BRAKE SYSTEM OF ELEVATOR

A brake apparatus for an elevator includes a brake apparatus main body having a brake coil, and a discharge circuit connected in parallel to the brake coil. The brake apparatus main body serves to apply a braking force to a car by stopping the supply of electric power to the brake coil and release the braking force applied to the car by supplying electric power to the brake coil. The discharge circuit attenuates a current of the brake coil when the supply of electric power to the brake coil is stopped. In addition, the discharge circuit has a discharge parallel part that includes a resistor, and an overvoltage absorber which is connected in parallel to the resistor for maintaining a voltage impressed on the resistor within a predetermined range.

FIG. 2
Description

[TECHNICAL FIELD]

[0001] The present invention relates to a brake apparatus for an elevator that serves to apply a braking force to a car.

[BACKGROUND ART]

[0002] In the past, there has been proposed a brake control apparatus for an elevator in which a discharge circuit for attenuating the current of a brake coil is connected in parallel to the brake coil in order to prevent the operation delay of a brake. The discharge circuit is composed of a parallel circuit comprising a resistor and a capacitor. When the supply of electric power to the brake coil is stopped, resonance is generated in the circuit including the brake coil, the capacitor and the resistor, whereby the current of the brake coil is attenuated in a period of time shorter than that in the case where the capacitor is not included in the discharge circuit (see, a first patent document).


[DISCLOSURE OF THE INVENTION]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

[0004] However, since the attenuation factor of the current of the brake coil is decided by the inductance and resistance of the brake coil, so the attenuation speed of the current decreases as the current of the brake coil becomes smaller. Accordingly, it becomes difficult to further prevent the operation delay of the brake.

[0005] The present invention is intended to obviate the problem as referred to above, and has for its object to obtain a brake apparatus for an elevator which is capable of shortening a period of time from the time when the supply of electric power to a brake coil is stopped until the time when a braking force is applied to an elevator car.

[MEANS FOR SOLVING THE PROBLEMS]

[0006] A brake apparatus for an elevator according to the present invention includes: a brake apparatus main body that has a brake coil, and serves to apply a braking force to a car by stopping the supply of electric power to the brake coil and release the braking force applied to the car by supplying electric power to the brake coil; and a discharge circuit that is connected in parallel to the brake coil, and serves to attenuate a current of the brake coil when the supply of electric power to the brake coil is stopped; wherein the discharge circuit has a discharge parallel part that includes a resistor, and an overvoltage absorber which is connected in parallel to the resistor for maintaining a voltage impressed on the resistor within a predetermined range.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Fig. 1 is a schematic construction view showing an elevator equipped with a brake apparatus according to a first embodiment of the present invention.
Fig. 2 is a circuit diagram showing a brake control unit and a brake coil of Fig. 1.
Fig. 3 is a graph showing the electric characteristic of a voltage regulator diode of Fig. 2.
Fig. 4 is a graph showing the change over time of a voltage generated in a resistor after the supply of electric power to the brake coil of Fig. 2 is stopped.
Fig. 5 is a graph showing the change over time of a current of the brake coil after the supply of electric power to the brake coil of Fig. 2 is stopped.
Fig. 6 is a graph showing the change over time of the speed of a car after the supply of electric power to the brake coil of Fig. 2 is stopped.
Fig. 7 is a schematic construction view showing an elevator equipped with a brake apparatus according to a second embodiment of the present invention.
Fig. 8 is a circuit diagram showing individual brake coils and a first brake control unit and a second brake control unit of Fig. 7.
Fig. 9 is a graph showing the changes over time of individual voltages generated in a first resistor and a second resistor, respectively, after the supply of electric power to the individual brake coils of Fig. 8 is stopped.
Fig. 10 is a graph showing the changes over time of respective currents of the individual brake coils after the supply of electric power to the individual brake coils of Fig. 8 is stopped.
Fig. 11 is a graph showing the change over time of the speed of a car after the supply of electric power to the individual brake coils of Fig. 8 is stopped.
Fig. 12 is a graph showing the changes over time of individual voltages generated in a first resistor and a second resistor, respectively, after the supply of electric power to individual brake coils is stopped in a brake apparatus for an elevator according to a third embodiment of the present invention.
Fig. 13 is a graph showing the changes over time of respective currents of the individual brake coils after the supply of electric power to the individual brake coils is stopped in the brake apparatus for an elevator according to the third embodiment of the present invention.
Fig. 14 is an essential part circuit diagram showing a brake apparatus for an elevator according to a fourth embodiment of the present invention.
Hereinafter, preferred embodiments of the present invention will be described while referring to the accompanying drawings.

**Embodiment 1.**

Fig. 1 is a schematic construction view showing an elevator equipped with a brake apparatus according to a first embodiment of the present invention. In this figure, a car 2 and a counterweight 3 are arranged in a hoistway 1 so as to be movable up and down. A winch (drive unit) 4 for driving the car 2 and the counterweight 3 to move up and down is arranged at an upper portion of the hoistway 1. The winch 4 has a winch main body 5 including a motor, and a drive sheave 6 that is driven to rotate by means of the winch main body 5. A plurality of main ropes 7, which serve to hang the car 2 and the counterweight 3, are wrapped around the drive sheave 6. The car 2 and the counterweight 3 are driven to move up and down in the hoistway 1 by the rotation of the drive sheave 6.

The rotation of the drive sheave 6 is braked by a brake apparatus 8. The brake apparatus 8 has a rotating member 9 that is rotated together with the drive sheave 6, a brake apparatus main body 10 that is installed on the winch main body 5 for providing a braking force to the rotating member 9, and a brake control unit 11 that serves to control the operation of the brake apparatus main body 10. The brake control unit 11 is installed on a control panel 12 of the elevator arranged in the hoistway 1.

The brake apparatus main body 10 has a brake member 13 that can be moved into or out of contact with the rotating member 9, a biasing spring 14 that serves to bias or urge the brake member 13 in a direction to contact the rotating member 9, and an electromagnet 15 that serves to displace the brake member 13 in a direction away from the rotating member 9 against the biasing force of the biasing spring 14.

The electromagnet 15 has a magnet main body (iron core) 16, and a brake coil 17 that is built into the magnet main body 16. The electromagnet 15 generates an electromagnetic attraction force by supplying electric power to the brake coil 17.

When the supply of electric power to the brake coil 17 is stopped, the brake member 13 is caused to displace in a direction to contact the rotating member 9 by means of the biasing force of energization spring 13. Due to the contact of the brake member 13 with the rotating member 9, a braking force is given to the car 2 and the counterweight 3. In addition, when electric power is supplied to the brake coil 17, the brake member 13 is caused to displace in a direction away from the rotating member 9 by means of the electromagnetic attraction force generated by the electromagnet 15. The braking force given to the car 2 and the counterweight 3 is released due to the movement of the brake member 13 away from the rotating member 9.

Fig. 2 is a circuit diagram showing the brake control unit 11 and the brake coil 17 in Fig. 1. In this figure, the brake control unit 11 serves to control electric power supplied from a power supply 18 to the brake coil 17. In addition, the brake control unit 11 includes: a discharge circuit 19 that is connected in parallel to the brake coil 17 for attenuating the current of the brake coil 17 when the supply of electric power to the brake coil 17 is stopped; a first contact 20 that serves to open and close electrical connection between the brake coil 17 and a positive terminal of the power supply 18, and between the discharge circuit 19 and the positive terminal of the power supply 18, respectively; and a second contact 21 that serves to open and close electrical connection between the brake coil 17 and a negative terminal of the power supply 18, and between the discharge circuit 19 and the negative terminal of the power supply 18, respectively.

The discharge circuit 19 includes a discharge parallel part 22, and a diode 23 that is connected in series to the discharge parallel part 22 for permitting an electric current to pass in a predetermined direction. The discharge parallel part 22 includes a resistor 24, and a voltage regulator diode (overvoltage absorber) 25 that is connected in parallel to the resistor 24 for maintaining a voltage impressed on the resistor 24 within a predetermined range.

Here, Fig. 3 is a graph showing the electric characteristic of the voltage regulator diode 25 of Fig. 2. As shown in this figure, in case where a reverse voltage is impressed on the voltage regulator diode 25, the amount of the current flowing through the voltage regulator diode 25 is extremely limited when the reverse voltage is smaller than a predetermined drop voltage, but increases rapidly when the reverse voltage becomes equal to or higher than the predetermined drop voltage. That is, the voltage regulator diode 25 has a characteristic in which it becomes less prone to allow the current to flow therethrough when the reverse voltage is smaller than the predetermined drop voltage, but it rapidly becomes liable to allow the current to flow therethrough when the reverse voltage becomes equal to or higher than the predetermined drop voltage. In addition, the voltage regulator diode 25 is set in such a manner that it has a maximum allowed current when the reverse voltage becomes a predetermined clamp voltage value higher than the drop voltage. The clamp voltage value of the voltage regulator diode 25 is set to be an upper limit value that can be allowed for the circuit protection of the brake apparatus 8.

Specifically, when the reverse voltage impressed on the resistor 24 and the voltage regulator diode 25, respectively, is about to exceed the clamp voltage value, current flows through the voltage regulator diode 25. As a result, the voltage impressed on the resistor 24 is maintained within the predetermined range equal to or less than the clamp voltage value. That is, the voltage regulator diode 25 serves to prevent the reverse voltage.
impressed on the resistor 24 and the voltage regulator diode 25 from exceeding the clamp voltage value.

When the car 2 and the counterweight 3 are driven to move, the first and second contacts 20, 21 are closed to supply electric power to the brake coil 17. In addition, when the car 2 and the counterweight 3 are held stopped or are emergency stopped, the first and second contacts 20, 21 are opened to stop the supply of electric power to the brake coil 17.

Now, the operation of this embodiment will be described below. When the car 2 and the counterweight 3 are to be driven to move, electric power is supplied from the power supply 18 to the brake coil 17 by means of the brake control unit 11. At this time, the brake member 13 is out of contact with the rotating member 9, so the braking force given to the car 2 and the counterweight 3 is released.

When the car 2 is emergency stopped for example, the supply of electric power from the power supply 18 to the brake coil 17 is stopped by the brake control unit 11. At this time, a surge voltage is generated in the resistor 24, and the current of the brake coil 17 flows into the discharge circuit 19.

Fig. 4 is a graph showing the change over time of the voltage generated in the resistor 24 after the supply of electric power to the brake coil 17 of Fig. 2 is stopped. Fig. 5 is a graph showing the change over time of the current of the brake coil 17 after the supply of electric power to the brake coil 17 of Fig. 2 is stopped.

As shown in these figures, a surge voltage 31 generated in the resistor 24 is maintained at the predetermined clamp voltage value by the voltage regulator diode 25 until a period of time X elapses from the time when the supply of electric power to the brake coil 17 is stopped (at an electric power supply stopping time point A). That is, when the surge voltage 31 is about to exceed the clamp voltage value, the current flowing through the voltage regulator diode 25 is adjusted in an automatic manner, whereby the surge voltage 31 is maintained to the predetermined clamp voltage value (Fig. 4). As a result, damage to the first and second contacts 20, 21, the power supply 18, etc., can be prevented. At this time, a large amount of current flows into the resistor 24, and the current 32 of the brake coil 17 (hereinafter referred to simply as a "brake current") is attenuated in a rapid manner (Fig. 5).

After this, the surge voltage 31 decreases continuously from the clamp voltage value, and the brake current 32 flows through the resistor 24, so it is also attenuated in a continuous manner. As a result, the electromagnetic attraction force of the electromagnet 15 is reduced. Thereafter, when the electromagnetic attraction force of the electromagnet 15 decreases below the biasing force of the biasing spring 14, the brake member 13 is caused to move away from the electromagnet 15 so that it is displaced toward the rotating member 9. Subsequently, at a brake member abutment time point B (Fig. 5), the brake member 13 is placed into abutment with the rotating member 9.

Thereafter, the brake current 32 is further attenuated, and the pushing force of the brake member 13 to the rotating member 9 becomes larger. As a consequence, a braking force is given to the rotating member 9, so that the braking force is applied to the car 2 and the counterweight 3.

In this regard, note that in case where the discharge parallel part 22 of Fig. 2 is composed of a resistor alone, the change over time of a surge voltage 33 generated in the resistor (hereinafter referred to as a "comparison surge voltage") is shown in Fig. 4. In addition, in case where the discharge parallel part 22 of Fig. 2 is composed of the resistor alone, the change over time of a current 34 of the brake coil 17 (hereinafter referred to as a "comparison brake current") is also shown in Fig. 5.

In the case of the discharge parallel part 22 being composed of only the resistor, in order to prevent the generation of an excessively large surge voltage, the resistance value of the resistor is set to be lower than the resistance value of the resistor 24 in case where the resistor 24 is connected in parallel to the voltage regulator diode 25.

The period of time from the electric power supply stopping time point A until the time when the attenuation of the surge voltage 31 is completed becomes shorter than the period of time from the electric power supply stopping time point A until the time when the attenuation of the comparison surge voltage 33 is completed. In addition, the period of time from the electric power supply stopping time point A until the time when the attenuation of the brake current 32 is completed becomes shorter than the period of time from the electric power supply stopping time point A until the time when the attenuation of the comparison brake current 34 is completed. Accordingly, the brake member 13 is placed into abutment with the rotating member 9 at an earlier time when the discharge parallel part 22 shown in Fig. 2 is used than when the discharge parallel part composed of only the resistor is used, whereby the braking force given to the car 2 is generated at an early time.

Also, Fig. 6 is a graph showing the change over time of a speed 35 of the car 2 after the supply of electric power to the brake coil 17 of Fig. 2 is stopped (hereinafter referred to simply as a "car speed"). As shown in this figure, at the electric power supply stopping time point A, the supply of electric power to the motor of the winch main body 5 (Fig. 1) is also stopped, so the car speed 35 rises temporarily. After this, a braking force is applied to the car 2 by the operation of the brake apparatus main body 10. As a result, the car speed 35 is decreased in a continuous manner, whereby the car 2 is stopped.

In Fig. 6, there is also shown, for the purpose of a comparison between the periods of time until the car 2 is stopped, the change over time of a speed 36 of the car 2 in case where the discharge parallel part 22 of Fig. 2 is composed of only the resistor (hereinafter referred
to as a "comparison car speed"). As shown in this figure, it is found that the car speed 35 is changed to deceleration at an earlier point in time than the comparison car speed 36 is. Accordingly, the period of time from the electric power supply stopping time point A until the car 2 is stopped becomes shorter when the discharge parallel part 22 shown in Fig. 2 is used than when the discharge parallel part composed of only the resistor is used.

[0030] In such a brake apparatus for an elevator, the discharge circuit 19 connected in parallel to the brake coil 17 has the discharge parallel part 22, and the discharge parallel part 22 has the resistor 24 and the voltage regulator diode 25 connected to each other. With this arrangement, the surge voltage generated in the resistor 24 when the supply of electric power to the brake coil 17 is stopped can be maintained within the predetermined range by means of the voltage regulator diode 25. Accordingly, the resistance value of the resistor 24 can be set larger, and hence the current of the brake coil 17 can be attenuated in a shorter time. As a result, the brake member 13 can be displaced at an early time. Thus, it is possible to shorten the period of time from the time when the supply of electric power to the brake coil 17 is stopped until the time when a braking force is applied to the car 2.

Embodiment 2.

[0031] Fig. 7 is a schematic construction view showing an elevator equipped with a brake apparatus according to a second embodiment of the present invention. In this figure, a brake apparatus 8 includes a rotating member 9 that is driven to rotate together with a drive sheave 6, a first and a second brake apparatus main body 41, 42 (i.e., a plurality of brake apparatus main bodies) that are respectively installed on a winch main body 5 for respectively providing individual braking forces to the common rotating member 9, a first brake control unit 43 for controlling the first brake apparatus main body 41, and a second brake control unit 44 for controlling the second brake apparatus main body 42. The first and second brake apparatus main bodies 41, 42 are similar in construction to the brake apparatus main body 10 (Fig. 1) of the first embodiment. In addition, the first and second brake control units 43, 44 are installed on a control panel 12.

[0032] Fig. 8 is a circuit diagram showing individual brake coils 17 and the first and second brake control units 43, 44 in Fig. 7. In this figure, the first and second brake control units 43, 44 are connected to a common power supply 18. The first and second brake control units 43, 44 serve to control electric power supplied from the power supply 18 to the individual brake coils 17, respectively. The construction of each of the first and second brake control units 43, 44 is similar to the brake control unit 11 of the first embodiment (Fig. 2) except for each discharge parallel part 22.

[0033] A discharge circuit 19 of the first brake control unit 43 is connected in parallel to one of the brake coils 17, and a discharge circuit 19 of the second brake control unit 44 is connected in parallel to the other of the brake coils 17. That is, the discharge circuits 19 of the individual brake control units 43, 44 are separately connected in parallel to the individual brake coils 17, respectively.

[0034] The discharge parallel part 22 of the first brake control unit 43 has a first resistor 45, and a first voltage regulator diode (overvoltage absorber) 46 that is connected in parallel to the first resistor 45. Also, the discharge parallel part 22 of the second brake control unit 44 has a second resistor 47, and a second voltage regulator diode (overvoltage absorber) 48 that is connected in parallel to the second resistor 47.

[0035] The individual resistance values of the first and second resistor 45, 47 are equal to each other. In addition, the individual clamp voltage values of the first and second voltage regulator diodes 46, 48 are different from each other. That is, predetermined ranges within which voltages are maintained by the first and second voltage regulator diodes 46, 48, respectively, are different from each other. In this example, a clamp voltage value V1 of the first voltage regulator diode 46 is set to be lower than a clamp voltage value V2 of the second voltage regulator diode 48. The construction of this second embodiment other than the above is similar to that of the first embodiment.

[0036] Now, the operation of this embodiment will be described below. When the car 2 and the counterweight 3 are to be driven to move, electric power is supplied from the power supply 18 to the individual brake coils 17 separately by means of the first and second brake control units 43, 44, respectively. With this, all the brake members 13 are out of contact with the rotating member 9, so the braking force given to the car 2 and the counterweight 3 is released.

[0037] When the car 2 is urgently stopped for example, the supply of power from the power supply 18 to the individual brake coils 17 is stopped at the same time by the operations of the first and second contacts 20, 21 of the individual brake control units 11. At this time, surge voltages are generated in the first and second resistors 45, 47, respectively, and the currents of the individual brake coils 17 flow into the individual discharge circuits 19, respectively.

[0038] Fig. 9 is a graph showing the changes over time of individual voltages generated in the first and second resistors 45, 47, respectively, after the supply of electric power to the individual brake coils 17 of Fig. 8 is stopped. Fig. 10 is a graph showing the changes over time of respective currents of the individual brake coils 17 after the supply of electric power to the individual brake coils 17 of Fig. 8 is stopped.

[0039] When the supply of electric power to the individual brake coils 17 is simultaneously stopped at the electric power supply stopping time point A, as shown in these figures, a surge voltage 49 generated in the first resistor 45 (hereinafter referred to as a "first surge voltage") is maintained at the clamp voltage value V1 by the
first voltage regulator diode 46, and a surge voltage 50 generated in the second resistor 47 (hereinafter referred to as a "second surge voltage") is maintained at the clamp voltage value V2 by the second voltage regulator diode 48 (Fig. 9). At this time, a current 51 of one brake coil 17 (hereinafter referred to as a "first brake current") flows through the first resistor 45, and a current 52 of the other brake coil 17 (hereinafter referred to as a "second brake current") flows through the second resistor 47. As a result, the first and second brake currents 51, 52 are attenuated rapidly (Fig. 10). After this, the first and second surge voltages 49, 50 are reduced in a continuous manner, and the first and second brake currents 51, 52 are also attenuated in a continuous manner.

[0040] Since the clamp voltage value V1 is set to be lower than the clamp voltage value V2, a period of time X1 for which the first surge voltage 49 is maintained at the clamp voltage value V1 becomes longer than a period of time X2 for which the second surge voltage 50 is maintained at the clamp voltage value V2. As a result, the second brake current 52 is attenuated in a shorter period of time than the first brake current 51 is.

[0041] Accordingly, the brake member 13 of the second brake apparatus main body 42 is moved away from an electromagnet 15, after which the brake member 13 of the first brake apparatus main body 41 is moved away from another electromagnet 15. After this, the individual brake members 13 are brought into abutment with the rotating member 9 at the brake member abutment time points B, B', respectively, which are different from each other. That is, the individual brake members 13 are placed into abutment with the common rotating member 9 in a time shifted manner. Thereafter, the first and second brake currents 51, 52 are attenuated, whereby the braking force is provided to the car 2.

[0042] In this regard, note that in case where each of the discharge parallel parts 22 of Fig. 8 is composed of a resistor alone, the change over time of a surge voltage 53 generated in the resistor (hereinafter referred to as a "comparison surge voltage") is also shown in Fig. 9. In addition, in case where each of the discharge parallel parts 22 of Fig. 2 is composed of the resistor alone, the change over time of a current 54 of each of the brake coils 17 (hereinafter referred to as a "comparison brake current") is also shown in Fig. 10. The resistance value of the resistor in the case of the discharge parallel parts 22 being each composed of only the resistor is set to be the same as the resistance value of each of the first and second resistors 45, 47. Accordingly, in case where the discharge parallel parts 22 are each composed of only the resistor, a voltage impressed on the resistor becomes a voltage value V3 that is higher than the individual clamp voltage values V1, V2 at the electric power supply stopping time point A.

[0043] As shown in these figures, the periods of time from the electric power supply stopping time point A until the times when the attenuations of the first and second brake currents 51, 52 are completed become shorter than the period of time from the electric power supply stopping time point A until the time when the attenuation of the comparison brake current 54 is completed. Accordingly, the brake members 13 are placed into abutment with the rotating member 9 at an earlier time when the discharge parallel parts 22 shown in Fig. 8 are used than when the discharge parallel parts each composed of only the resistor is used, whereby a braking force given to the car 2 is generated at an early time.

[0044] Also, Fig. 11 is a graph showing the change over time of a speed 55 of the car 2 after the supply of electric power to the individual brake coils 17 of Fig. 8 is stopped (hereinafter referred to simply as a "car speed"). As shown in the figure, the car speed 55, after having risen temporarily, lowers in a continuous manner by the braking force being applied to the car 2.

[0045] In Fig. 11, there are also shown, for the purpose of a comparison among the periods of time until the car 2 is stopped, the individual changes over time of a speed 56 of the car 2 when the clamp voltage value V1 of the first voltage regulator diode 46 of Fig. 8 is equal to the clamp voltage value V2 of the second voltage regulator diode 48, and of a speed 57 of the car 2 when the individual discharge parallel parts 22 of Fig. 8 are each composed of only the resistor.

[0046] As shown in this figure, the time from the electric power supply stopping time point A until the car 2 is stopped becomes longer in the order of the case where the first and second voltage regulator diodes 46, 48 are both set to the clamp voltage value V2 (speed waveform 56), the case where the first voltage regulator diode 46 is set to the clamp voltage value V1, and the second voltage regulator diode 48 is set to the clamp voltage value V2 (speed waveform 55), and the case where the individual discharge parallel parts 22 are each composed of only the resistor (speed waveform 57).

[0047] In such a brake apparatus for an elevator, the discharge circuits 19 are connected in parallel to the individual brake coils 17 of the plurality of brake apparatus main bodies 41, 42 respectively, and the discharge parallel parts 22 of the individual discharge circuits 19 have the first and second voltage regulator diodes 46, 48, respectively, of which the clamp voltages are different from each other. With such an arrangement, the first and second brake apparatus main bodies 41, 42 can be controlled in such a manner that the attenuation speeds of the currents of the brake coils 17 are made to be different from each other. As a result, the generation time of the braking force given to the rotating member 9 can be shifted between the first and second brake apparatus main bodies 41, 42, whereby an impact to the car 2 can be suppressed.

Embodiment 3.

[0048] In the second embodiment, the resistance values of the first and second resistors 45, 47 are set equal to each other, but the resistance values of the first and
second resistors 45, 47 may be set different from each other.

[0049] In this example, a resistance value R1 of a first resistor 45 is set to be larger than a resistance value R2 of a second resistor 47. In addition, the first and second voltage regulator diodes 46, 48 are set to the same clamp voltage value V. The construction of this embodiment other than the above is similar to that of the second embodiment.

[0050] Fig. 12 is a graph showing the changes over time of individual voltages generated in the first resistor 45 and the second resistor 47, respectively, after the supply of electric power to the individual brake coils 17 is stopped in a brake apparatus for an elevator according to a third embodiment of the present invention. In addition, Fig. 13 is a graph showing the changes over time of individual currents of the individual brake coils 17, respectively, after the supply of electric power to the individual brake coils 17 is stopped in the brake apparatus for an elevator according to the third embodiment of the present invention.

[0051] When the supply of electric power to the individual brake coils 17 is simultaneously stopped at an electric power supply stopping time point A, as shown in these figures, a surge voltage 61 (hereinafter referred to as a "first surge voltage") generated in the first resistor 45 and a surge voltage 62 (hereinafter referred to as a "second surge voltage") generated in the second resistor 47 are maintained at the clamp voltage value V. At this time, a current 63 of the one brake coil 17 (hereinafter referred to as a "first brake current") flows through the first resistor 45, and a current 64 of the other brake coil 17 (hereinafter referred to as a "second brake current") flows through the second resistor 47. As a result, the first and second brake currents 63, 64 are attenuated rapidly.

[0052] Since the resistance value R1 of the first resistor 45 is set to be larger than the resistance value R2 of the second resistor 47, a period of time Y1 for which the first surge voltage 61 is maintained at the clamp voltage value V becomes longer than a period of time Y2 for which the second surge voltage 62 is maintained at the clamp voltage value V. As a result, the first brake current 63 is attenuated in a shorter period of time than the second brake current 64 is. Accordingly, a brake member 13 of a first brake apparatus main body 41 is moved away from an electromagnet 15, after which a brake member 13 of a second brake apparatus main body 42 is moved away from another electromagnet 15. The individual brake members 13 being moved away from the electromagnets 15, respectively, are brought into abutment with the rotating member 9 at brake member abutment time points B, B', respectively, which are different from each other. The operation of this embodiment after this is similar to that of the second embodiment.

[0053] In such a brake apparatus for an elevator, the individual resistance values R1, R2 of the first and second resistors 45, 47 are different from each other, so the generation time of a braking force given to the rotating member 9 can be shifted between the first and second brake apparatus main bodies 41, 42, whereby an impact to the car 2 can be suppressed.

[0054] In the above example, the individual clamp voltage values of the first and second voltage regulator diodes 46, 48 are set equal to each other, but the individual clamp voltage values of the first and second voltage regulator diodes 46, 48 may be made different from each other, as in the second embodiment.

Embodiment 4.

[0055] Fig. 14 is an essential part circuit diagram showing a brake apparatus for an elevator according to a fourth embodiment of the present invention. In this figure, a discharge circuit 19 has a plurality of discharge parallel parts 22 and a diode 23 connected in series with one another. The construction of each of the individual discharge parallel parts 22 and the diode 23 is similar to the construction of each of the discharge parallel part 22 and the diode 23 of the first embodiment. The construction of this fourth embodiment other than the above is similar to that of the first embodiment.

[0056] That is, in case where there is only one discharge parallel part 22, there will be the following problems. When the voltage regulator diode 25 becomes an open circuit failure for example, a high voltage is impressed on circuitry, whereas when the voltage regulator diode 25 becomes a short circuit failure, the attenuation of the current of the brake coil 17 is slowed. However, it is possible to prevent the occurrence of such problems by the use of the plurality of discharge parallel parts 22.

Claims
1. A brake apparatus for an elevator characterized by comprising:

   a brake apparatus main body that has a brake coil, and serves to apply a braking force to a car by stopping the supply of electric power to the brake coil and release the braking force applied to the car by supplying electric power to the brake coil; and
   a discharge circuit that is connected in parallel to the brake coil, and serves to attenuate a current of the brake coil when the supply of electric power to the brake coil is stopped;

   wherein the discharge circuit has a discharge parallel part that includes a resistor, and an overvoltage absorber which is connected in parallel to the resistor for maintaining a voltage impressed on the resistor within a predetermined range.

2. The brake apparatus for an elevator as set forth in claim 1, characterized by further comprising:
a plurality of the brake apparatus main bodies; and
a plurality of the discharge circuits that are separately connected in parallel to the individual brake coils of the brake apparatus main bodies, respectively;

wherein the predetermined ranges within which voltages are maintained by means of the individual overvoltage absorbers, respectively, are different from each other.

3. The brake apparatus for elevator as set forth in claim 1, characterized by further comprising:

a plurality of the brake apparatus main bodies; and
a plurality of the discharge circuits that are separately connected in parallel to the individual brake coils of the brake apparatus main bodies, respectively;

wherein the resistance values of the individual resistors are different from one another.

4. The brake apparatus for an elevator as set forth in claim 1, characterized in that the discharge circuit has a plurality of the discharge parallel parts connected in series to one another.
FIG. 3
FIG. 9

FIG. 10
# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER

**B66B1/32 (2006.01)**

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**B66B1/32**

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

- Jitsuyo Shinan Koho 1992-1996
- Jitsuyo Shinan Toroku Koho 1996-2007
- Kokai Jitsuyo Shinan Koho 1971-2007
- Toroku Jitsuyo Shinan Koho 1994-2007

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>JP 2003-081543 A (Toshiba Elevator and Building Systems Corp.), 19 March, 2003 (19.03.03), (Family: none)</td>
<td>1-4</td>
</tr>
<tr>
<td>Y</td>
<td>JP 09-069434 A (Fuji Electric Co., Ltd.), 11 March, 1997 (11.03.97), Par. No. [0099] (Family: none)</td>
<td>1-4</td>
</tr>
<tr>
<td>Y</td>
<td>JP 03-115080 A (Mitsubishi Electric Corp.), 16 May, 1991 (16.05.91), &amp; GB 2236365 A</td>
<td>2-4</td>
</tr>
</tbody>
</table>

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

- **Y** document defining the general state of the art which is not considered to be of particular relevance
- **E** earlier application or patent but published on or after the international filing date
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Date of the actual completion of the international search: 02 March, 2007 (02.03.07)

Date of mailing of the international search report: 13 March, 2007 (13.03.07)

Name and mailing address of the ISA/ Japanese Patent Office

Authorized officer: [Telemhole No.]

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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 088362/1979 (Laid-open No. 007308/1981) (Nachi-Fujikoshi Corp.), 22 January, 1981 (22.01.81), (Family: none)</td>
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