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- YASUE, Masanori,
c/o Mitsubishi Denki Kabushiki
Chiyoda-ku, Tokyo 100-8310 (JP)
- WATANABE, Seiji,
c/o Mitsubishi Denki Kabushiki
Chiyoda-ku, Tokyo 100-8310 (JP)

(71) Applicant: MITSUBISHI DENKI KABUSHIKI
KAISHA
Tokyo 100-8310 (JP)

(74) Representative: HOFFMANN - EITLE
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(72) Inventors:
• KARIYA, Yoshitaka,
c/o Mitsubishi Denki Kabushiki
Chiyoda-ku, Tokyo 108310 (JP)

(54) BRAKE CONTROLLER OF ELEVATOR

(57) When braking force is produced in a brake of an elevator in which an armature (17) is attracted against a spring (7) by means of energization of a brake coil (16), and, as a result of attraction of the armature, a brake shoe (9) remaining in pressed contact with a brake wheel (6) is released from the pressed contact, first brake coil control means (38) decreases energization of the brake coil (16) such that the armature (17) is released from an attracted state. When the rate of decrease in a brake coil current (Ib) has been slowed to a

level below a predetermined value or the brake coil current (Ib) has turned into an increase during the course of the first brake coil control means (38) releasing the armature (17) from an attracted state, the brake coil (16) is energized within a range in which the armature (17) is not again attracted, by means of effecting a switch to the second brake coil control means (39), thereby lessening impact sound which arises between the brake shoe (9) and the brake wheel (6) by means of the force of the spring (7).

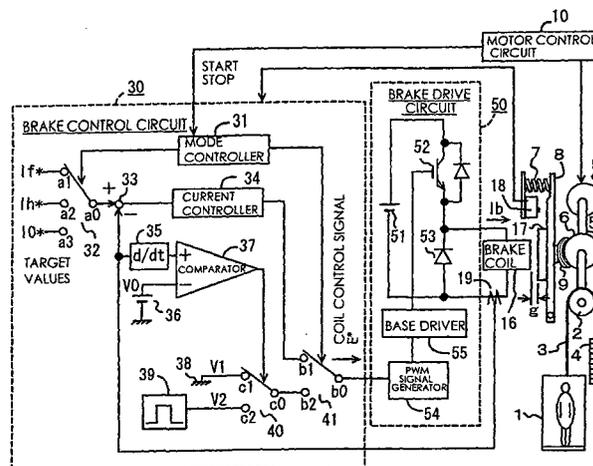


Fig. 1

Description

TECHNICAL FIELD

[0001] The invention relates to control of a brake of an elevator, wherein, when an elevator start signal is issued, an energization circuit is closed, to thereby energize a brake coil, attract an armature against the force of a spring, disengage from a brake wheel a brake shoe remaining in pressed contact with the brake wheel, by means of the attracting action, and release braking force, thereby enabling activation of an elevator; and, when an elevator stop signal is issued, the energization circuit is interrupted so as to release the armature and cause the spring to press the brake shoe against the brake wheel, thereby producing braking force.

BACKGROUND ART

[0002] Fig. 10 shows the schematic configuration of a brake that is commonly used in a cable-type elevator. A car 1 of an elevator is suspended by a counterweight 4 in the manner of a windlass by means of a main cable 3 passed around a sheave 2 of a hoisting machine and driven by a hoisting motor 5. A brake wheel 6 is attached to a shaft 5a for coupling the hoisting motor 5 to the sheave 2. When the car 1 remains stationary, a brake shoe 9 is pressed against an outer peripheral surface of the brake wheel 6 via a brake lever 8 by means of a spring 7. Brake force is generated by frictional force.

[0003] When the car 1 is activated, a motor control circuit 10 energizes the hoisting motor 5, and a start signal is sent to a brake controller 11, thereby activating a brake control circuit 12. A PWM signal generation circuit 14 of a brake drive circuit 13 activates a chopper circuit 15, thereby energizing a brake coil 16 with a variable d. c. voltage. When the brake coil 16 is energized, an armature 17 is attracted against the force of the spring 7. Pressure applied to press the brake shoe 9 against the brake wheel 6 is released by way of the brake lever 8, thereby canceling the brake. When the armature 17 is attracted, a brake switch 18 is closed, whereby completion of release of the brake is detected.

[0004] When a stop signal is issued, the motor control circuit 10 de-energizes the hoisting motor 5 and also de-energizes the brake coil 16 by way of the brake control circuit 12 and the brake drive circuit 13, thereby disengaging the armature 17 from the attracted state and causing the spring 7 to press the brake shoe 9 against the brake wheel 6.

[0005] Specifically, when the brake coil 16 is de-energized by the chopper circuit 15 provided in the brake control circuit shown in Fig. 10, a circulating current flows into the brake coil 16 by way of a diode 20. The circulating current is reduced in accordance with a time constant T_c determined by the resistance R and reactance L of the brake coil 16. As a brake coil current is reduced, attracting force also decreases. When the at-

tracting force has become smaller than the force of the spring 7, the armature 17 is disengaged from the brake coil 16. As a result, the brake shoe 9 is pressed against the brake wheel 6 by the spring 7, thus generating braking force.

[0006] The outline of operation of the brake controller will now be described by reference to Fig. 11. A voltage E designated by broken lines is output from the brake controller 11. Specifically, when an attraction voltage E_f to be used for attracting the armature 17 is applied to the brake coil at time t_{40} , a brake coil current I_b increases gradually.

[0007] During the course of the armature 17 being attracted, the brake coil current I_b is temporarily diminished. The reason for this is that the inductance L is changed by an air gap " g " and that electromotive force (hereinafter called "speed electromotive force") is produced at the rate of change in the inductance L ; that is, the travel speed of the armature 17. After attraction of the armature 17 is completed at time t_{41} , the brake coil current I_b gradually increases at the inductance L yielded in that status.

[0008] At time t_{42} , which is achieved after lapse of a predetermined period of time after closing of the brake switch 18 as a result of attraction of the armature 17, the brake controller 11 decreases the voltage E applied to the armature 17 to a holding voltage E_h required to hold the armature in the attracted state. In association with a decrease in the applied voltage, the brake coil current I_b is decreased to a holding current I_h .

[0009] When an elevator stop signal is issued at time t_{43} , the applied voltage E falls to zero. As a result of interruption of an energization circuit, the brake coil current I_b is decreased while circulating through the diode 20 connected in parallel with the brake coil 16. In association with a decrease in the brake coil current, the armature 17 is disengaged from an attracted state, and the brake shoe 9 is pressed by the spring 7, thus generating braking force.

[0010] During the course of de-energization of the brake coil 16, the brake coil current I_b is temporarily increased. The reason for this is that an air gap is increased in association with the armature 17 being disengaged from the attracted state in the manner set forth, thereby decreasing the inductance L of the brake coil 16. The temporary increase in brake coil current is also attributable to the speed electromotive force. When release of the armature 17 is finished at time t_{44} , the brake coil current I_b is gradually decreased with the inductance L yielded in this state and reaches zero at time t_{45} .

[0011] Accordingly, when a current sensor 19 detects the brake coil current I_b and releases braking force, the instant when the braking force is released can be detected by means of detecting a point at which a decrease has arisen in the braking current I_b . When braking force is produced, the instant when the braking force is generated can be detected by means of detecting a point at which an increase has arisen in the braking current I_b .

[0012] The brake of the conventional elevator is constructed in the manner set forth. The voltage applied to the brake coil 16 at the time of stoppage of the car 1 becomes 0. The brake coil current I_b is a time constant defined by the resistance and inductance of the brake coil 16 and is gradually decreased. The attracting force of the brake coil 16 required to attract the armature 17 is proportional to the square of the brake coil current I_b and substantially inversely proportional to the air gap between the armature 17 and the brake coil 16. Accordingly, when the attracting force is decreased as a result of a decrease in the brake coil current I_b , the brake shoe 9 is pressed by the tensile force of the spring 7, to thereby impinge on the brake wheel 7. The impinging action induces noise.

[0013] These days, a hoisting machine of an elevator is made compact, and a brake is also forced to be downsized. Hence, the brake shoe 9 or other elements must be made compact. In order to ensure required braking force while satisfying such requirements on the outer shape of the brake, the tensile force of the spring 7 used for pressing the brake shoe 9 must be increased. This in turn raises a problem of an increase in noise generated by impingement.

[0014] Especially, the elevator having a hoisting machine installed within a hoistway entails a problem of ride comfort of the car 1 being deteriorated as a result of propagation of operating sound of the brake.

[0015] To address this problem, JP-B-7-64493 (JP-A-63-158681) and USP 4,974,703 based thereon describe the following invention, which utilizes the characteristic of the brake of the elevator. Specifically, when an elevator start instruction signal is issued, a decrease in a brake coil current is detected during the course of the brake coil current being increased as a result of energization of a brake coil, and then a start instruction is sent to a hoisting motor, thereby energizing the motor. When an elevator stop instruction signal is issued, an increase in the brake coil current is detected during the course of the brake coil current being decreased as a result of de-energization of the brake coil, and then a stop instruction is sent to the hoisting motor, thereby de-energizing the hoisting motor. In this way, switching between the brake and the hoisting motor 5 is performed smoothly, thereby attempting an improvement in ride comfort.

[0016] However, detection of a change in the brake coil current which arises at the time of energization and de-energization of the brake coil described in the patent publication is intended for improving ride comfort, and the aforementioned patent publication fails to refer to a reduction in operating sound of the brake. Hence, the invention does not contribute to solution of the problem.

[0017] JP-B-7-68016 describes the following invention. Specifically, at the time of start of an elevator, a brake coil current is immediately boosted within a range in which unbalance torque can be maintained. Then, the brake coil current is gradually increased, thereby reduc-

ing brake torque of the brake. In this state, a hoisting motor is driven, and from then on a small current which can retain an released state of the brake is caused to flow to the brake coil, thereby improving ride comfort and suppressing generation of heat in the brake coil.

[0018] This patent publication also fails to refer to a reduction in operating sound of the brake and hence does not contribute to solution of the problem.

[0019] Moreover, JP-A-7-2441 describes a braking device which produces braking force by means of grasping a rail. In order to reduce operating sound, a position immediately before a movable piece comes into collision with an electromagnet is detected. Further, a position immediately before a brake shoe grasps the rail is detected. A brake coil current is controlled so as to reduce operating sound.

[0020] This braking device is aimed at reducing operating sound of the brake. However, the position of the movable piece and that of the brake shoe cannot be detected easily. Even when the positions can be detected, there also arises a problem of the positions being susceptible to changes, for reasons of abrasion of brake linings and adjustment of the brake.

[0021] Moreover, JP-B-7-80650 describes the following invention. Specifically, a current pattern used for controlling a brake current is compared with a detected brake current. On the basis of a result of comparison, activation or deactivation of the brake current is controlled, thus inhibiting generation of operating sound, which would otherwise be caused by opening or closing the brake.

[0022] However, in relation to the brake, resistance of the brake coil is changed by temperature, and abrasion of a brake lining differs from one brake to another. Even in the case of brakes of the same type, braking torque settings of the brake differ from one brake to another. For these reasons, operating sound cannot be readily suppressed by uniform control of a brake current through use of the current pattern.

[0023] JP-A-7-2452 also describes the following invention. Specifically, a brake shoe is gently pressed against a guide rail, thereby reducing operating sound. Further, in order to shorten an operation time, a brake coil current is diminished to essentially the same level as that of the holding current.

[0024] However, there may arise a problem of the brake being erroneously activated by fluctuations in voltage as a result of a decrease in the brake coil current.

[0025] The invention aims at solving the problem of the brake of the conventional elevator and providing an elevator brake whose operating sound is reduced.

DISCLOSURE OF THE INVENTION

[0026] The invention is arranged in the following manner. In a case where braking force is caused to develop in a brake of an elevator in which braking force is released when an armature is attracted by energization of

a brake coil and when pressure exerted to press a brake shoe against a brake wheel is released by attraction, thereby releasing braking force, first brake coil control means decreases energization of the brake coil such that the armature is released from an attracted state. When the rate of decrease in the brake coil current has become slow or the brake coil current has turned into an increase during the course of the armature being released from an attracted state by the first brake coil control means, there is effected switching to second brake coil control means which energizes the brake coil with a current that produces power greater than that applied by the first brake coil control means within a range in which the armature is not attracted again, and the brake coil is then energized.

[0027] As a result, the pressing force of the spring becomes weaker as a result of the attracting force of the armature being increased again by the brake coil during the course of release of the armature from an attracted state. Therefore, the pressure stemming from the force of the spring is lessened, which in turn enables a reduction in operating sound caused when the brake shoe collides with the brake wheel. Switching to the second brake coil control means is performed when the rate of decrease in the brake coil current has become slowed to a level lower than a predetermined value or when the brake coil current has turned into an increase. Hence, the armature is released from the attracted state, and energization of the brake coil is increased immediately after the armature has started moving. Moreover, a limitation is imposed on an energization value to be increased. Even when the brake coil is energized by the second brake coil control means, a delay in release of the armature from an attracted state is limited. Further, the energization value is increased after actual movement of the armature has been detected. Hence, even when a resistance value is varied for reasons of a temperature change, switching to the second brake coil control means can be effected at an appropriate time.

[0028] Further, according to the invention, the first brake coil control means is arranged such that the armature is released from the attracted state by means of a gradual decrease in the brake coil current circulating through a branch circuit connected in parallel with the brake coil, by means of interruption of an energization circuit.

[0029] Since the brake coil current circulating through the branch circuit is attenuated within a short period of time, a delay in release of the armature from the attracted state is limited, and hence the availability factor of an elevator can be improved.

[0030] Moreover, according to the invention, the first brake coil control means controls the brake coil such that the brake coil is energized with a voltage which gradually lowers with lapse of time and such that the armature is released from an attracted state in association with a reduction in the voltage. Hence, the first brake coil control means can be smoothly switched to

the second brake coil means.

[0031] Further, according to the invention, the first brake coil control means is switched to the second brake coil control means when the rate of decrease in brake coil current assumes a value of zero or when the brake coil current has turned into an increase. Hence, even when fluctuations have arisen in the force of the spring required to press the brake shoe against the brake wheel or when the resistance of the brake coil has been changed by temperature, switching can be effected at an appropriate time.

[0032] Further, according to the invention, the second brake coil control means energizes the brake coil with a voltage obtained by multiplication of the brake coil current value with the resistance of the brake coil, the current and resistance being obtained when the rate of decrease in the brake coil current assumes a value of zero.

[0033] Therefore, the brake coil can be energized with an electric current close to the maximum current obtained within a range in which the armature is not attracted again, thereby reducing operating sound of the armature.

[0034] Further, according to the invention, the brake coil resistance value is determined from a ratio of a voltage of the brake coil to the brake coil current, the ratio being obtained when the brake coil current has assumed a constant value while the braking force is released in response to an elevator start signal.

[0035] Therefore, even when the resistance has been changed by a temperature change, the brake coil can be energized with a current value close to the maximum current obtained within an allowable range of the thus-changed resistance value. Hence, the effectiveness of the invention can be achieved.

[0036] Moreover, according to the invention, the rate of change in the brake coil current is computed, and a limitation is imposed on the rate of change such that the armature is not attracted again. The brake coil is energized with a voltage proportional to a value obtained through computation.

[0037] Therefore, the brake coil is energized on the basis of the rate of change in the brake coil current. Hence, the brake can be caused to sensitively respond to actuation of the armature.

[0038] Further, according to the invention, the second brake coil control means has a circuit model of a brake coil. A model current is obtained by application, to the circuit model, of a voltage to be applied to the brake coil. The model current is subtracted from the brake coil current, and the brake coil is energized with a voltage proportional to the rate of change in a result of subtraction.

[0039] Since the inductance of the circuit model is a constant value, the brake coil is energized on the basis of the speed of movement of the armature; that is, an increment in the brake current stemming from speed electromotive force. Hence, movement of the armature can be controlled smoothly.

[0040] Moreover, according to the invention, a time

constant of the brake coil is determined from an increment ΔI of the brake coil current obtained when a voltage E_i is applied to the brake coil in a stepped manner. The inductance L of the circuit model of the brake coil is determined by multiplying the resistance R of the brake coil by the time constant.

[0041] Therefore, the circuit model of the brake coil can be constituted in accordance with the status of each brake.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042]

Fig. 1 is a block diagram showing a control circuit of a brake controller of an elevator according to a first embodiment of the invention, and Fig. 2 is a view for describing operation of the control circuit; Fig. 3 is a block diagram showing a control circuit of a brake controller of an elevator according to a second embodiment of the invention, and Figs. 4 and 5 are views for describing operation of the control circuit;

Fig. 6 is a block diagram showing a control circuit of a brake controller of an elevator according to a third embodiment of the invention, and Fig. 7 is a view for describing operation of the control circuit; Fig. 8 is a flowchart showing procedures for measuring inductance of a brake coil, and Fig. 9 is a descriptive view; and

Fig. 10 is a block diagram showing a control circuit of a brake controller of a related-art elevator, and Fig. 11 is a view for describing operation of the control circuit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0043] In order to describe the invention in more detail, the invention will be described by reference to the accompanying drawings.

[0044] Figs. 1 and 2 show a first embodiment of a brake controller of an elevator according to the invention. Fig. 1 is a block diagram showing a control circuit of a brake. In the illustration, reference numeral 1 designates a car; 2 designates a sheave of a hoisting machine; 3 designates a main cable passed around the sheave 2; 4 designates a counterweight suspended by the main cable 3 with the car 1 in the manner of a windlass; 5 designates a hoisting motor which rotatively drives the sheave 2 via a shaft 5a; and 6 designates a brake wheel coupled directly to the shaft 5a.

[0045] Reference numeral 7 designates a spring which presses and brings a brake shoe 9 against and into pressing contact with an outer peripheral surface of the brake wheel 6 via a brake lever 8 at all times, thereby producing braking force from frictional force. Reference numeral 10 designates a motor control circuit for con-

trolling the hoisting motor 5. Reference numeral 16 designates a brake coil; and 17 designates an armature which opposes the brake coil 16 with an air gap "g" interposed between the armature and the brake coil and which is attracted by the brake coil 16 against the force of the spring 7 by means of energization of the brake coil 16. By means of attracting action, pressure exerted to press the brake shoe 9 against the brake wheel 6 is released. When the brake coil 16 is de-energized, the spring 7 releases the armature 17 from the attracted state. Reference numeral 18 designates a brake switch which is closed when the armature 17 is attracted, thereby sensing completion of release of the braking force; and 19 designates a current sensor for sensing the brake coil current I_b .

[0046] Reference numeral 30 designates a brake control circuit which controls energization and de-energization of the brake coil and is constituted in the following manner. Reference numeral 31 designates a mode controller for controlling energization of the brake coil 16; and I_f^* , I_h^* , and I_0^* designate target values of the brake coil current I_b . I_f^* takes an attracting current as a target value; I_h^* takes a holding current as a target value; and I_0^* takes a value of zero as a target value. Reference numeral 32 designates a changeover switch for selecting any one from the target values I_f^* , I_h^* , and I_0^* of the brake coil current I_b . Reference numeral 33 designates a subtracter for computing a difference between the target value I_f^* and the brake current I_b , a difference between the target value I_h^* and the brake current I_b , and a difference between the target value I_0^* and the brake current I_b . Reference numeral 34 designates a current controller for performing control operation such that the brake current I_b assumes any one of the target values I_f^* , I_h^* and I_0^* on the basis of the difference.

[0047] Reference numeral 35 designates a differentiating circuit for computing a differential value of the brake current I_b ; and 36 designates a reference voltage circuit which outputs a threshold value and is usually set to zero. Reference numeral 37 designates a comparator for outputting a positive saturation voltage when the differential value is greater than a threshold value.

[0048] Reference numerals 38 and 39 designate control voltage circuits for outputting voltage values V_1 and V_2 used for energizing the brake coil 16 after a stop signal has been issued from the motor control circuit 10. V_1 is set to a value of zero; and V_2 designates a pulse-like voltage which is increased in response to a stop signal and reduced after lapse of a predetermined period of time since the brake switch 18 was released. V_1 is set to a high constant voltage within a range in which the armature 17 is not attracted again. Here, the control voltage circuit 38 corresponds to first brake coil control means, and the control voltage circuit 39 corresponds to second brake coil control means.

[0049] Reference numeral 40 designates a changeover switch which is connected to the control voltage circuit 38 at all times and switched to the control voltage

circuit 39 by means of a positive saturation voltage output from the comparator 37; and 41 designates a changeover switch which is switched by the mode controller 34 and connected selectively to the current controller 34 or an output terminal c0 of the changeover switch 40, thereby outputting a coil control signal E*.

[0050] Reference numeral 50 designates a brake drive circuit which energizes the brake coil 16 and is constituted in the following manner. Reference numeral 51 designates a d.c. power supply for energizing the brake coil 16; and 52 designates a chopper circuit which outputs a variable d.c. voltage and constitutes the circuit for energizing the brake coil 16. Reference numeral 53 designates a branch circuit connected in parallel with the brake coil 16. Here, the branch circuit 53 is constituted of a diode. When the chopper circuit 52 interrupts energization of the brake coil 16, the brake coil current Ib is circulated. Reference numeral 54 designates a PWM signal generator which is connected to the changeover switch 41 and produces a PWM signal corresponding to the coil control signal E*; and 55 designates a base driver which controls activation and deactivation of the chopper circuit 52 by means of the PWM signal.

[0051] Operation of the brake controller will now be described by reference to Fig. 2.

1. Mode 0 (a3, b1, c1)

[0052] When the car 1 remains stationary, the changeover switch 32 is switched to a terminal a3, and the changeover switch 41 is switched to a terminal b1. For this reason, a coil control signal E* assumes a value of 0, and the brake coil 16 is de-energized.

2. Mode 1 (a1, b1, c1)

[0053] When the motor control circuit 10 issues a start signal, the changeover switch 41 is switched to a terminal a1 by a mode controller 31, thereby selecting the target value If*. The coil control signal E* corresponding to the target value If* is output, whereby the brake coil current Ib rises from time t11. Attracting force fc is also increased gradually. At time t12, the attracting force fc becomes equal to force fs of the spring 7. The armature 17 is attracted as a result of further energization of the brake coil, and the brake coil current Ib is temporarily decreased. The reason for this is that the inductance L of the brake coil 16 is increased as a result of a decrease having arisen in the air gap "g" in association with attraction of the armature 17. Another reason is responsible for speed electromotive force. When attraction of the armature 17 is completed, the brake coil current Ib is increased gradually with the inductance L yielded in that state.

[0054] When the brake coil current Ib has reached the attraction current If at time t13, the coil control signal E* is decreased, whereby the brake coil current Ib is main-

tained at the attraction current If.

3. Mode 2 (a2, b1, c1)

[0055] At time t14, which is achieved after lapse of a predetermined period of time since the brake switch 18 was closed as a result of attraction of the armature 17, the changeover switch 32 selects the target value Ih*. By means of such a selection operation, the brake coil current Ib drops to the holding current Ih required to hold the armature 17 in an attracted state.

4. Mode 3 (a3, b2, c1)

[0056] When the motor control circuit 10 issues the stop signal at time t15, the changeover switch 32 selects the target value I0*, and the changeover switch 41 is connected to a terminal b2. Since the changeover switch 40 is connected to a terminal c1 at this time, the coil control signal E* assumes a value of 0. The brake coil current Ib circulates through a diode 53 and is gradually decreased at a predetermined time constant Tc, and the attracting force fc is also decreased. At time t16 the attracting force becomes equal to the force fs of the spring 7. The brake coil current Ib is further decreased to a level below the force fs of the spring, whereupon the armature 17 starts being disengaged from the brake coil 16. In association with movement of the armature 17, speed electromotive force develops. The rate of decrease in the brake coil current Ib is slowed and turns into a gradual increase.

5. Mode 4 (a3, b2, c2)

[0057] When the rate of decrease in the brake coil current Ib assumes a value of zero or turns into an increase, the comparator 37 switches the changeover switch 40 to a terminal c2 at time t17, and a voltage value V2 is output from the voltage circuit 39 as the coil control signal E*. The brake coil 16 is again energized, whereupon the coil current Ib is increased gradually. The attracting force fc is shifted substantially constant as a result of a gradual increase in the coil current Ib. The armature 17 keeps moving under the attracting force fc and is released at time t18. The changeover switch 40 is reset at time t19, which is achieved after lapse of a predetermined period of time since the brake switch 18 was released, and is then connected to the terminal c1, thereby outputting a value of 0.

6. Mode 5 (a3, b1, c1)

[0058] Mode 0 is set at time t19, and the coil current Ib is gradually decreased and assumes a value of 0.

[0059] According to the first embodiment, when the armature 17 starts moving, the brake coil 16 is energized at the high voltage V2 within a range in which the armature is not again attracted, thereby producing the

attracting force f_c slightly smaller than the force of the spring 7. Hence, noise generated by the force of spring 7 when the armature is released from an attracted state can be reduced.

[0060] Figs. 3 to 5 show a second embodiment of the brake controller of the elevator according to the invention.

[0061] In Fig. 3, those reference numerals which are the same as those shown in Fig. 1 designate the same elements, and their explanations are omitted.

[0062] Reference numeral 60 designates a brake control circuit which controls energization and de-energization of the brake coil and is constituted in the following manner. Reference numeral 61 designates a pattern signal generator for outputting a ramp signal which decreases linearly. Reference numeral 62 designates a latch circuit for holding an output from the pattern signal generator 61 at a point in time when the comparator 37 has output a positive saturation voltage; 63 designates a differentiating circuit for computing a differential value of the brake coil current I_b ; 64 designates a proportionality element of gain K_d ; 65 designates a limiter for suppressing the armature 17 within a range in which the armature 17 is not attracted again; and 66 designates a changeover switch which is switched to the limiter 65 by an output from the comparator 37 and returns to the terminal c_1 after lapse of a predetermined period of time since the brake switch 18 was released. Reference numeral 67 designates an adder for adding an output V_p from the latch circuit 62 to an output V_d from the limiter 65, to thereby output the coil control signal E^* .

[0063] Here, the pattern signal generator 61 corresponds to first brake coil control means; and the pattern signal generator 61, the latch circuit 62, the differentiating circuit 63, the proportionality element 64, and the limiter 65 correspond to second brake coil control means.

[0064] Operation of the brake controller will now be described by reference to Fig. 4.

1. Operations pertaining to Mode 0, Mode 1, Mode 2, and Mode 5 are the same as those shown in Fig. 2, and hence their explanations are omitted.
2. Mode 3 (a3, b2, c1)

When the motor control circuit 10 has issued a stop signal at time t_{15} , the changeover switch 32 selects the target value I_0^* , and the changeover switch 41 is connected to the terminal b_2 , thereby outputting the ramp signal V_p of the pattern signal generator 61 as the coil control signal E^* . The brake coil 16 is controlled by the ramp signal V_p , whereby the brake coil current I_b is gradually decreased, thereby decreasing the attracting force f_c . The attracting force becomes equal to the force f_s of the spring 7 at time t_{16} , and the brake coil current I_b is further decreased. As a result, the attracting force becomes lower than the force f_s of the spring, and the armature 17 starts being disengaged from the

brake coil 16. In association with movement of the armature 17, the air gap "g" is increased, thereby producing speed electromotive force. The rate of decrease in the brake coil current I_b is slowed and eventually turns into a gradual increase.

3. Mode 4 (a3, b2, c2)

When the rate of decrease in the brake coil current I_b assumes a value of 0 or turns into an increase, the comparator 37 switches the changeover switch 66 to the terminal c_2 at time t_{17} . The latch circuit 62 holds an output V_p produced by the pattern signal generator 61 when the comparator 37 has issued a saturation signal. Further, a differential value of the brake coil current I_b output from the differentiating circuit 63 is limited by the limiter 65, whereby a value V_d is output. The outputs V_p and V_d are added together, to thereby produce the coil control signal E^* . The coil control signal E^* further increases the brake coil current I_b that has turned into an increase. However, re-attraction of the armature 17 is not intended, and hence an increase in the brake coil current I_b has become slow and turned into an increase. By means of such a variation in the brake coil current I_b , an output from the differentiating circuit 63 is also changed and pulsed in the manner shown in Fig. 4.

[0065] By reference to Fig. 5, the operation of the brake controller to be performed in mode 4 will be described in detail.

(1) τ_1 - τ_2 : By means of slowing or gradually increasing the rate of decrease in the brake coil current I_b , the comparator 37 is activated, thereby switching the changeover switch 66 to the limiter 65. When the brake coil current I_b starts being increased as a result of the armature 17 being subjected to displacement, the output V_d of the limiter 65 is also increased. The output V_d and the output V_p are added together, to thereby produce the coil control signal E^* .

(2) τ_2 - τ_3 : The limiter 65 causes the coil control signal E^* to assume a constant value. Since the brake coil current I_b is increased, the speed of disengagement of the armature 17 becomes slow.

(3) τ_3 - τ_4 : Since the coil control signal E^* is limited by the limiter 65, an increase in the brake coil current I_b is stopped, and a differential value assumes 0. When the brake coil current I_b is decreased, the differential value becomes negative. Accordingly, $E^* < V_p$, and the attracting force is reduced, whereby the speed of disengagement of the armature 17 is increased.

(4) Operation pertaining to τ_4 - τ_5 : identical with that pertaining to τ_1 - τ_2 .

(5) Operation pertaining to τ_5 - τ_6 : identical with that pertaining to τ_2 - τ_3 .

(6) Operation pertaining to τ_6 - τ_7 : identical with that

pertaining to τ_3 - τ_4 .

[0066] The armature 17 is disengaged from the brake coil 16 while repeatedly performing the same fluctuations.

[0067] According to the second embodiment, when the armature 17 starts moving, the brake coil 16 is energized with a high voltage (V_p+V_d) within a range in which the armature 17 is not again attracted, thereby generating the attracting force f_c slightly smaller than the force f_s of the spring 7. Hence, there can be reduced noise generated when the armature 17 is released from an attracted state.

[0068] In particular, according to the second embodiment, the brake coil 16 is energized with a differential value of the brake coil current I_b . Hence, noise can be reduced quickly in accordance with fluctuations in the brake coil current I_b .

[0069] Figs. 6 to 9 show a third embodiment of the brake controller of the elevator according to the invention.

[0070] In Fig. 6, those reference numerals which are the same as those shown in Fig. 1 or 3 designate the same elements, and their explanations are omitted.

[0071] Reference numeral 71 designates a model circuit which simulates the brake coil 16 through use of the resistance R of the brake coil 16 and the inductance L obtained at the time of attraction of the armature 17. The model circuit outputs a model current I_{hat} on the basis of the output V_d from the differentiating circuit 63 and the proportionality element 64. Reference numeral 72 designates a subtracter for determining a difference value between the actual brake coil current I_b and the model current I_{hat} ; and 73 designates a reference voltage circuit for outputting a reference voltage E_i . The reference voltage circuit is for measuring the inductance L of the brake coil 16. Reference numeral 74 designates a changeover switch which is selectively connected to any one of the current controller 34, the adder 67, and the reference voltage circuit 73 and outputs the coil control signal E^* .

[0072] Here, the pattern signal generator 61 corresponds to first brake coil control means; and the pattern signal generator 61, the latch circuit 62, the differentiating circuit 63, the proportionality element 64, and the model circuit 71 correspond to second brake coil control means.

[0073] Reference numeral 80 designates a CPU; 81 designates ROM in which is stored a program to be used for computing the inductance L of the brake coil 16; 82 designates RAM for storing temporary data; and 83 designates an input/output device.

[0074] Operation of the brake controller will now be described by reference to Fig. 7.

1. Operations pertaining to a period of Mode 1 to Mode 3 and that pertaining to a period of Mode 5 are identical with those shown in Fig. 4, and their

explanations are omitted.

2. Mode 4 (a_3 , b_2 , c_2)

When the rate of decrease in the brake coil current I_b has assumed a value of 0 or turned into an increase, the comparator 37 switches the changeover switch 66 to the terminal c_2 at time τ_{21} . The connected status of the changeover switch is maintained, and the latch circuit 62 holds the output V_p from the pattern signal generator 61 at time τ_{21} . The subtracter 72 computes a difference value (I_b-I_{hat}) between the brake coil current I_b and the model current I_{hat} produced by the model circuit 71. The difference value (I_b-I_{hat}) is output as the value V_d by way of the differentiating circuit 63 and the proportionality element 64. The output V_d is added to the output V_p by the adder 67, to thereby produce the coil control signal E^* .

[0075] Operation of the brake controller in Mode 4 will be described in detail by reference to Fig. 7.

(1) τ_{21} - τ_{22} : The armature 17 starts becoming displaced, and the difference value (I_b-I_{hat}) is also increased as a result of slowing of the rate of decrease in the brake coil current I_b or a gradual increase in the same. The output V_d proportional to a differential value is added to the output V_p , thereby producing the coil control signal E^* . Hence, the attracting force is increased, whereby the speed of disengagement of the armature 17 is decreased.

(2) τ_{22} - τ_{23} : When the speed of disengagement of the armature 17 is decreased, the speed electromotive force developing in the brake coil 16 is also decreased. For this reason, the brake coil current I_b is decreased, and the difference value (I_b-I_{hat}) between the brake coil current I_b and the model current I_{hat} is also decreased. For this reason, the coil control signal E^* is decreased, which in turn results in a decrease in attracting force. Accordingly, the speed of disengagement of the armature 17 is increased.

(3) τ_{23} - τ_{24} : When the speed of disengagement of the armature 17 is increased, the difference value (I_b-I_{hat}) is increased again, whereby the coil control signal E^* is increased. As a result, the attracting force is increased, whereby the speed of disengagement of the armature 17 is decreased.

(4) Operation pertaining to τ_{24} - τ_{25} : identical with that pertaining to (τ_{22} - τ_{23}), and its explanation is omitted.

[0076] The above-described operations are repeated, whereby the armature 17 is released from an attracted state.

[0077] Measurement of the inductance L of the brake coil 16 will now be described by reference to Figs. 8 and 9.

[0078] In step S11, a determination is made as to

whether or not the brake coil current I_b has reached the holding current I_h . In step S12, the changeover switch 74 is connected to the reference voltage circuit 73. The reference voltage E_i is applied in a stepped manner to the brake coil 16. In step S13, the time "t"; that is, time T31 shown in Fig. 9, is recorded in the memory T1. The brake coil current I_b is increased gradually, and an increment ΔI is computed in step S14. In step S15, a determination is made as to whether or not the increment ΔI has reached a value which is computed from the target value I_i of the brake coil I_b corresponding to the reference voltage E_i , by means of an equation of $0.632x(I_i - I_h)$. If the value has been reached, the time "t"; that is, time T32 shown in Fig. 9, is recorded in the memory T2. In step S17, a difference between the data stored in the memory T2 and those stored in the memory T1; that is, the time constant T_c of the brake coil 16, is determined. In step S18, the inductance L can be determined from a product of the time constant T_c and the resistance R of the brake coil 16.

[0079] Here, a previously-measured value may be used for the resistance R . However, in consideration of a change in temperature, in the third embodiment the resistance R is determined from the coil control signal E^* obtained when the brake coil current I_b has reached the holding current I_h .

[0080] As mentioned above, even in the third embodiment, when the armature 17 starts moving, the brake coil 16 is energized within a range in which the armature 17 is not attracted again. Hence, there can be reduced noise generated by the force of the spring 7 required at the time of disengagement of the armature from an attracted state.

[0081] In particular, the model circuit 71 simulates the brake coil 16 remaining in the state in which the armature 17 is attracted. Hence, the inductance L is eventually that achieved in the attracted state. Accordingly, the coil control signal E^* can be computed from an increment ($I_b - I_{hat}$) of the brake coil current I_b determined by the speed of movement of the armature 17. A vibration component of the coil control signal E^* can be suppressed, thereby rendering the speed of movement of the armature 17 smooth.

[0082] In the third embodiment, actually-measured values are adopted as the resistance R and inductance L of the model circuit 17. Even when changes in temperature have arisen, effective reduction of noise can be achieved.

INDUSTRIAL APPLICABILITY

[0083] As has been mentioned, an elevator brake controller of the invention can be widely used with a so-called drum-type elevator brake. In this brake, an armature is attracted against the force of a spring when a brake coil is energized, and a brake shoe remaining in pressed contact with a brake wheel is then released from a pressed state by means of attraction. When en-

energization of the brake coil is interrupted, the armature is released from an attracted state. The brake shoe is pressed by the force of the spring, thereby producing braking force. In particular, the brake controller is suitable for use with a brake which applies strong pressure to a brake shoe by increasing the force of the spring required to produce required braking force in association with downsizing of a brake itself.

[0084] The brake controller is also suitable for use with an elevator in which a hoisting machine is installed in a hoistway and involves a high probability of propagation of operating sound of a brake to a car.

[0085] The brake controller is further suitable for use with an elevator installed in an apartment building; particularly, in an environment in which noise presents problems.

Claims

1. An elevator brake controller, wherein an armature is attracted against the force of a spring when a brake coil is energized as a result of closing of an energization circuit; a brake shoe remaining in pressed contact with a brake wheel is released from the pressed contact by means of attraction of the armature, thereby releasing braking force; the armature is released from an attracted state when the energization circuit is interrupted; and the brake shoe is pressed by the spring force, thereby producing braking force, the elevator brake controller comprising:

brake release means for releasing braking force by causing the energization circuit to energize the brake coil when an elevator start signal is issued, thereby releasing braking force; first brake coil control means for controlling the brake coil such that, when an elevator stop signal is issued, the energization circuit is interrupted, to thereby reduce energization of the brake coil and to release the armature from the attracted state;

second brake coil control means for energizing the brake coil to a level higher than that achieved as a result of the brake coil being energized by the first brake coil control means within a range in which the armature is not attracted again; and

switching means for performing switch to the second brake coil control means, to thereby energize the brake coil, while a rate of decrease in the brake coil current is slowed to a point below a predetermined value or while the brake coil current has turned to an increase, during the course of the armature being released from an attracted state by the first brake coil control means.

2. The elevator brake controller according to claim 1, wherein the first brake coil control means controls the brake coil such that the brake coil is energized by a brake coil current, the current circulating through a branch circuit connected in parallel with the brake coil, by interruption of the energization circuit and such that the armature is released from an attracted state in association with a decrease in the brake coil current. 5
3. The elevator brake controller according to claim 1, wherein the first brake coil control means controls the brake coil such that the brake coil is energized by a voltage which gradually reduces with lapse of time and such that the armature is released from an attracted state in association with a reduction in the voltage. 10
4. The elevator brake controller according to claim 1, wherein the switching means performs switching to the second brake coil control means during a period in which the rate of decrease in brake coil current assumes a value of zero or when the brake coil current has turned into an increase, thereby energize the brake coil. 15
5. The elevator brake controller according to claim 1, wherein the second brake coil control means energizes the brake coil with a voltage obtained by multiplication of the brake coil current value by a brake coil resistance value, both values being obtained when the rate of decrease in the brake coil current assumes a value of zero. 20
6. The elevator brake controller according to claim 5, wherein the brake coil resistance value is determined from a ratio of a voltage of the brake coil to the brake coil current, the ratio being obtained when the brake coil current has assumed a constant value while the braking force is released in response to an elevator start signal. 25
7. The elevator brake controller according to claim 1, wherein the second brake coil control means energizes the brake coil with a voltage proportional to the rate of change in the brake coil current whose upper limit value is limited such that the armature is not attracted again. 30
8. The elevator brake controller according to claim 1, wherein the second brake coil control means has a circuit model of a brake coil, and the brake coil is energized with a voltage proportional to the rate of change in a result of subtraction of a model current from the brake coil current, the model current being obtained by application, to the circuit model, of a voltage to be used for energizing the brake coil. 35
9. The elevator brake controller according to claim 8, wherein the reactance L of the circuit model of the brake coil is set to a value obtained by multiplying the resistance R of the brake coil by a time Tc at which an increment ΔI of the brake coil current has assumed a value represented by $\Delta I = 0.632 \times (I_i - I_h)$ instead of a target value I_i of the brake coil current against the voltage E_i , the increment being obtained by application of a voltage E_i to the brake coil in a stepped manner when the braking force is released as a result of the armature being attracted in accordance with an elevator start signal and when the brake coil current assumes a constant value I_h . 40
- 45
- 50
- 55

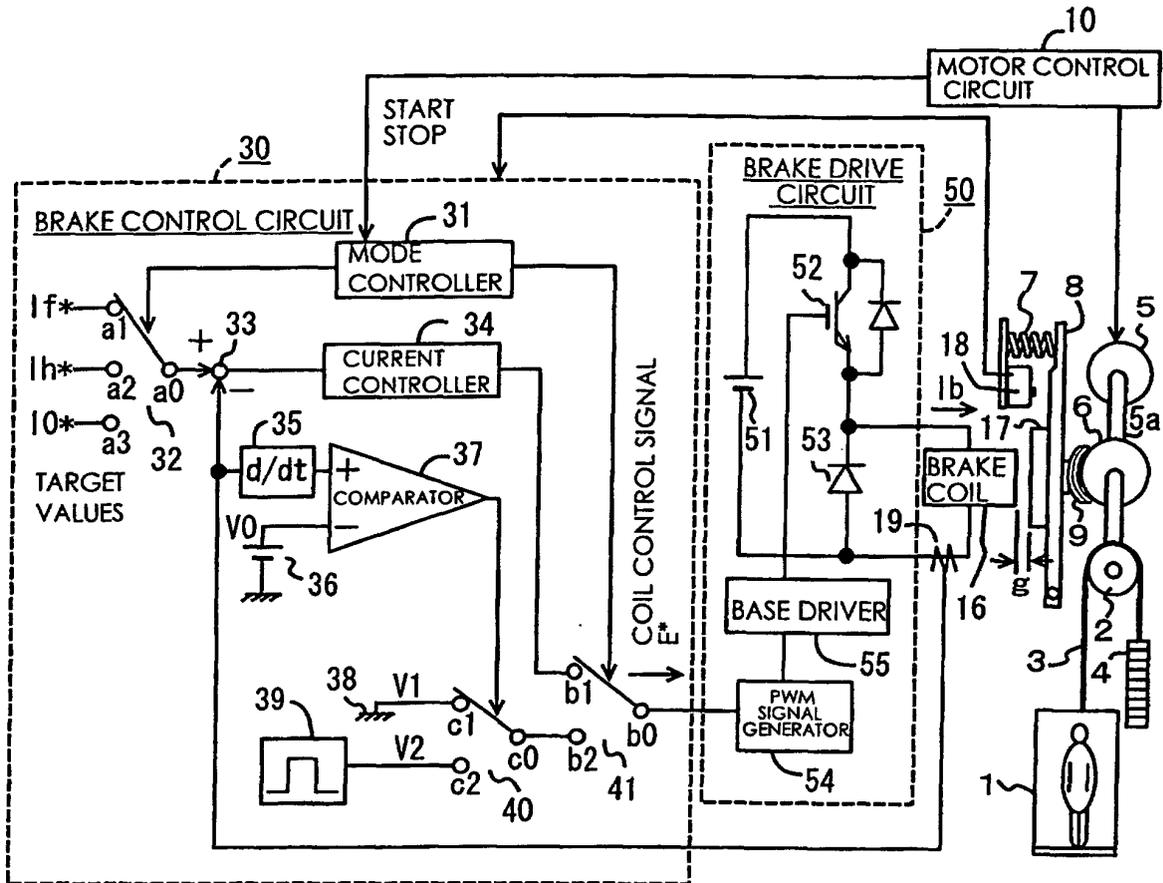
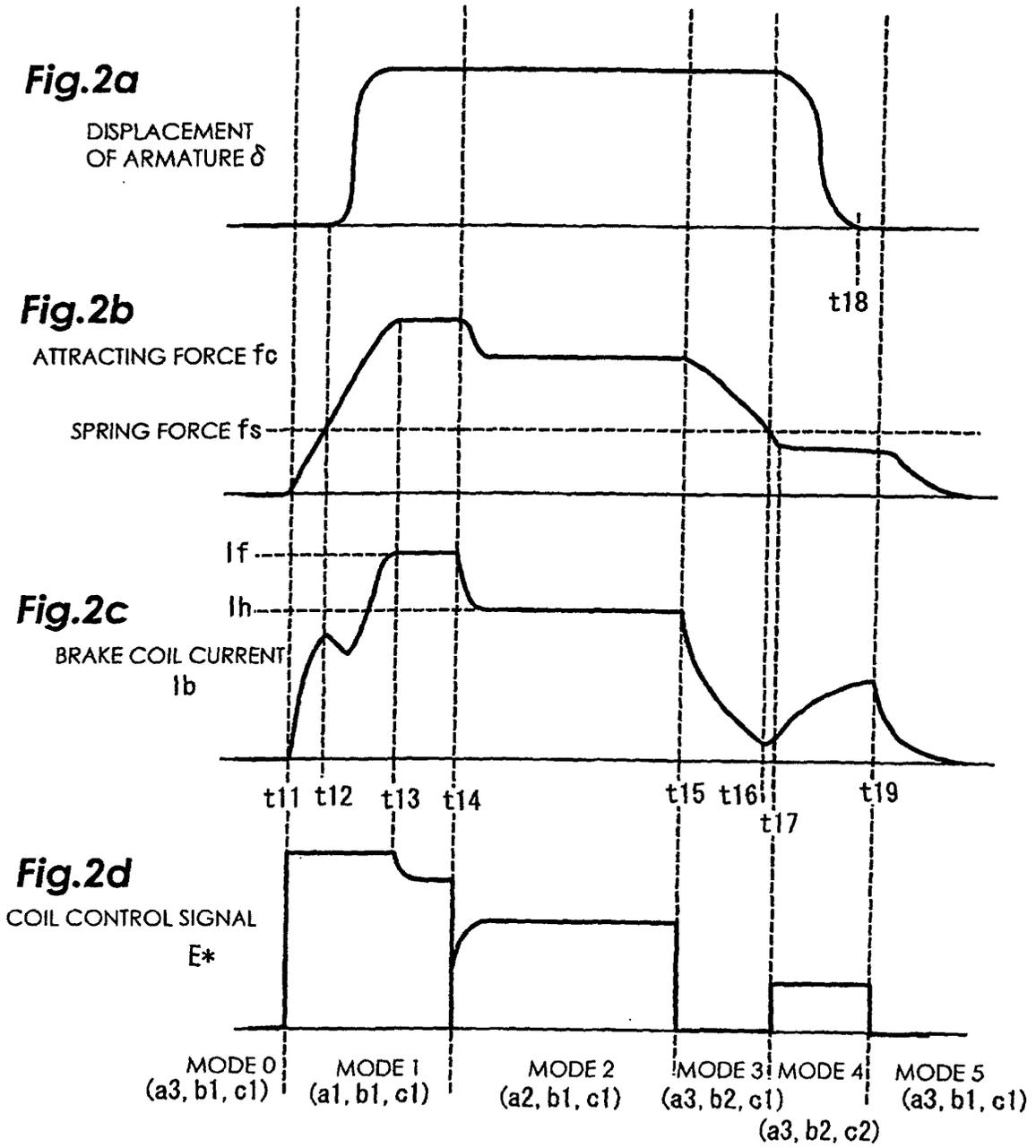


Fig. 1



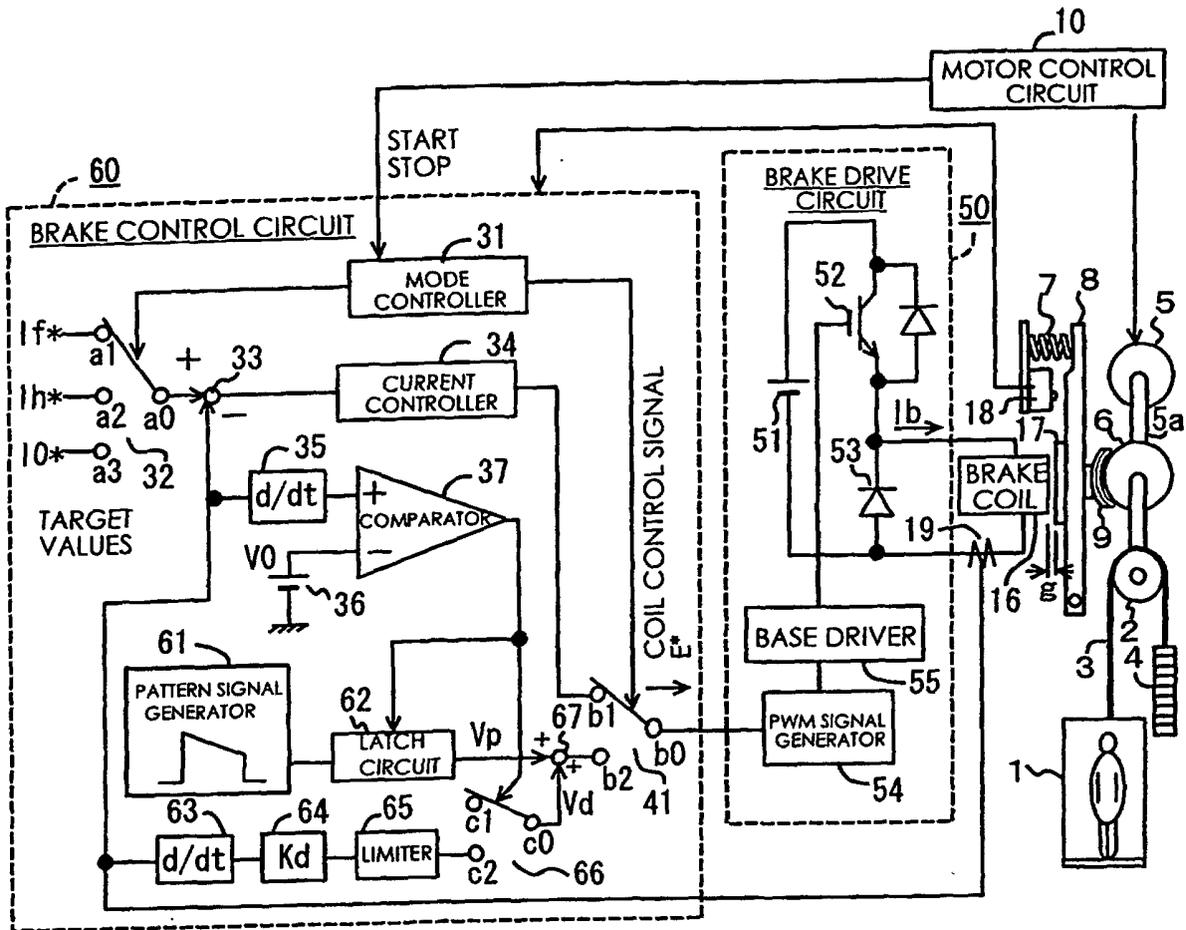
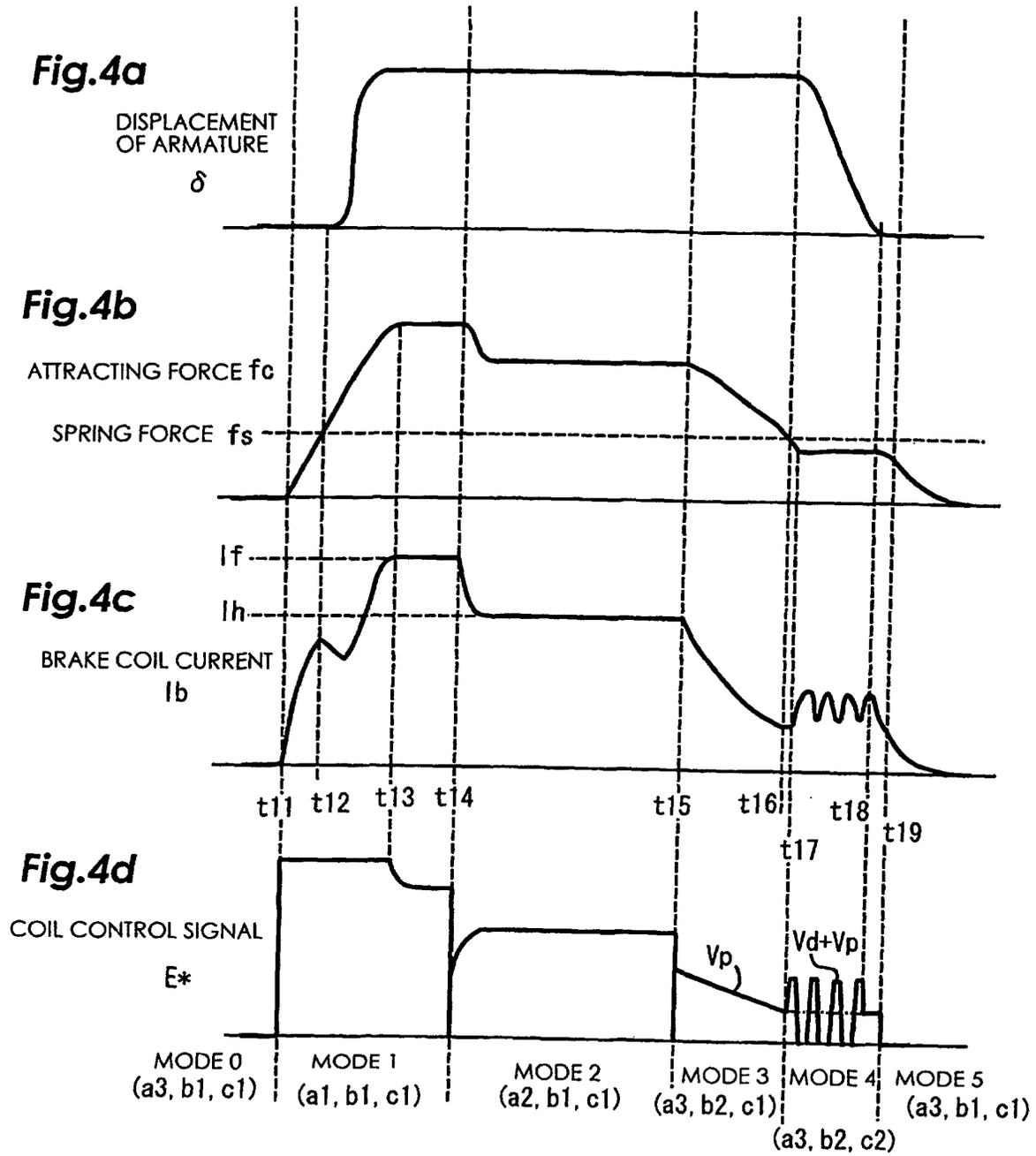
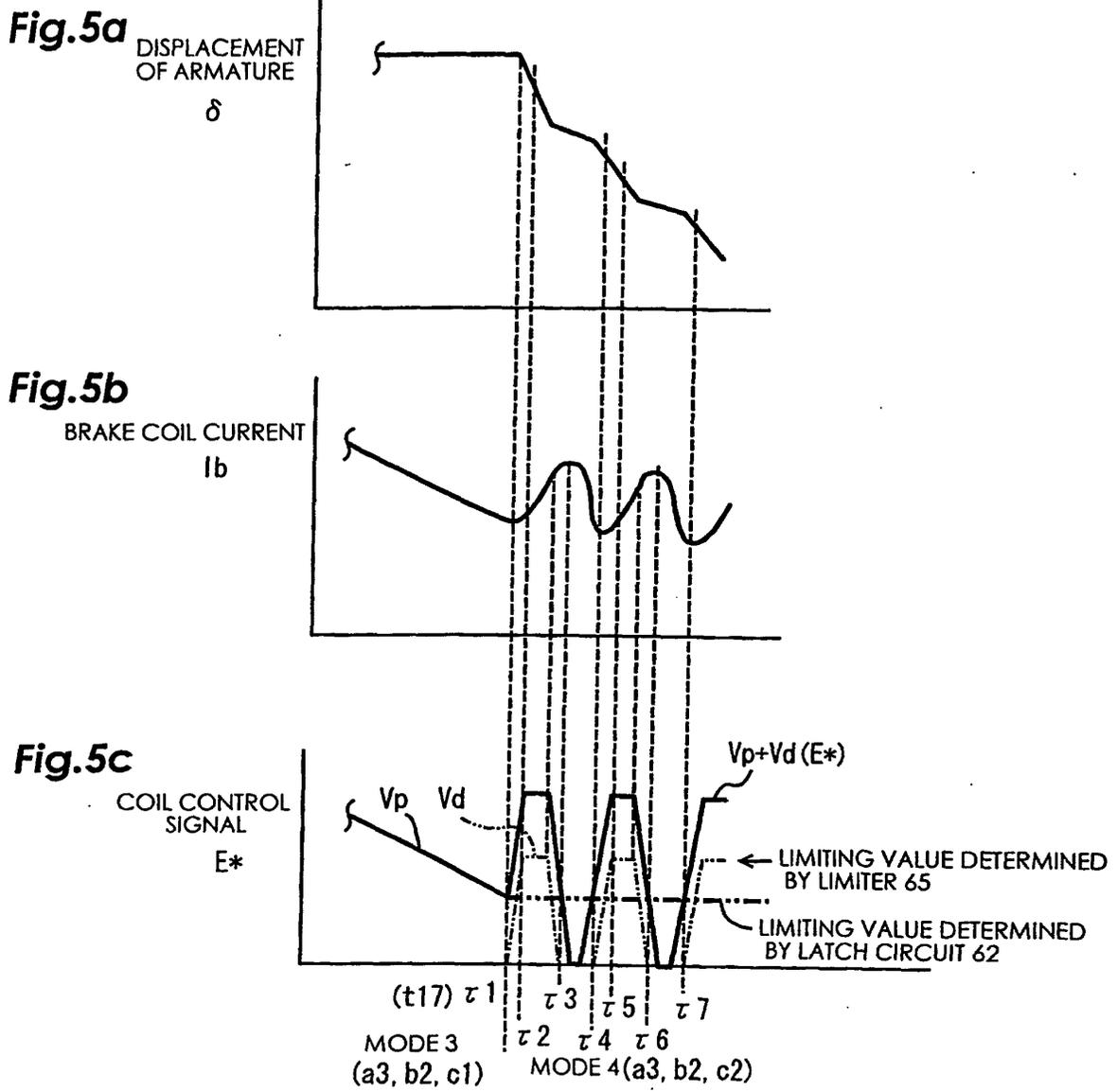


Fig.3





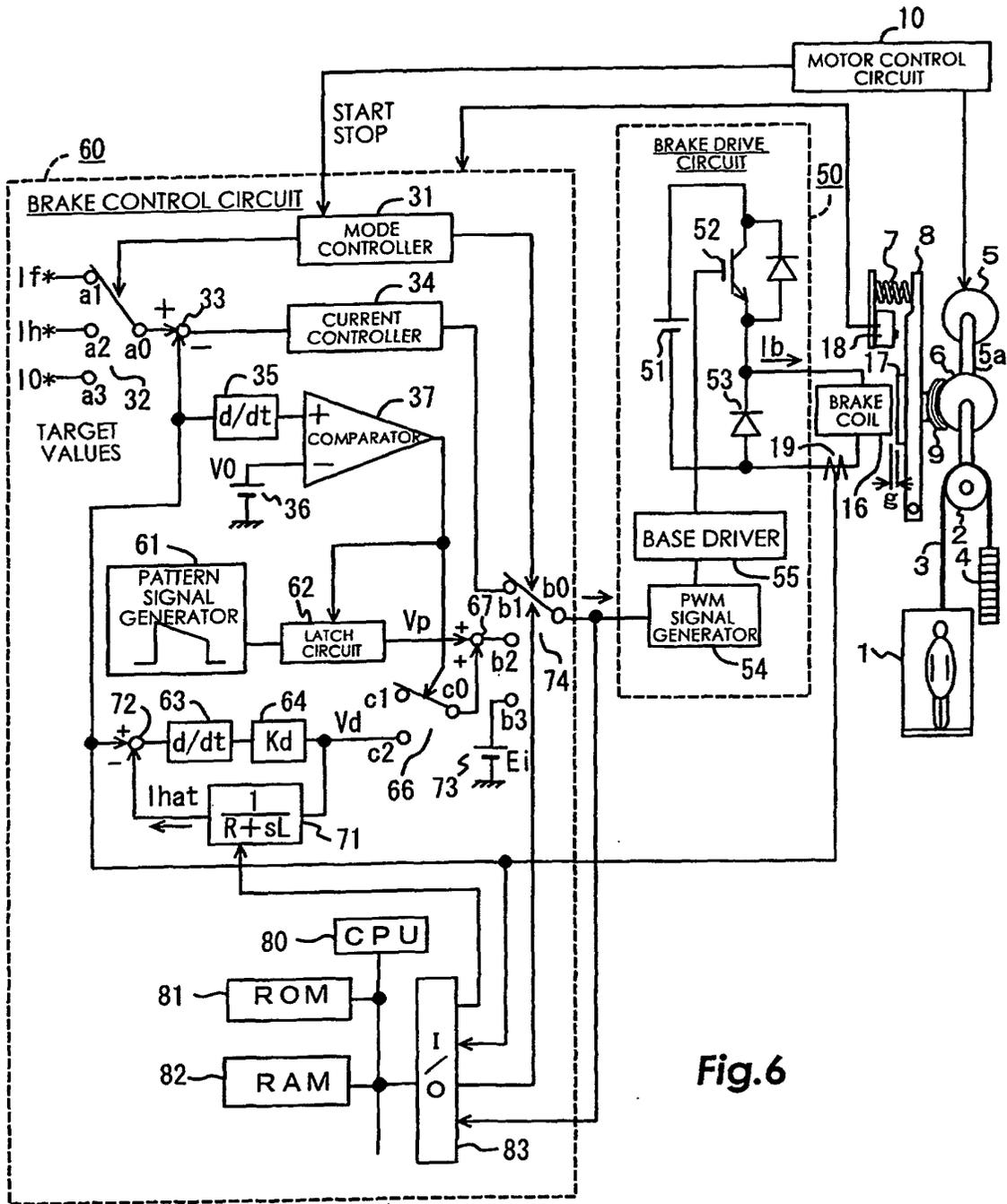


Fig.6

Fig.7a

DISPLACEMENT
OF ARMATURE

δ

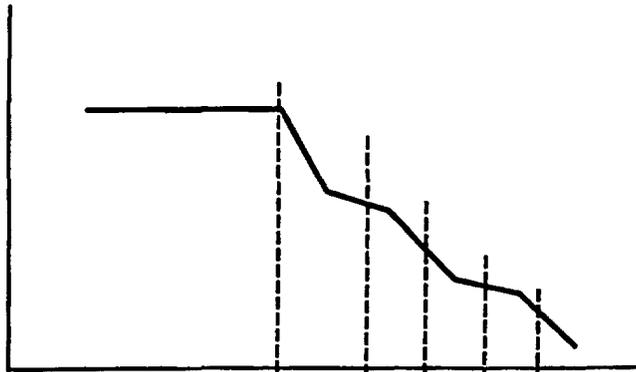


Fig.7b

BRAKE COIL
CURRENT

I_b

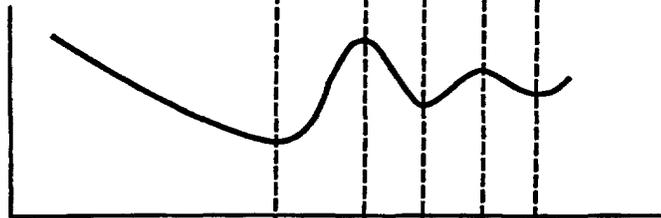


Fig.7c

MODEL
CURRENT

I_{hat}

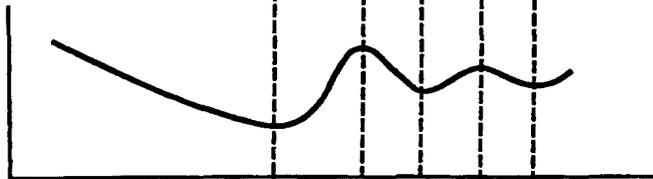


Fig.7d

DIFFERENCE
CURRENT

$I_b - I_{hat}$

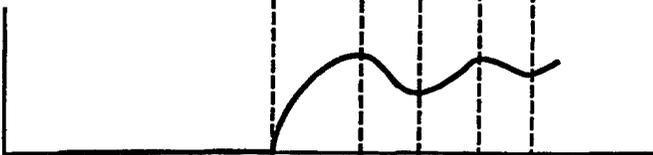
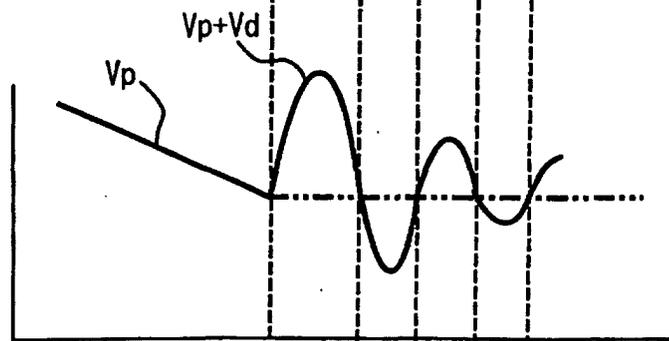


Fig.7e

COIL CONTROL
SIGNAL
 E^*



τ_{21}
(t_{17})

τ_{22} τ_{23} τ_{24} τ_{25}

MODE3
(a3, b2, c1)

MODE4
(a3, b2, c2)

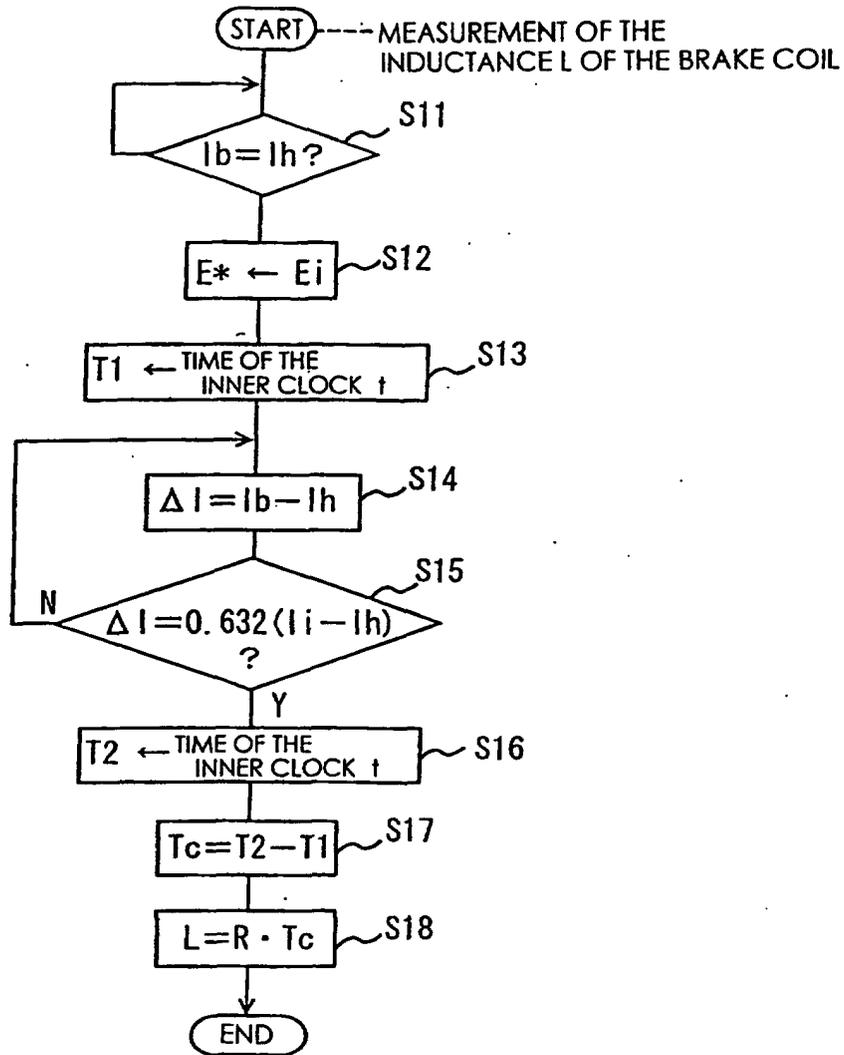
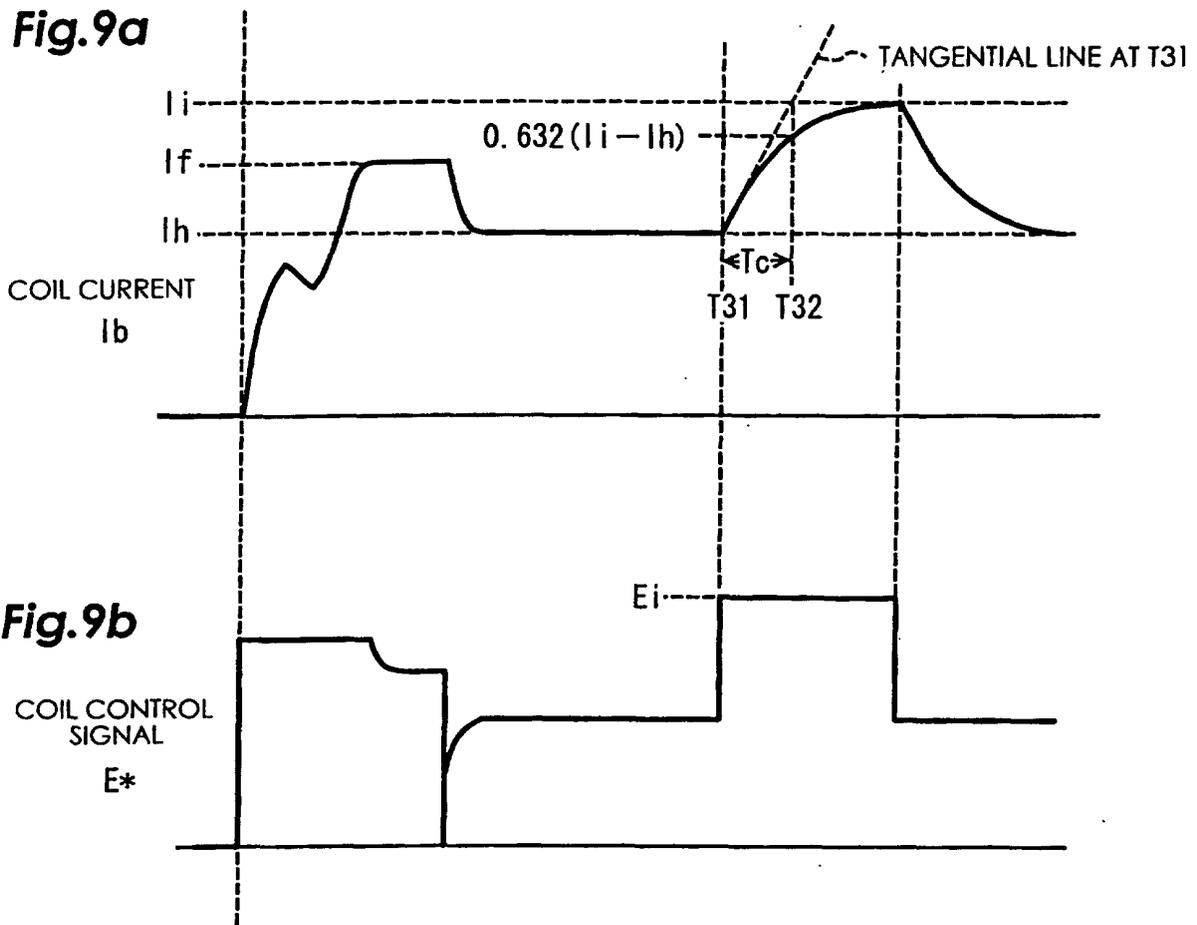


Fig. 8



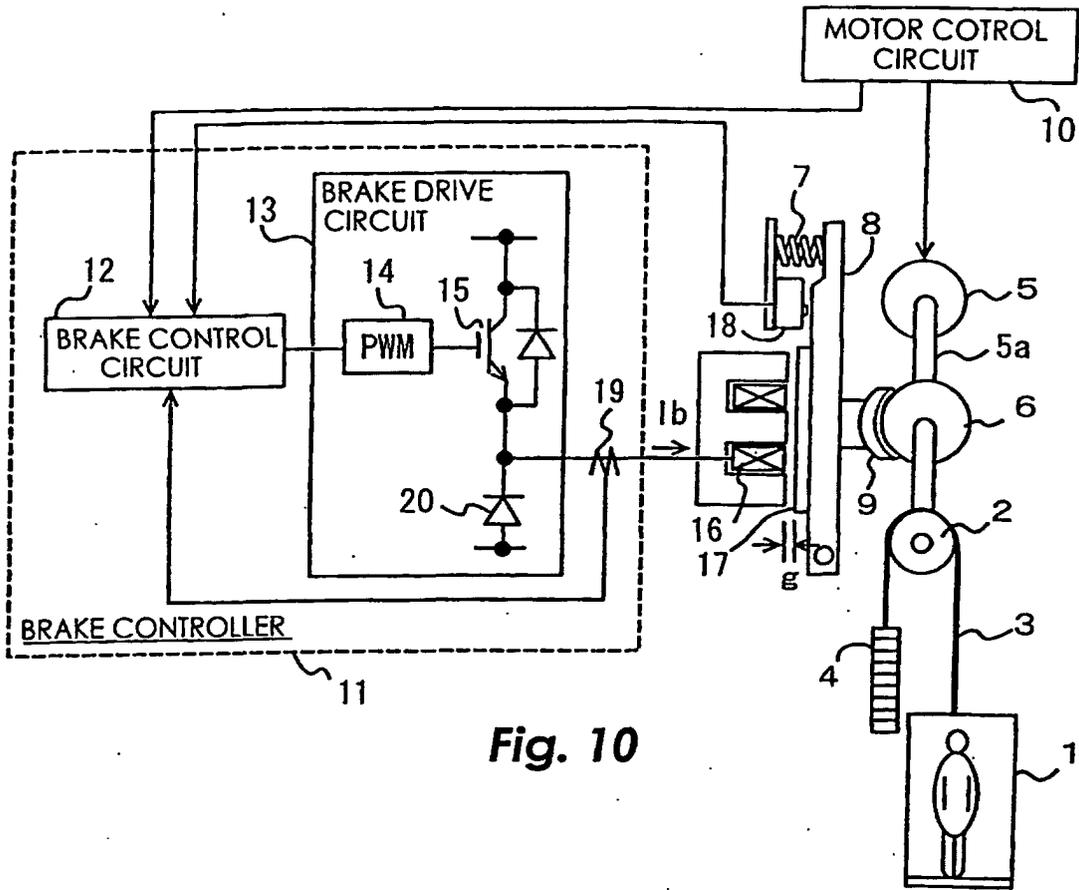


Fig. 10

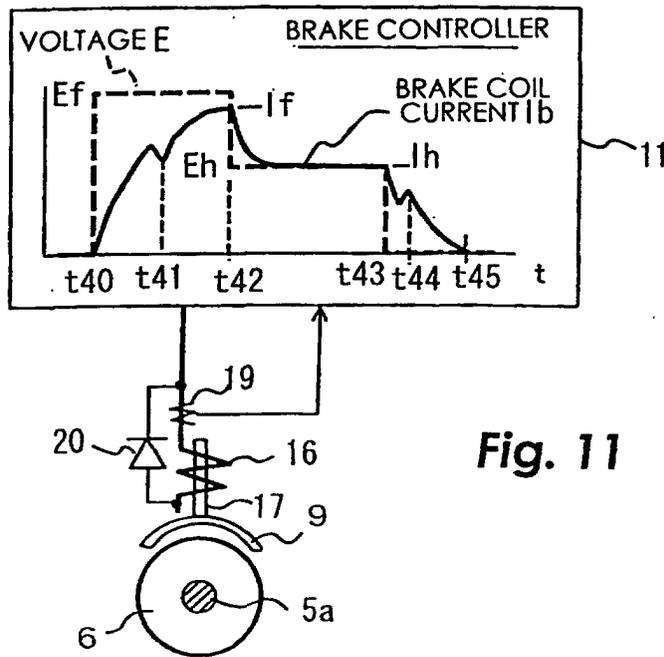


Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/08510

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁷ B66B1/32, H01F7/06, H01F7/18		
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) Int.Cl ⁷ B66B1/00-B66B11/08, H01F7/06, H01F7/18		
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 1996-2002 Kokai Jitsuyo Shinan Koho 1971-2002 Toroku Jitsuyo Shinan Koho 1994-2002		
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.
A	JP 7-64493 B2 (Mitsubishi Electric Corp.), 12 July, 1995 (12.07.95), & JP 2-8175 A & CN 1038994 A & US 4974703 A & KR 9207366 B	1-9
A	JP 7-68016 B2 (Mitsubishi Electric Corp.), 26 July, 1995 (26.07.95), & JP 2-175575 A & CN 1043680 A & GB 2230360 A & US 4987977 A & KR 9211082 B	1-9
A	JP 7-2441 A (Mitsubishi Electric Corp.), 06 January, 1995 (06.01.95), (Family: none)	1-9
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> 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 document 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 "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "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 21 June, 2002 (21.06.02)		Date of mailing of the international search report 02 July, 2002 (02.07.02)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/08510

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 7-80650 B2 (Japan Otis Elevator Co., Meidensha Corp.), 30 August, 1995 (30.08.95), & JP 4-96675 A & US 5247140 A	1-9
A	JP 7-2452 A (Mitsubishi Electric Corp.), 06 January, 1995 (06.01.95), (Family: none)	1-9
E,A	JP 2001-294372 A (Mitsubishi Electric Corp.), 23 October, 2001 (23.10.01), (Family: none)	1-9

Form PCT/ISA/210 (continuation of second sheet) (July 1998)