- eine Einheit (34) zum Integrieren der von der Schätzeinheit (30) geschätzten elektromotorischen Kraft;
- eine Zielwert-Vorgabeeinheit (22) zum Bereitstellen eines Zielwertes für die elektromotorische Kraft;
- eine erste Differenzberechnungseinheit (23c) zum Berechnen einer Differenz zwischen einem Ausgangssignal der Zielwert-Vorgabeeinheit (22) und einem Ausgangssignal von der Einheit (34) zum Integrieren der elektromotorischen Kraft;
- eine zweite Differenzberechnungseinheit (23d) zum Berechnen einer Differenz zwischen einem Ausgangssignal der Schätzeinheit (30) für elektromotorische Kraft und einem Ausgangssignal der ersten Differenzberechnungseinheit (23c), um einen Spannungsbefehl an den Elektromagneten (10) bereitzustellen;
- eine nichtlineare Kompensationseinheit (32) zum Durchführen einer Kompensation in einer derartigen Weise, daß das Ausgangssignal des Stromdetektors (13) und der Spannungsbefehl an den Elektromagneten (10) eine proportionale Beziehung relativ zueinander aufweisen; und
- eine Einheit zum Einstellen eines Induktivitätswertes des Elektromagneten (10) in der Schätzeinheit (30) für elektromotorische Kraft in Abhängigkeit von dem Ausgangssignal des Stromdetektors (13).

4. Vorrichtung nach Anspruch 2,
gekennzeichnet durch eine Kompensator-Einstelleinheit (36) zum Ändern der Verstärkung der Kompensationseinheit (24) in Abhängigkeit von dem Ausgangswert des Stromdetektors (13), wenn die elektromotorische Kraft erzeugt wird, auf der Basis des Ausgangssignals der Schätzeinheit (30) für elektromotorische Kraft und des Ausgangssignals des Stromdetektors (13).

5. Vorrichtung nach Anspruch 1,
gekennzeichnet durch:

- einen Stromdetektor (13) zum Detektieren eines elektrischen Stroms, der durch den Elektromagneten (10) als Bremsspule fließt;
- wobei die Schätzeinheit (30) für eine elektromotorische Kraft dazu ausgebildet ist, eine von dem Elektromagneten (10) erzeugte elektromotorische Kraft auf der Basis eines Spannungsbefehls an den Elektromagneten (10) und eines Ausgangssignals des Stromdetektors (13) zu schätzen;
- eine Einheit (34) zum Integrieren einer von der Schätzeinheit (30) geschätzten elektromotorischen Kraft;
- eine Zielwert-Vorgabeeinheit (22) zum Bereitstellen eines Zielwertes für einen integrierten Wert der elektromotorischen Kraft;
- eine Differenzberechnungseinheit (23c) zum Berechnen einer Differenz zwischen einem Ausgangssignal der Zielwert-Vorgabeeinheit (22) und einem Ausgangssignal von der Einheit (34) zum Integrieren der elektromotorischen Kraft;
- eine Ankerbetätigungsstrom-Erfassungseinheit (18) zum Detektieren eines Spulenstromwerts, bei dem der Anker (11) des Elektromagneten (10) den Betrieb aufnimmt, auf der Basis des Ausgangssignals des Stromdetektors (13);
- wobei die Kompensationseinheit (24) dazu ausgebildet ist, dem Elektromagneten (10) einen Spannungsbefehl auf der Basis der Ausgangssignale des Stromdetektors (13), der Schätzeinheit (30) für elektromotorische Kraft, der Differenzberechnungseinheit (23c) und der Ankerbetätigungsstrom-Erfassungseinheit (18) zuzuführen; und
- eine Einheit zum Einstellen eines Induktivitätswertes des Elektromagneten (10) in der Schätzeinheit (30) für eine elektromotorische Kraft in Abhängigkeit von dem Ausgangssignal des Stromdetektors (13).

6. Vorrichtung nach einem der Ansprüche 2, 3 und 5,
dadurch gekennzeichnet,

daß die Schätzeinheit (30) für eine elektromotorische Kraft folgendes aufweist:

- eine Einheit zum Differenzieren des Ausgangssignals des Stromdetektors (13);
- eine Einheit zum Multiplizieren des differenzierten Signals mit der Induktivität des Elektromagneten (10);
- eine Einheit zum Multiplizieren des Ausgangssignals des Stromdetektors (13) mit einem Widerstandswert des Elektromagneten (10);
- eine Addiereinheit (25b) in der Schätzeinheit zum Addieren der beiden Multiplikationssignale; und
- eine Differenzberechnungseinheit (23b) in der Schätzeinheit zum Subtrahieren eines Ausgangssignals der Addiereinheit (25b) von dem Spannungsbefehl an den Elektromagneten (10).

7. Vorrichtung nach einem der Ansprüche 2, 3 und 5,
dadurch gekennzeichnet,
daß die Schätzeinheit (30) für eine elektromotorische Kraft folgendes aufweist:

- eine erste Filtereinheit (33b), um an dem Ausgangssignal des Stromdetektors (13) eine vorbestimmte Filterung mit einem Nullpunkt vorzunehmen, der aus der Induktivität und dem Widerstand des Elektromagneten (10) berechnet wird;
- eine zweite Filtereinheit (33a) zum Filtern des Spannungsbefehls an den Elektromagneten (10); und
- eine Differenzberechnungseinheit (23b) in der Schätzeinheit zum Berechnen einer Differenz zwischen den Ausgangssignalen von den beiden Filtereinheiten (33a, 33b);
- wobei bei beiden Filtereinheiten (33a, 33b) deren Zeitkonstanten auf den gleichen Wert eingestellt sind.

8. Vorrichtung nach Anspruch 5,
dadurch gekennzeichnet,
daß die Kompensationseinheit (24) folgendes aufweist:

- eine Kompensationseinheit (40) für eine elektromotorische Kraft, um die Verstärkung und die Phase des Ausgangssignals der Schätzeinheit (30) für eine elektromotorische Kraft zu kompensieren;
- eine Federkraft-Kompensationseinheit (41), die betriebsmäßig dazu ausgebildet ist, ihren Ausgangswert in Abhängigkeit von dem Ausgangssignal der Ankerbetätigungsstrom-Erfassungseinheit (18) zu ändern;
- eine Kompensationseinheit (42) für eine elektromagnetische Kraft, die betriebsmäßig dazu ausgebildet ist, ihren Ausgangswert auf der Basis des Ausgangssignals der Ankerbetätigungsstrom-Erfassungseinheit (18) und des Ausgangssignals des Stromdetektors (13) zu ändern;
- eine Multipliziereinheit (44) in der Kompensationseinheit (24) zum Multiplizieren von Ausgangssignalen der Kompensationseinheit (40) für eine elektromagnetische Kraft, der Federkraft-Kompensationseinheit (41) und der Kompensationseinheit (42) für eine elektromagnetische Kraft miteinander;
- eine Differenzberechnungseinheit (23d) in der Kompensationseinheit (24) zum Berechnen einer Differenz zwischen einem Ausgangssignal der Differenzberechnungseinheit (23c) und einen Ausgangssignal der Multipliziereinheit (44) in der Kompensationseinheit (24);
- eine Differenziereinheit (27a) in der Kompensationseinheit (24) zum Differenzieren des Ausgangssignals des Stromdetektors (13);
- eine Schalteinheit (45) zum Umschalten zwischen einem Ausgangssignal der Differenzberechnungseinheit (23d) in der Kompensationseinheit (24) und einem Null-Signal mittels eines Ausgangssignals der Differenziereinheit (27a) in der Kompensationseinheit (24); und
- eine Ausgleichs-Spannungskompensationseinheit (47) zum Abgeben eines Spannungssignals, um die elektromagnetische Kraft mit einer Kraft einer Feder (7) in Abhängigkeit von dem Ausgangssignal des Stromdetektors (13) ins Gleichgewicht zu bringen; und
- eine Addiereinheit (25c) in der Kompensationseinheit (24) zum Addieren eines Ausgangssignals der Schalteinheit (45) und eines Ausgangssignals der Ausgleichs-Spannungskompensationseinheit (47).

9. Vorrichtung nach Anspruch 8,
gekennzeichnet durch:

- eine Zeitgebereinheit (43) zum Zählen einer Zeitdauer, während der Elektromagnet (10) den Anker (11) anzieht, um **dadurch** die Bremse zu lösen; und
- eine Einheit (50a) zum Ändern der Verstärkung der Kompensationseinheit (40) für eine elektromotorische Kraft auf der Basis eines Ausgangssignals der Zeitgebereinheit (43).

10. Vorrichtung nach Anspruch 8,
gekennzeichnet durch:

eine Widerstandswert-Schätzeinheit (51) zum Schätzen eines Widerstandswerts des Elektromagneten (10) auf der Basis des Spannungsbefehls an den Elektromagneten (10) und des Ausgangssignals des Stromdetektors (13), wenn der Elektromagnet (10) den Anker (11) anzieht,
um **dadurch** die Bremse zu lösen, wobei die Widerstandswert-Schätzeinheit (51) betriebsmäßig dazu ausgebildet ist, den Widerstandswert in der Schätzeinheit (30) für eine elektromotorische Kraft in diesen Schätzwert zu ändern.

11. Vorrichtung nach Anspruch 10,
gekennzeichnet durch eine Einheit (50b) zum Ändern der Verstärkung in der Kompensationseinheit (24) in Abhängigkeit von einem Ausgangssignal der Widerstandswert-Schätzeinheit (51).

Revendications

1. Appareil de commande de frein pour un ascenseur, comprenant:

- une section d'estimation de force électromotrice (30) pour estimer une force électromotrice d'un électroaimant (10) à titre de bobine de frein résultant d'une vitesse de déplacement d'une armature (11) attirée vers l'électroaimant (10), laquelle armature (11) entraîne un sabot de frein (8) d'un frein d'ascenseur; et
- une section de compensation (24) pour fournir à l'électroaimant (10) un ordre de voltage qui est compensé de façon à accorder la force électromotrice ou une valeur intégrée de la force électromotrice à une valeur cible;

dans lequel le voltage fourni à l'électroaimant (10) est commandé de manière à supprimer la vitesse de déplacement de l'armature (11) à un instant (T4) quand l'armature (11) commence à se déplacer en éloignement de sa position de retenue attirée contre l'électroaimant (10).

2. Appareil selon la revendication 1,
caractérisé par:

- un détecteur de courant (13) pour détecter un courant électrique qui s'écoule à travers l'électroaimant (10) à titre de bobine de frein;
- dans lequel la section d'estimation de force électromotrice (30) est adaptée à estimer une force électromotrice générée par l'électroaimant (10) en se basant sur un ordre de voltage à l'électroaimant (10) et sur une sortie du détecteur de courant (13);
- une section de fixation de valeur cible (22) pour fournir une valeur cible pour la force électromotrice;
- une section de calcul de différence (23a, 23c) pour calculer une différence entre la valeur cible de force électromotrice et la force électromotrice estimée;
- dans lequel la section de compensation (24) est adaptée à mettre en forme le gain et la phase d'une sortie de la section de calcul de différence (23a, 23c) pour fournir l'ordre de voltage à l'électroaimant (10);
- une section de compensation non linéaire (32) pour effectuer une compensation de manière à faire que la sortie du détecteur de courant (13) et l'ordre de voltage à l'électroaimant (10) présentent une relation proportionnelle l'une avec l'autre; et
- une section pour ajuster une valeur d'inductance de l'électroaimant (10) dans la section d'estimation de force électromotrice (30) en accord avec la sortie du détecteur de courant (13).

3. Appareil selon la revendication 1,
caractérisé par:

- un détecteur de courant (13) pour détecter un courant électrique qui s'écoule à travers l'électroaimant (10) à titre de bobine de frein;
- dans lequel la section d'estimation de force électromotrice (30) est adaptée à estimer une force électromotrice générée par l'électroaimant (10) en se basant sur un ordre de voltage à l'électroaimant (10) et sur une sortie du détecteur de courant (13);
- une section (34) pour intégrer la force électromotrice estimée par la section d'estimation de force électromotrice (30);

- une section de fixation de valeur cible (22) pour fournir une valeur cible pour la force électromotrice;
- une première section de calcul de différence (23c) pour calculer une différence entre une sortie de la section de fixation de valeur cible (22) et une sortie de la section d'intégration de force électromotrice (34);
- une seconde section de calcul de différence (23d) pour calculer une différence entre une sortie de la section d'estimation de force électromotrice (30) et une sortie de la première section de calcul de différence (23c) pour fournir un ordre de voltage à l'électroaimant (10);
- une section de compensation non linéaire (32) pour effectuer une compensation de manière à faire que la sortie du détecteur de courant (13) et l'ordre de voltage à l'électroaimant (10) présentent une relation proportionnelle l'une par rapport à l'autre; et
- une section pour ajuster une valeur d'inductance de l'électroaimant (10) dans la section d'estimation de force électromotrice (30) en accord avec la sortie du détecteur de courant (13).

4. Appareil selon la revendication 2,
caractérisé par une section d'ajustement de compensateur (36) pour changer le gain de la section de compensation (24) en accord avec la valeur de sortie du détecteur de courant (13) quand la force électromotrice est générée, en se basant sur la sortie de la section d'estimation de force électromotrice (30) et sur la sortie du détecteur de courant (13).

5. Appareil selon la revendication 1,
caractérisé par:

- un détecteur de courant (13) pour détecter un courant électrique qui s'écoule à travers l'électroaimant (10) à titre de bobine de frein;
- dans lequel la section d'estimation de force électromotrice (30) est adaptée à estimer une force électromotrice générée par l'électroaimant (10) en se basant sur un ordre de voltage à l'électroaimant (10) et sur une sortie du détecteur de courant (13);
- une section (34) pour intégrer une force électromotrice estimée par la section d'estimation de force électromotrice (30);
- une section de fixation de valeur cible (22) pour fournir une valeur cible pour une valeur intégrée de la force électromotrice;
- une section de calcul de différence (23c) pour calculer une différence entre une sortie de la section de fixation de valeur cible (22) et une sortie de la section d'intégration de force électromotrice (34);
- une section de détection de courant de fonctionnement d'armature (18) pour détecter une valeur du courant de bobine à laquelle l'armature (11) de l'électroaimant (10) commence à fonctionner, en se basant sur la sortie du détecteur de courant (13);
- dans lequel la section de compensation (24) est adaptée à fournir un ordre de voltage à l'électroaimant (10) en se basant sur les sorties du détecteur de courant (13), de la section d'estimation de force électromotrice (30), de la section de calcul de différence (23c), et de la section de détection de courant de fonctionnement d'armature (18); et
- une section pour ajuster une valeur d'inductance de l'électroaimant (10) dans la section d'estimation de force électromotrice (30) en accord avec la sortie du détecteur de courant (13).

6. Appareil selon l'une quelconque des revendications 2, 3 et 5, caractérisé ensuite la section d'estimation de force électromotrice (30) comprend:

- une section pour différencier la sortie du détecteur de courant (13);
- une section pour multiplier le signal différencié par l'inductance de l'électroaimant (10);
- une section pour multiplier la sortie du détecteur de courant (13) par une valeur de résistance de l'électroaimant (10);
- une section d'addition (25b) dans la section d'estimation pour additionner les deux signaux de multiplication; et
- une section de calcul de différence (23b) dans la section d'estimation pour soustraire une sortie de la section d'addition (25b) depuis l'ordre de voltage à l'électroaimant (10).

7. Appareil selon l'une quelconque des revendications 2, 3 et 5, **caractérisé en ce que** la section d'estimation de force électromotrice (30) comprend:

- une première section de filtre (33b) pour appliquer à la sortie du détecteur de courant (13) un filtrage prescrit avec un point zéro calculé à partir de l'inductance et de la résistance de l'électroaimant (10);

- une seconde section de filtre (33a) pour filtrer l'ordre de voltage à l'électroaimant (10); et
- une section de calcul de différence (23b) dans la section d'estimation pour calculer une différence entre les sorties des deux sections de filtre (33a, 33b);
- dans lequel les deux sections de filtre (33a, 33b) sont telles que leurs constantes temporelles sont fixées à la même valeur.

8. Appareil selon la revendication 5,
caractérisé en ce que la section de compensation (24) comprend:

- une section de compensation de force électromotrice (40) pour compenser le gain et la phase de la sortie de la section d'estimation de force électromotrice (30);
- une section de compensation de force élastique (41) dont la fonction est de changer sa valeur de sortie en accord avec la sortie de la section de détection de courant de fonctionnement d'armature (18);
- une section de compensation de force électromagnétique (42) dont la fonction est de changer sa valeur de sortie pour la baser sur la sortie de la section de détection de courant de fonctionnement d'armature (18) et sur la sortie du détecteur de courant (13);
- une section de multiplication (44) dans la section de compensation (24) pour multiplier les sorties de la section de compensation de force électromotrice (40), de la section de compensation de force élastique (41) et de la section de compensation de force électromagnétique (42) les unes avec les autres;
- une section de calcul de différence (23d) dans la section de compensation (24) pour calculer une différence entre une sortie de la section de calcul de différence (23c) et une sortie de la section de multiplication (44) dans la section de compensation (24);
- une section de différenciation (27a) dans la section de compensation (24) pour différencier la sortie du détecteur de courant (13);
- une section de commutation (45) pour commuter entre une sortie de la section de calcul de différence (23d) dans la section de compensation (24) et un signal zéro au moyen d'une sortie de la section de différenciation (27a) dans la section de compensation (24);
- une section de compensation de voltage d'équilibrage (47) pour sortir un signal de voltage de manière à équilibrer la force électromagnétique avec une force d'un ressort (7) en accord avec la sortie du détecteur de courant (13); et
- une section d'addition (25c) dans la section de compensation (24) pour additionner une sortie de la section de commutation (45) et une sortie de la section de compensation de voltage d'équilibrage (47).

9. Appareil selon la revendication 8,
caractérisé par:

- une section de temporisation (43) pour compter une période temporelle pendant laquelle l'électroaimant (10) attire l'armature (11) pour relâcher ainsi le frein; et
- une section (50a) pour changer le gain de la section de compensation de force électromotrice (40) en se basant sur une sortie de la section de temporisation (43).

10. Appareil selon la revendication 8,
caractérisé par:

une section d'estimation de valeur de résistance (51) pour estimer une valeur de résistance de l'électroaimant (10) en se basant sur l'ordre de voltage à l'électroaimant (10) et sur la sortie du détecteur de courant (13) quand l'électroaimant (10) attire l'armature (11), pour relâcher ainsi le frein,
la section d'estimation de valeur de résistance (51) ayant pour fonction de changer la valeur de résistance dans la section d'estimation de force électromotrice (30) vers cette valeur estimée.

11. Appareil selon la revendication 10,
caractérisé par une section (50b) pour changer le gain dans la section de compensation (24) en accord avec une sortie de la section d'estimation de valeur de résistance (51).

FIG. 1

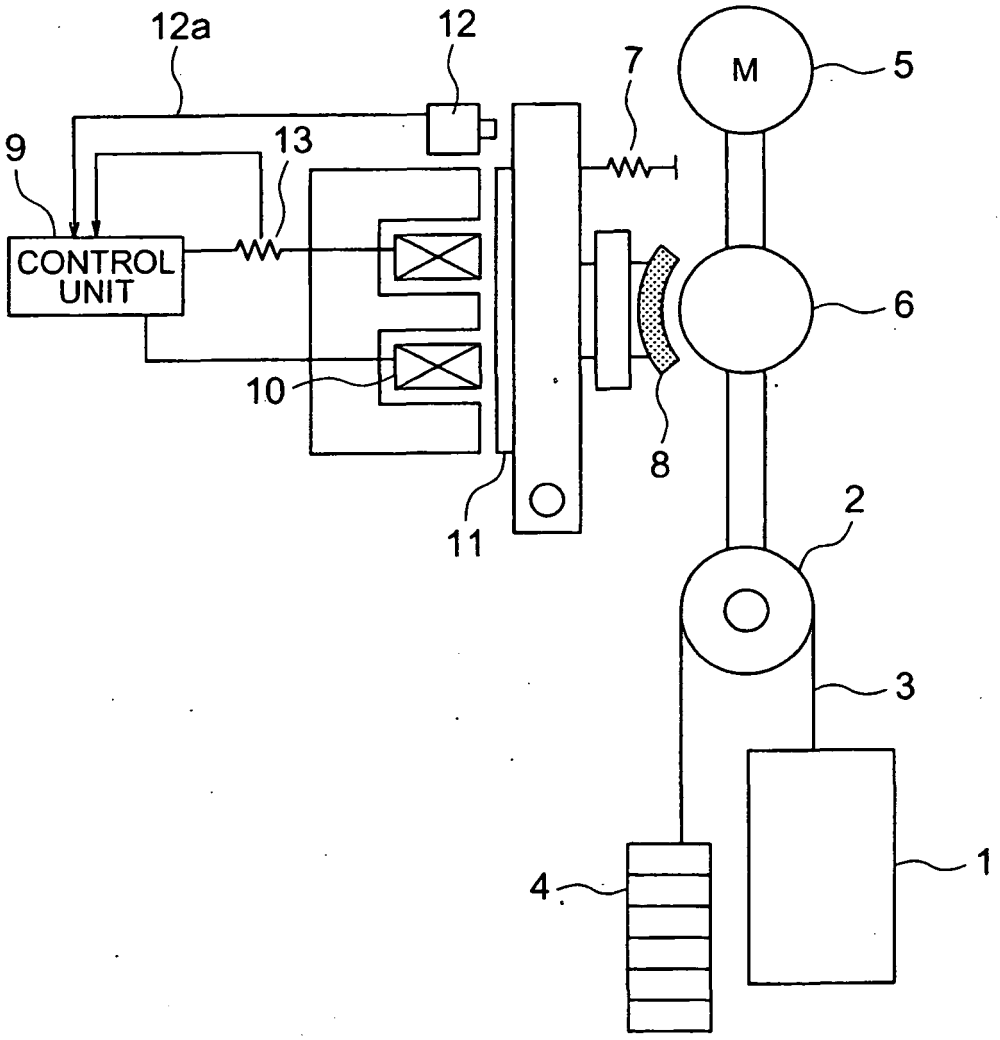


FIG. 2

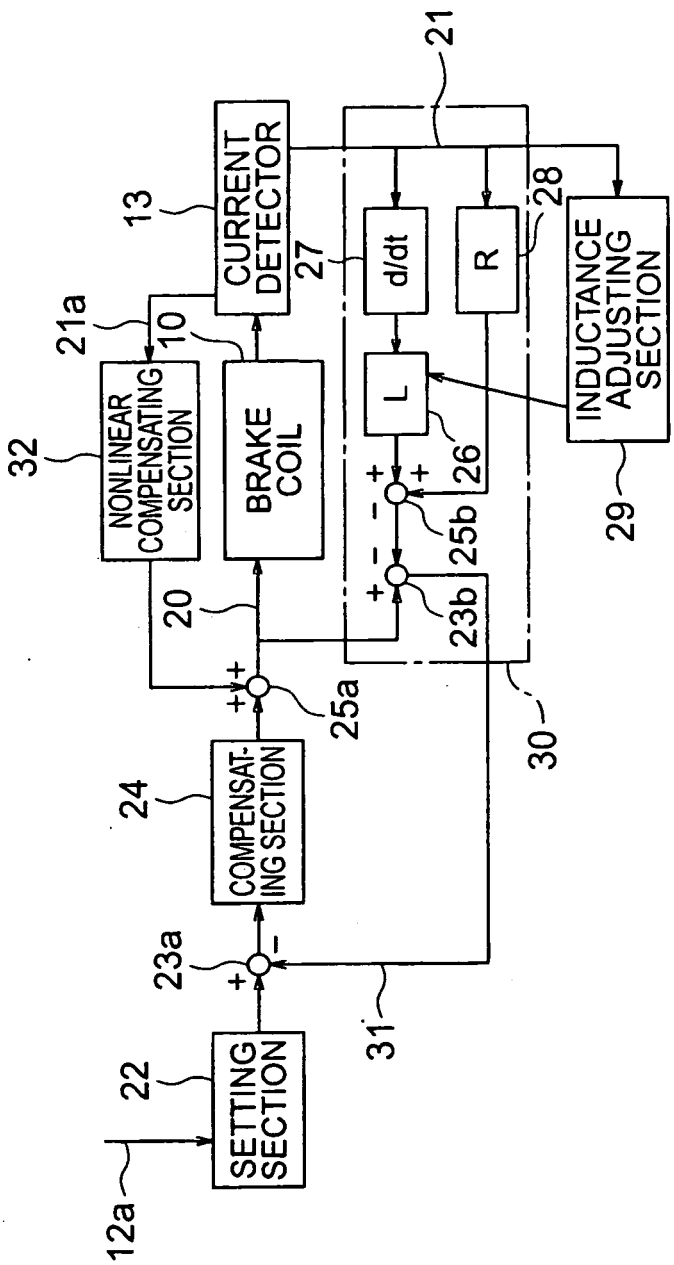

21
13
CURRENT DETECTOR
27
d/dt
R
28
INDUCTANCE ADJUSTING SECTION
29
21a
10
NONLINEAR COMPENSATING SECTION
32
BRAKE COIL
L
26
25b
23b
20
25a
30
24
COMPENSATING SECTION
23a
31
22
SETTING SECTION
12a

FIG. 3

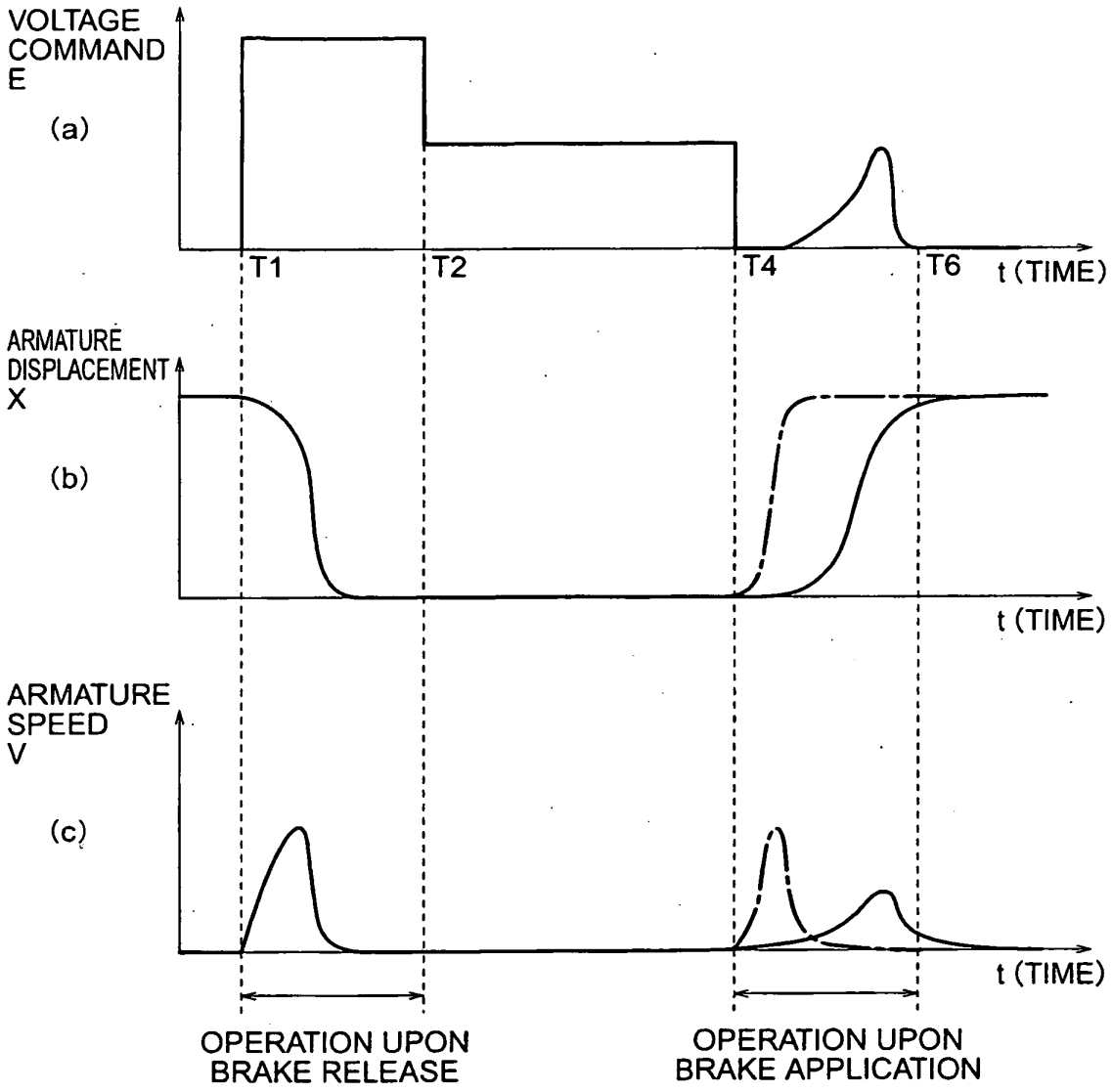

VOLTAGE COMMAND E
(a)
T1
T2
T4
T6
t (TIME)
ARMATURE DISPLACEMENT X
(b)
t (TIME)
ARMATURE SPEED V
(c)
t (TIME)
OPERATION UPON BRAKE RELEASE
OPERATION UPON BRAKE APPLICATION

FIG. 4

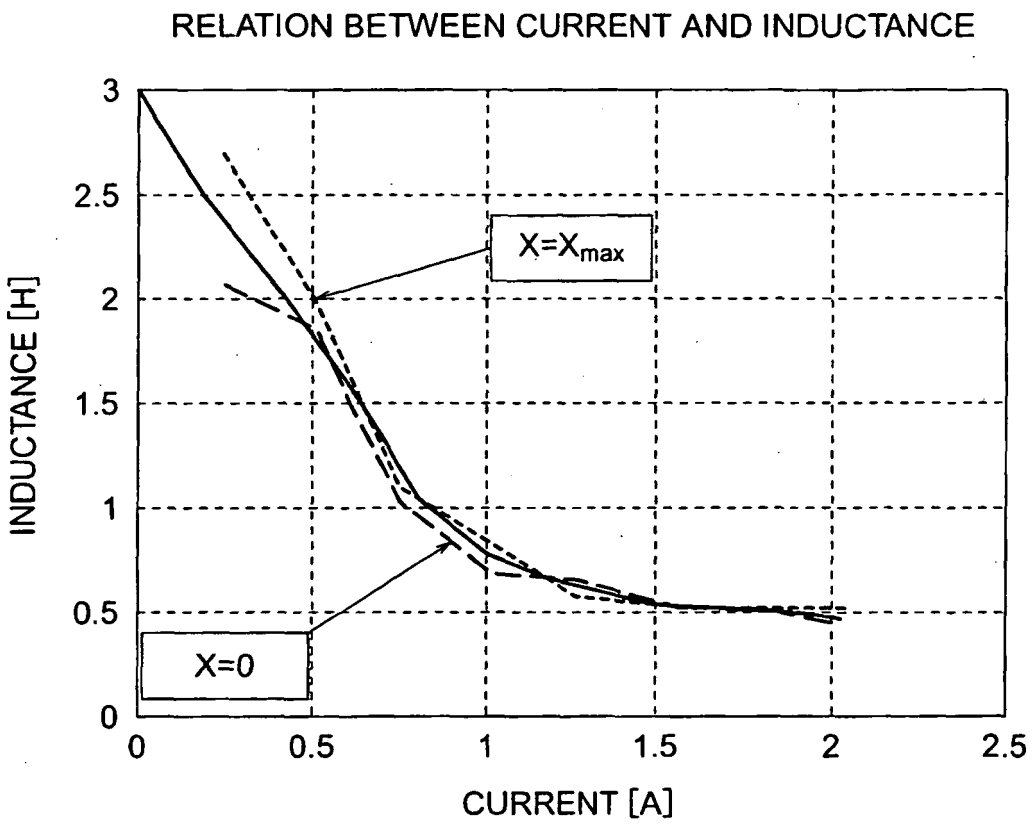

RELATION BETWEEN CURRENT AND INDUCTANCE
INDUCTANCE [H]
CURRENT [A]
X=Xmax
X=0
0
0.5
1
1.5
2
2.5
3

FIG. 5

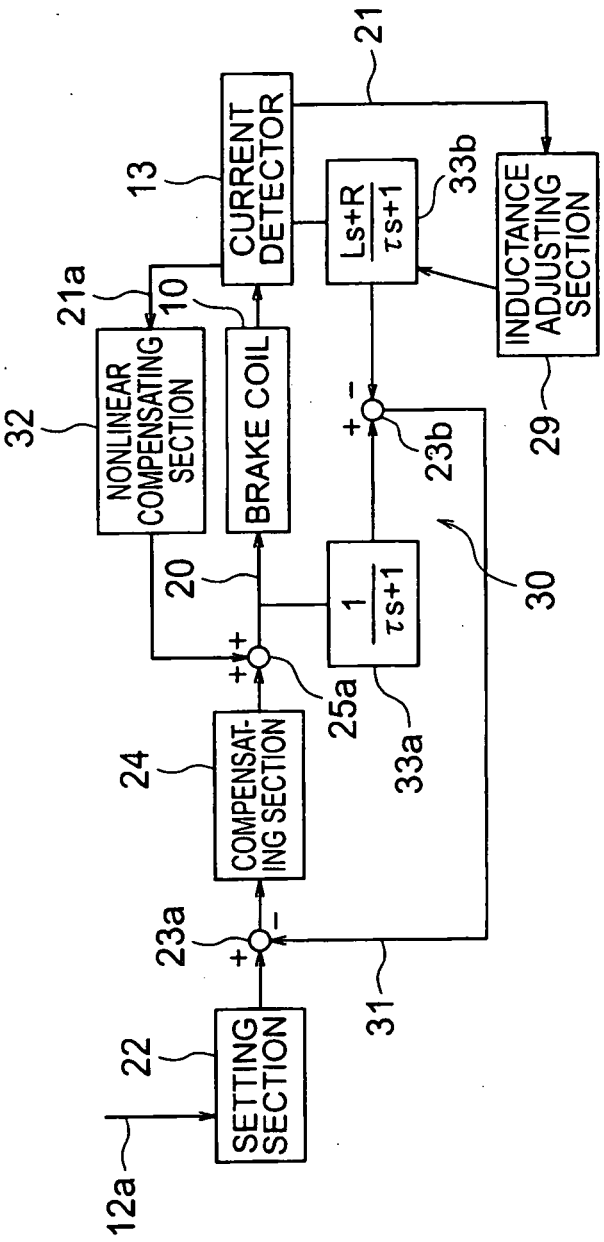

12a
SETTING SECTION
22
23a
+
−
COMPENSATING SECTION
24
+
+
20
25a
NONLINEAR COMPENSATING SECTION
32
21a
10
BRAKE COIL
13
CURRENT DETECTOR
21
Ls+R / τs+1
33b
1 / τs+1
33a
+
−
23b
30
31
INDUCTANCE ADJUSTING SECTION
29

FIG. 6

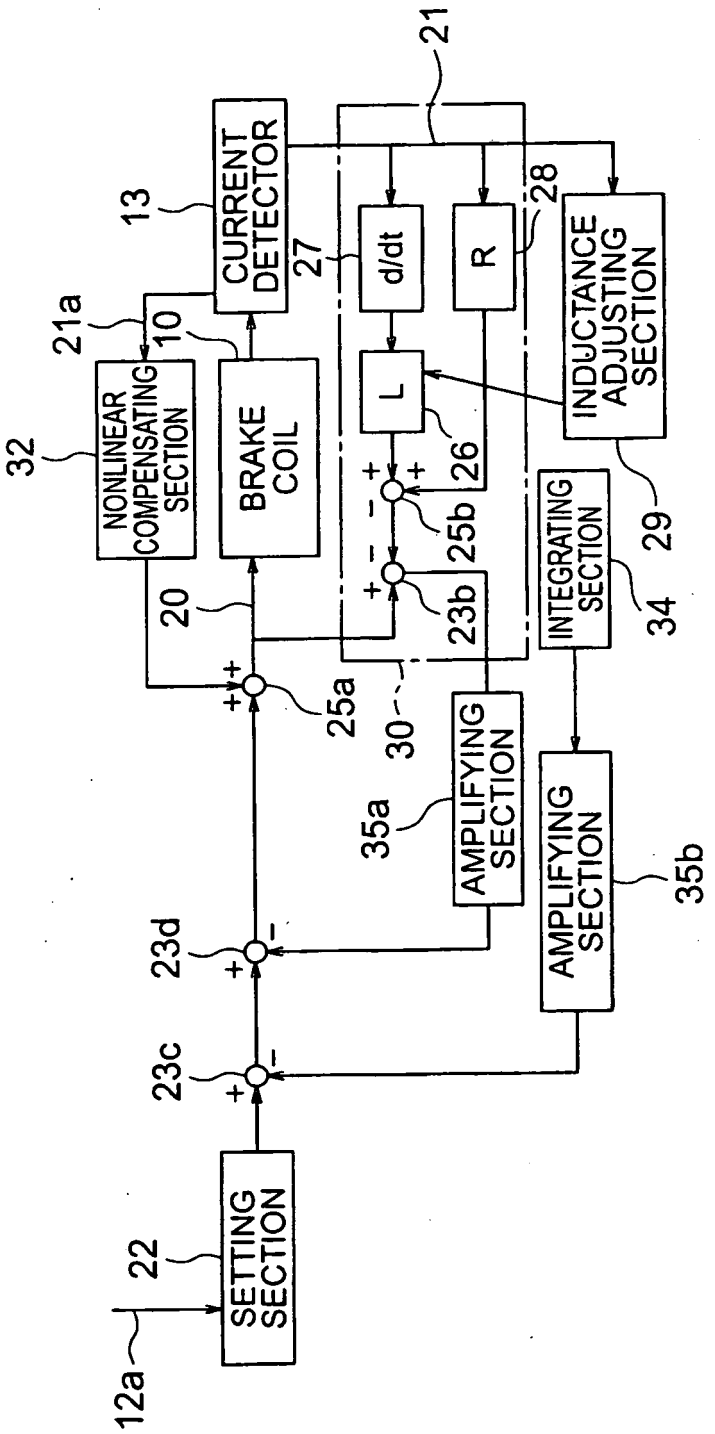

21
CURRENT DETECTOR
13
27
d/dt
R
28
INDUCTANCE ADJUSTING SECTION
21a
10
L
26
29
32
NONLINEAR COMPENSATING SECTION
BRAKE COIL
25b
INTEGRATING SECTION
34
20
23b
25a
30
AMPLIFYING SECTION
35a
AMPLIFYING SECTION
35b
23d
23c
SETTING SECTION
22
12a

FIG. 7

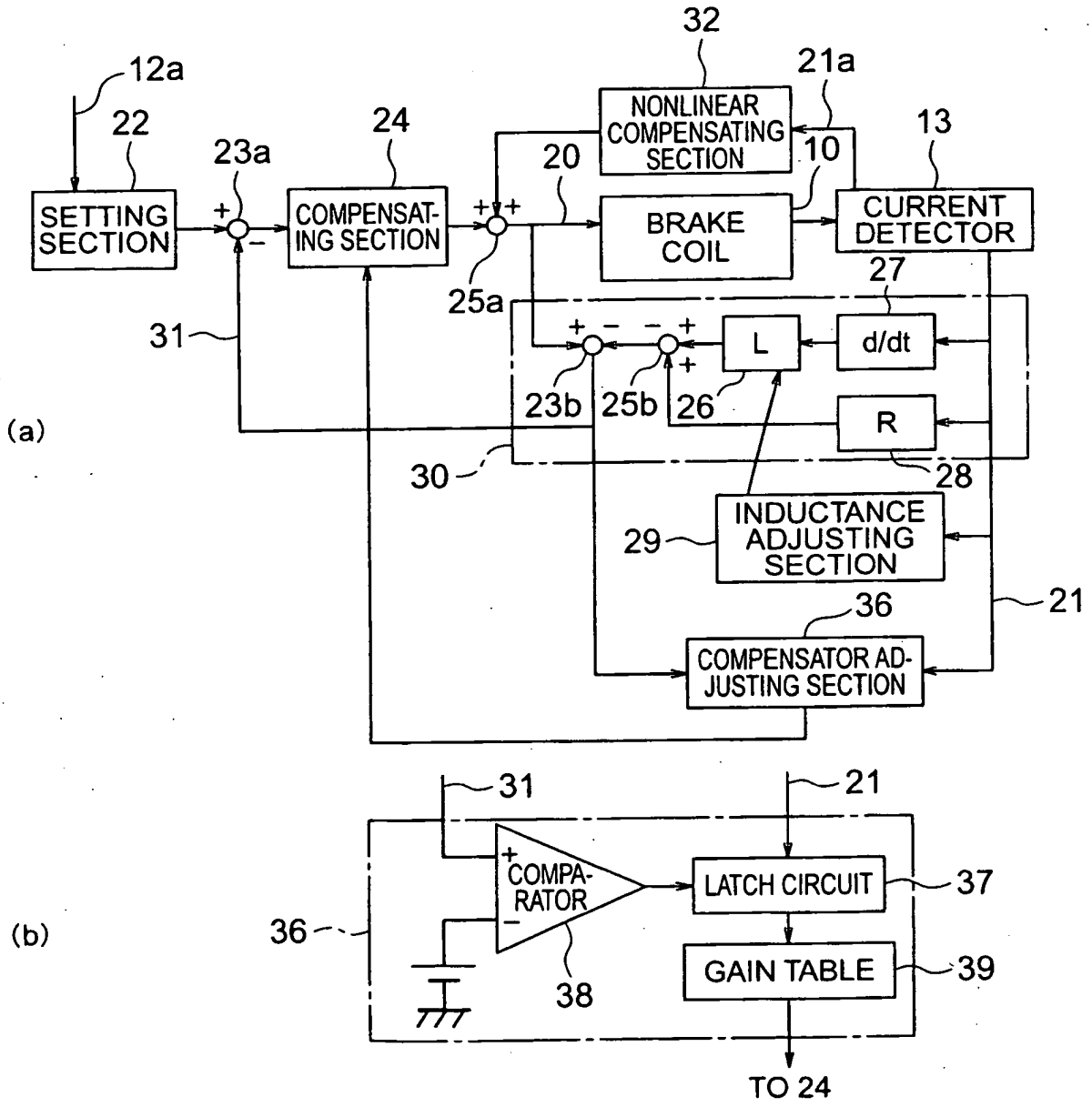

(a)
12a
22
SETTING SECTION
23a
24
COMPENSATING SECTION
20
32
NONLINEAR COMPENSATING SECTION
21a
10
BRAKE COIL
13
CURRENT DETECTOR
27
25a
31
L
d/dt
23b
25b
26
R
28
30
INDUCTANCE ADJUSTING SECTION
29
21
36
COMPENSATOR ADJUSTING SECTION
(b)
31
21
COMPARATOR
LATCH CIRCUIT
37
36
GAIN TABLE
39
38
TO 24

FIG. 8

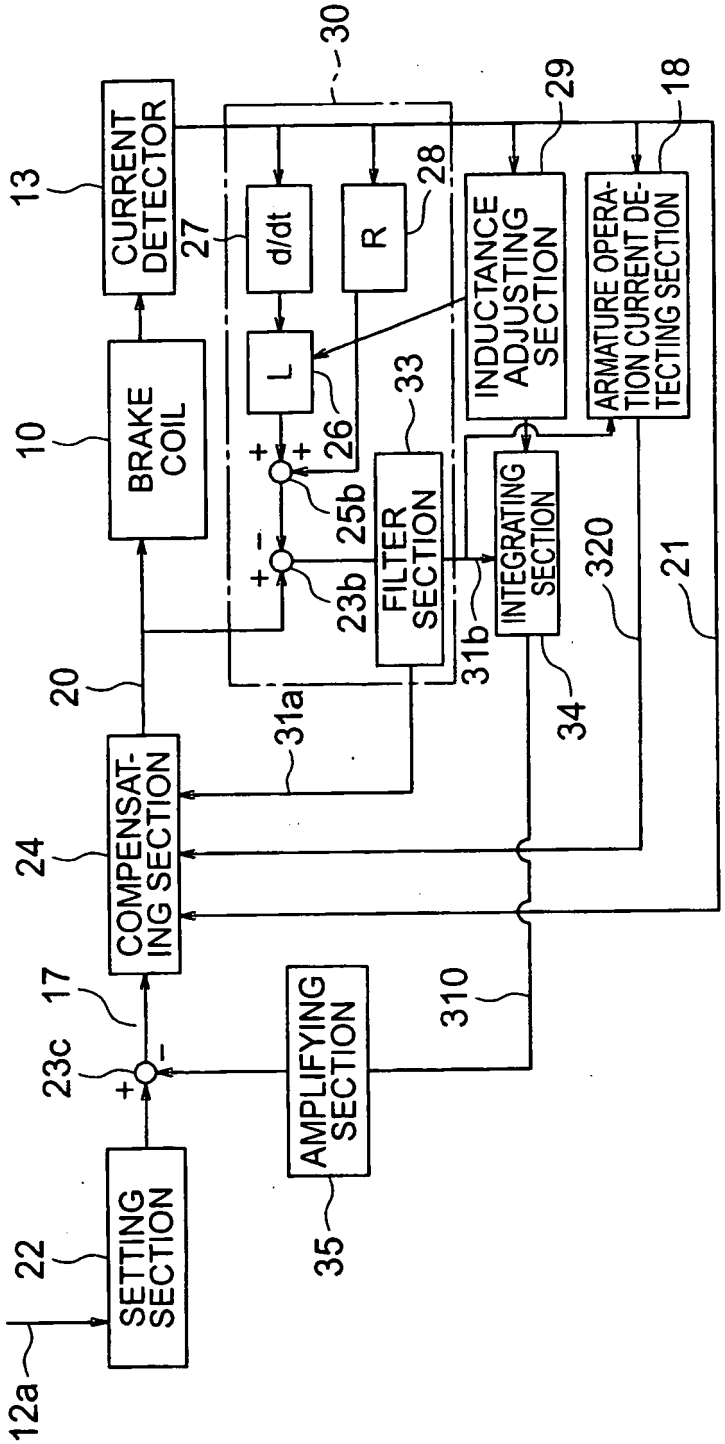

30
29
18
13
CURRENT DETECTOR
27
d/dt
R
28
INDUCTANCE ADJUSTING SECTION
ARMATURE OPERATION CURRENT DETECTING SECTION
10
BRAKE COIL
L
26
33
25b
23b
FILTER SECTION
INTEGRATING SECTION
320
21
20
31b
31a
34
COMPENSATING SECTION
24
17
23c
AMPLIFYING SECTION
310
22
SETTING SECTION
35
12a

FIG. 9

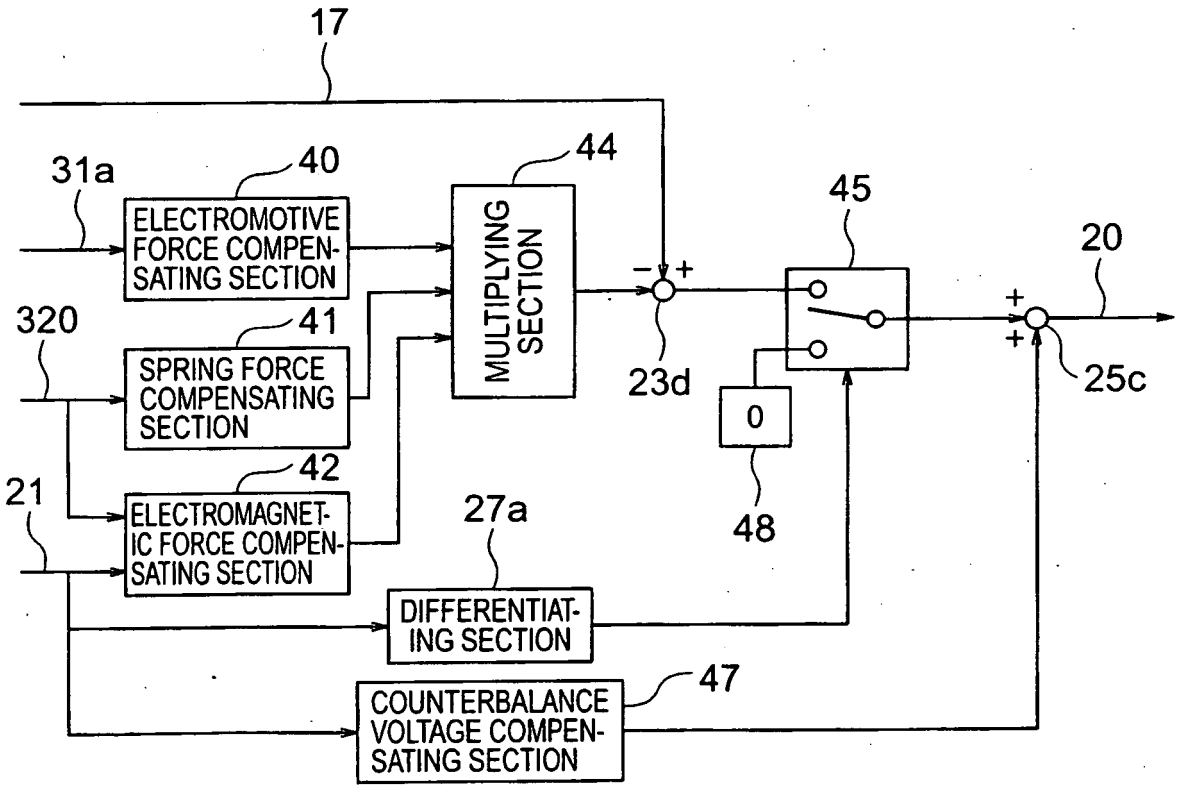

17
31a
40
ELECTROMOTIVE FORCE COMPEN-SATING SECTION
44
MULTIPLYING SECTION
45
20
320
41
SPRING FORCE COMPENSATING SECTION
23d
0
25c
21
42
ELECTROMAGNET-IC FORCE COMPEN-SATING SECTION
27a
48
DIFFERENTIAT-ING SECTION
47
COUNTERBALANCE VOLTAGE COMPEN-SATING SECTION

FIG. 10

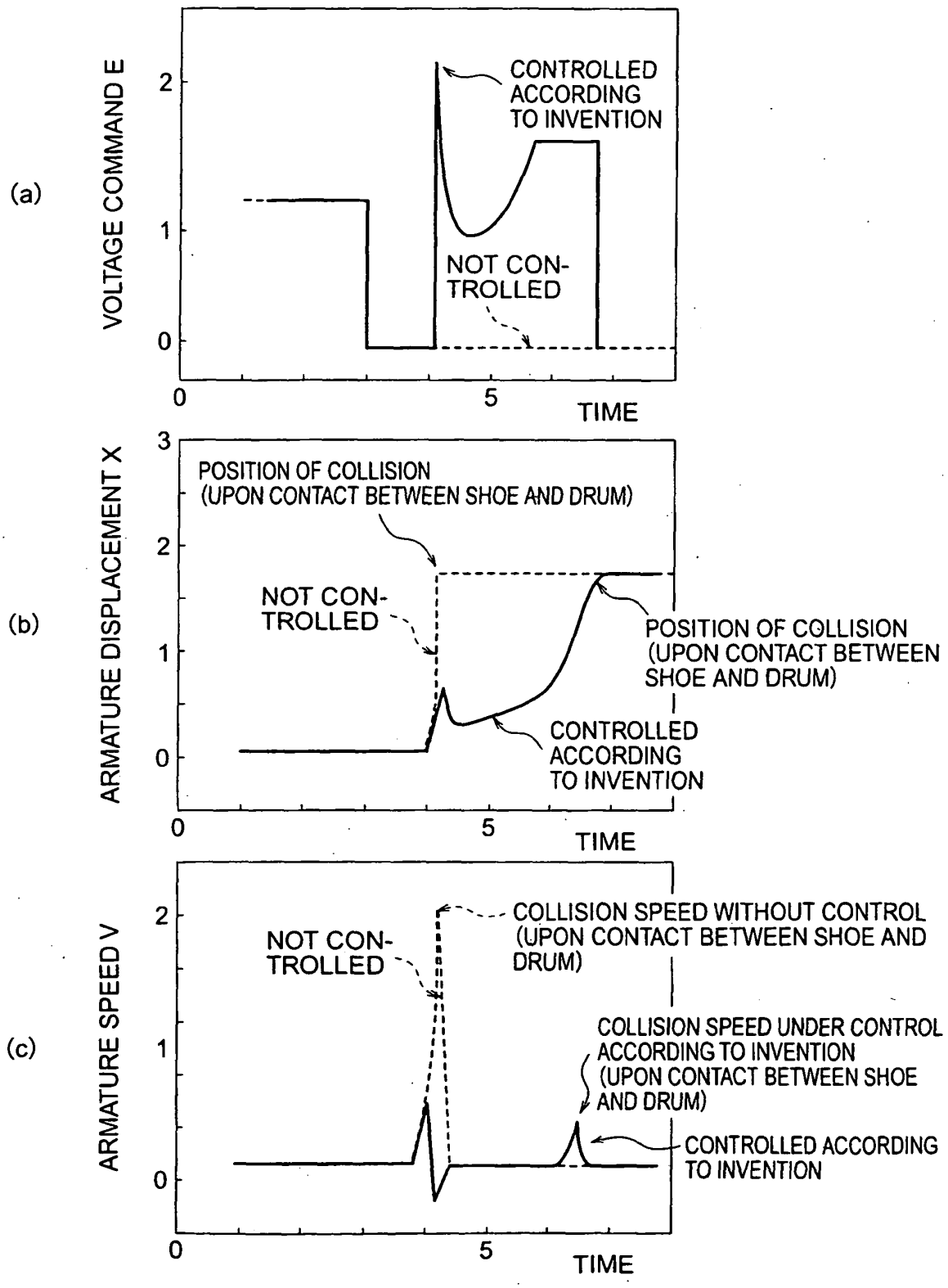

(a)
VOLTAGE COMMAND E
2
1
0
CONTROLLED ACCORDING TO INVENTION
NOT CON-TROLLED
0
5
TIME
(b)
ARMATURE DISPLACEMENT X
3
2
1
0
POSITION OF COLLISION (UPON CONTACT BETWEEN SHOE AND DRUM)
NOT CON-TROLLED
POSITION OF COLLISION (UPON CONTACT BETWEEN SHOE AND DRUM)
CONTROLLED ACCORDING TO INVENTION
0
5
TIME
(c)
ARMATURE SPEED V
2
1
0
NOT CON-TROLLED
COLLISION SPEED WITHOUT CONTROL (UPON CONTACT BETWEEN SHOE AND DRUM)
COLLISION SPEED UNDER CONTROL ACCORDING TO INVENTION (UPON CONTACT BETWEEN SHOE AND DRUM)
CONTROLLED ACCORDING TO INVENTION
0
5
TIME

FIG. 11

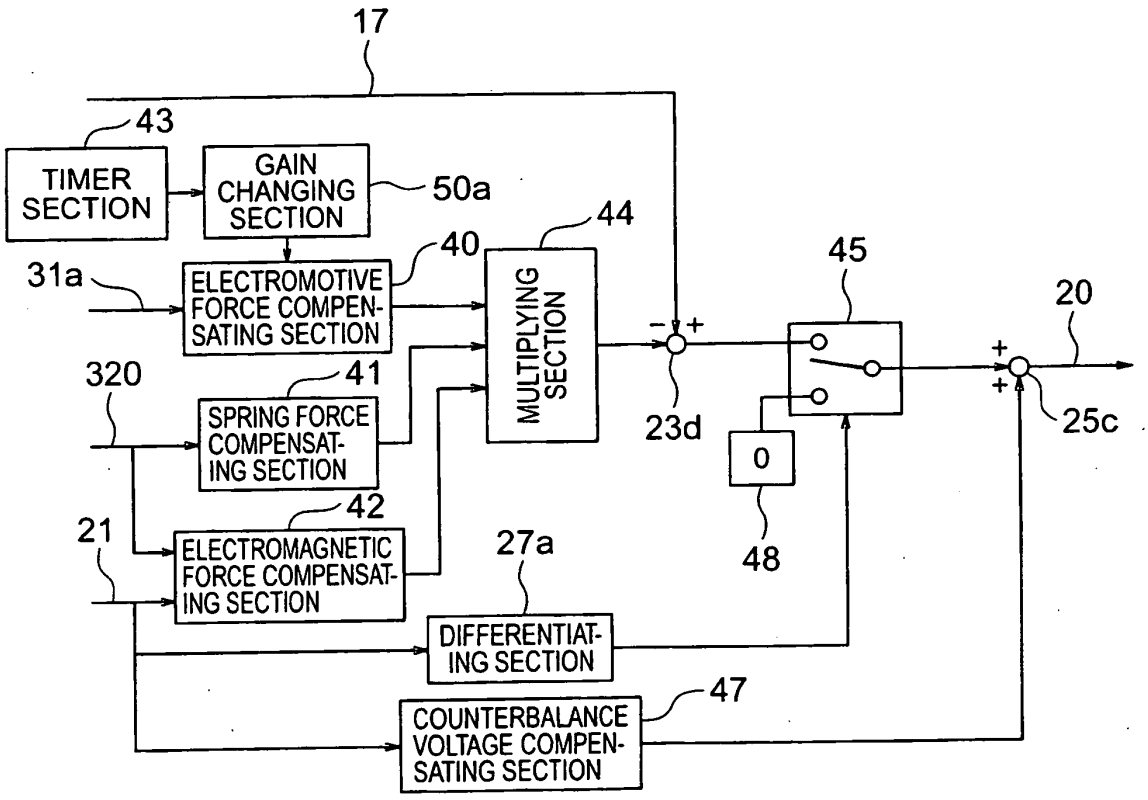

17
43
TIMER SECTION
GAIN CHANGING SECTION
50a
44
40
31a
ELECTROMOTIVE FORCE COMPENSATING SECTION
MULTIPLYING SECTION
45
20
320
41
SPRING FORCE COMPENSATING SECTION
23d
25c
0
48
42
21
ELECTROMAGNETIC FORCE COMPENSATING SECTION
27a
DIFFERENTIATING SECTION
47
COUNTERBALANCE VOLTAGE COMPENSATING SECTION

FIG. 12

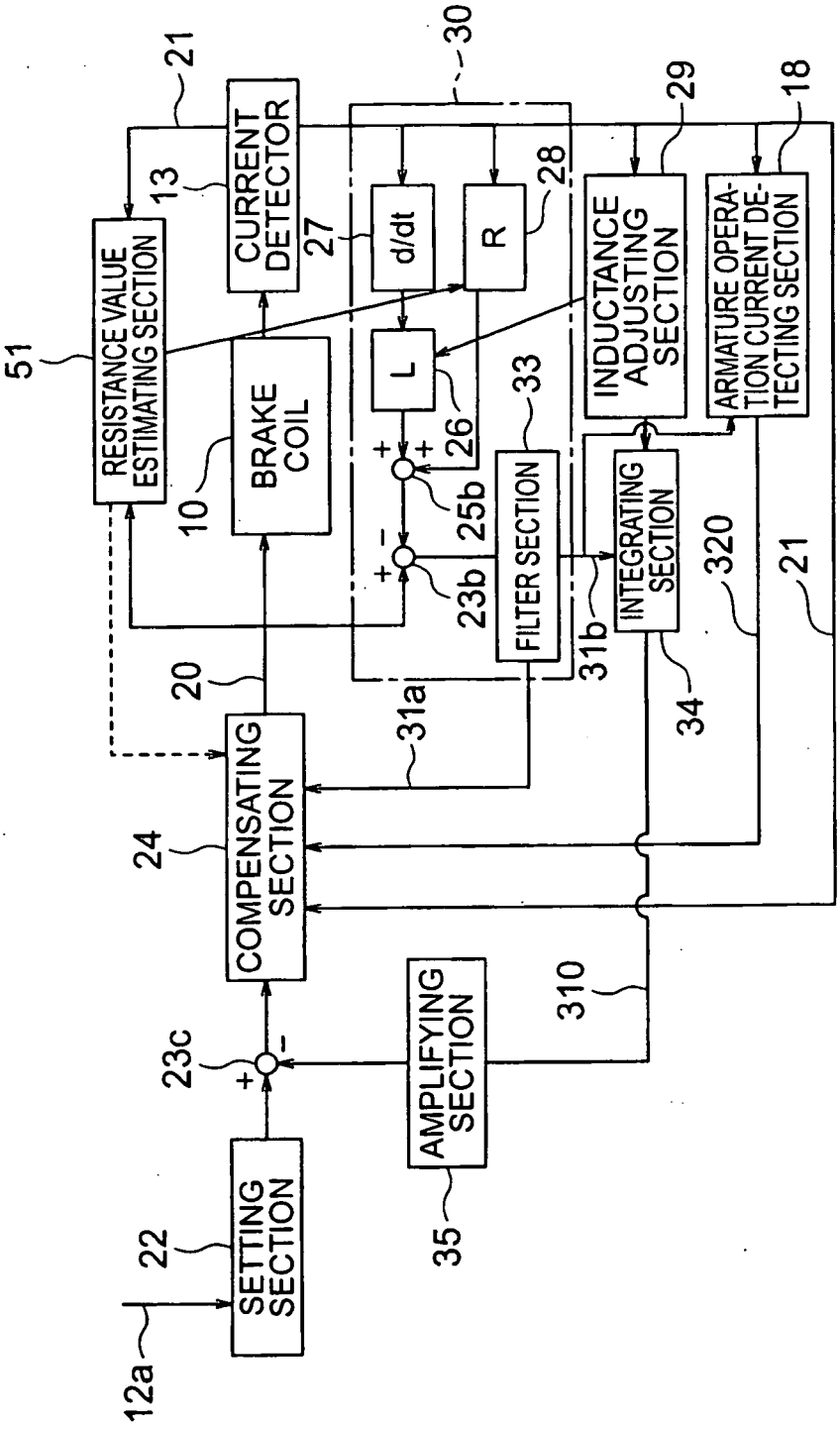
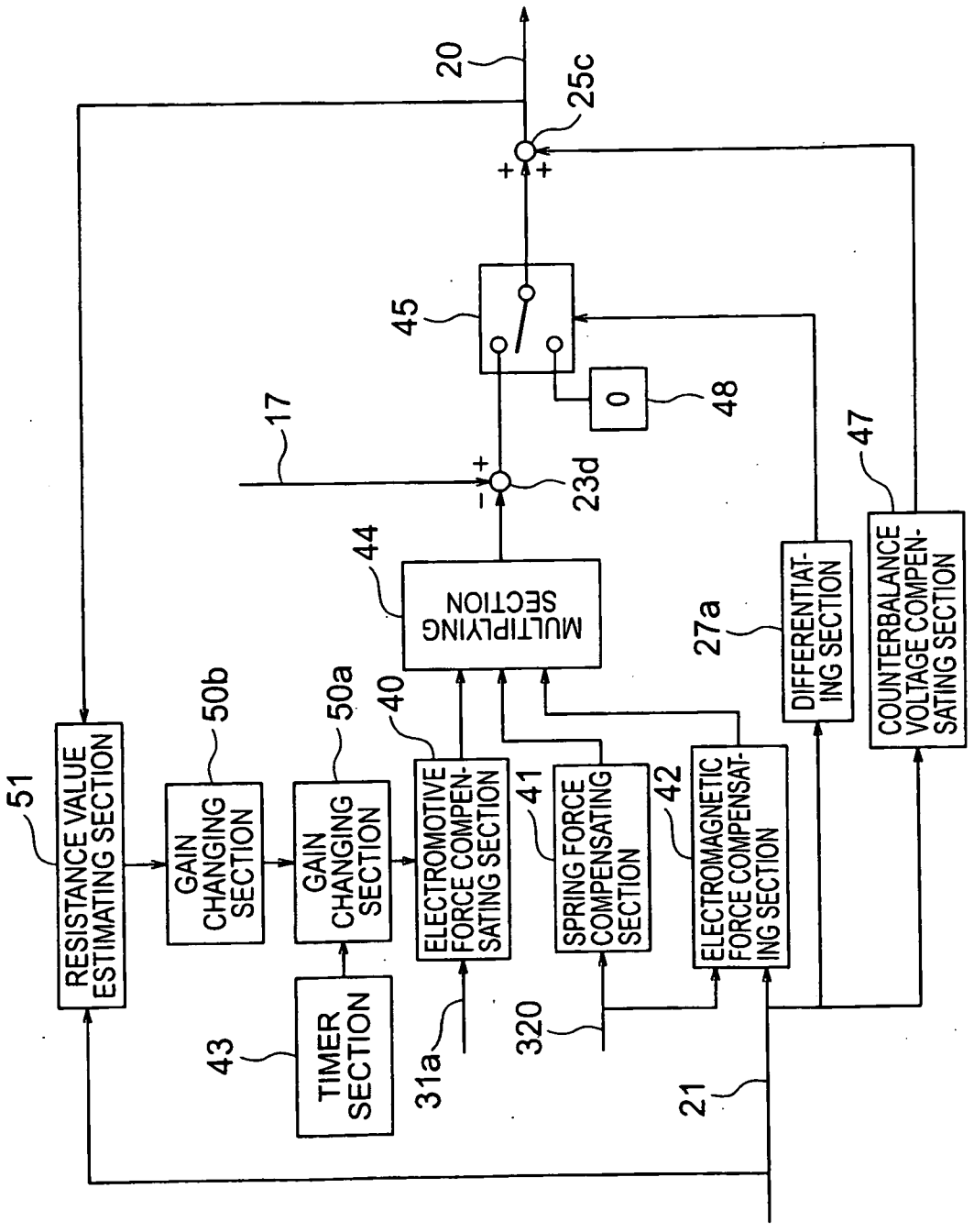

RESISTANCE VALUE ESTIMATING SECTION
51
CURRENT DETECTOR
13
21
30
29
18
d/dt
27
R
28
INDUCTANCE ADJUSTING SECTION
ARMATURE OPERATION CURRENT DETECTING SECTION
BRAKE COIL
10
L
26
33
25b
23b
FILTER SECTION
INTEGRATING SECTION
320
21
31b
34
20
31a
COMPENSATING SECTION
24
AMPLIFYING SECTION
310
23c
35
SETTING SECTION
22
12a

FIG. 13


20
25c
+
+
45
0
48
17
+
−
23d
47
44
MULTIPLYING SECTION
27a
DIFFERENTIATING SECTION
COUNTERBALANCE VOLTAGE COMPENSATING SECTION
51
RESISTANCE VALUE ESTIMATING SECTION
50b
GAIN CHANGING SECTION
50a
GAIN CHANGING SECTION
40
ELECTROMOTIVE FORCE COMPENSATING SECTION
41
SPRING FORCE COMPENSATING SECTION
42
ELECTROMAGNETIC FORCE COMPENSATING SECTION
43
TIMER SECTION
31a
320
21

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Patent documents cited in the description

- JP 9267982 A **[0002]**