



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
13.05.2009 Bulletin 2009/20

(51) Int Cl.:
B66B 1/32 (2006.01) B66B 5/02 (2006.01)
B66B 7/06 (2006.01) B66B 11/08 (2006.01)

(21) Application number: **06833965.4**

(86) International application number:
PCT/JP2006/324210

(22) Date of filing: **05.12.2006**

(87) International publication number:
WO 2008/068839 (12.06.2008 Gazette 2008/24)

(84) Designated Contracting States:
DE
Designated Extension States:
AL BA HR MK RS

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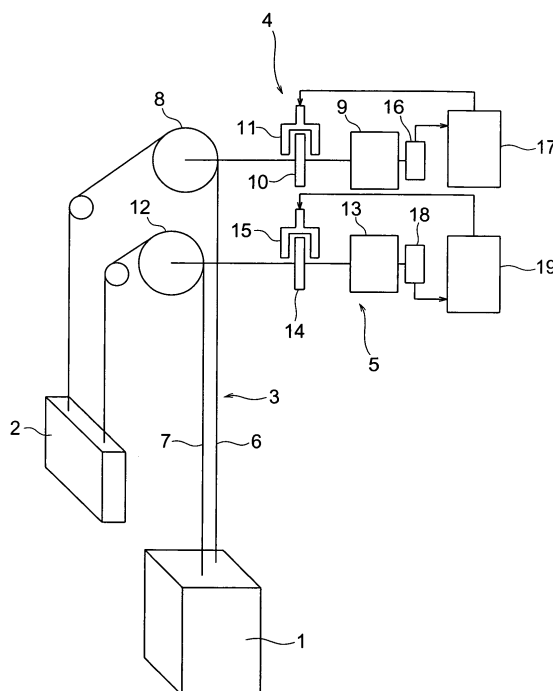
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(54) **ELEVATOR APPARATUS**

(57) In an elevator apparatus, a car is raised and lowered by a plurality of hoisting machines. Braking apparatuses are disposed on the respective hoisting machines. The braking apparatuses are controlled individually by respective brake controlling means. The respec-

tive brake controlling means detect states of rotation of the respective hoisting machines during emergency braking, and control braking forces from the respective braking apparatuses in response to the detected states of rotation.

FIG. 1



Description

TECHNICAL FIELD

[0001] The present invention relates to an elevator apparatus that raises and lowers a single car by a plurality of hoisting machines.

BACKGROUND ART

[0002] In recent years, with increases in building heights, elevator are being sought that can move more passengers sooner. In answer to this, one method is to enlarge the car, but in order to do that, a larger hoisting machine that has greater torque and higher output is required, increasing manufacturing costs, and lifting and installation costs, etc. In answer to that, an elevator apparatus has been proposed that raises and lowers a single car using two hoisting machines without enlarging the hoisting machines (see Patent Literature 1, for example).

[0003] [Patent Literature 1]
Japanese Patent Publication No. HEI 7-42063 (Gazette)

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004] In conventional elevator apparatuses such as that described above, since no consideration has been given to how to stop the two hoisting machines during emergency braking, there has been a risk that timing of operation of the braking apparatuses of the two hoisting machines may be unintentionally out of synchronization, or deceleration of the car may become excessive, etc.

[0005] The present invention aims to solve the above problems and an object of the present invention is to provide an elevator apparatus that can decelerate and stop a plurality of hoisting machines more appropriately during emergency braking.

MEANS FOR SOLVING THE PROBLEM

[0006] In order to achieve the above object, according to one aspect of the present invention, there is provided an elevator apparatus including: a plurality of hoisting machines that have respective braking apparatuses; a car that is raised and lowered by the hoisting machines; and a plurality of brake controlling means that control the respective braking apparatuses individually, wherein the respective brake controlling means detect states of rotation of the respective hoisting machines during emergency braking, and control braking forces from the respective braking apparatuses in response to the detected states of rotation.

According to another aspect of the present invention, there is provided an elevator apparatus including: a plurality of hoisting machines that have respective braking

apparatuses; a car that is raised and lowered by the hoisting machines; and a brake controlling means that controls the braking apparatuses, wherein the brake controlling means detects a state of rotation of any one of the hoisting machines during emergency braking, and controls braking forces from at least two of the braking apparatuses of the hoisting machines in response to the detected state of rotation.

According to yet another aspect of the present invention, there is provided an elevator apparatus including: a plurality of hoisting machines that have respective braking apparatuses; a car that is raised and lowered by the hoisting machines; and a brake controlling means that controls the braking apparatuses, wherein the brake controlling means detects a running state of the car during emergency braking, and controls braking forces from at least two of the braking apparatuses of the hoisting machines in response to the detected running state.

According to yet another aspect of the present invention, there is provided an elevator apparatus including: a plurality of hoisting machines that have respective braking apparatuses; a car that is raised and lowered by the hoisting machines; a brake controlling means that controls the braking apparatuses; and an emergency stop detecting means that detects generation of an emergency stop command, wherein: the emergency stop detecting means immediately makes the braking apparatus of at least one of the hoisting machines perform a braking action by disconnection from the brake controlling means when generation of an emergency stop command is detected; and the brake controlling means controls a braking force from the braking apparatus of at least one of the hoisting machines that is subject to control during emergency braking such that deceleration of the hoisting machine that is subject to control is at a predetermined rate of deceleration.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

Figure 1 is a structural diagram that shows an elevator apparatus according to Embodiment 1 of the present invention;

Figure 2 is a graph that shows time variations of rotational speed, deceleration, an energizing command to an electromagnetic coil, and current in the electromagnetic coil during emergency braking of one of the hoisting machines from Figure 1;

Figure 3 is a structural diagram that shows an elevator apparatus according to Embodiment 2 of the present invention;

Figure 4 is a graph that shows time variations of rotational speed, an energizing command to an electromagnetic coil, and current in the electromagnetic coil during emergency braking of one of the hoisting machines of an elevator apparatus according to Embodiment 3 of the present invention;

Figure 5 is a structural diagram that shows an elevator apparatus according to Embodiment 4 of the present invention;

Figure 6 is a structural diagram that shows an elevator apparatus according to Embodiment 5 of the present invention;

Figure 7 is a structural diagram that shows an elevator apparatus according to Embodiment 6 of the present invention; and

Figure 8 is a structural diagram that shows an elevator apparatus according to Embodiment 7 of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

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

Embodiment 1

[0009] Figure 1 is a structural diagram that shows an elevator apparatus according to Embodiment 1 of the present invention. In the figure, a car 1 and a counterweight 2 are suspended inside a hoistway by a suspending means 3, and are raised and lowered by driving forces from first and second hoisting machines 4 and 5. The suspending means 3 includes at least one first main rope 6 and at least one second main rope 7. Ropes that have a circular cross section or belt-shaped ropes can be used as the first and second main ropes 6 and 7.

[0010] The first hoisting machine 4 has: a first drive sheave 8; a first motor 9 that rotates the first drive sheave 8; a first brake wheel 10 that is rotated together with the first drive sheave 8; and a first braking apparatus 11 that brakes rotation of the first brake wheel 10 and the first drive sheave 8.

[0011] The first braking apparatus 11 has: a first brake shoe that can be placed in contact with and separated from the first brake wheel 10; a first brake spring that presses the first brake shoe against the first brake wheel 10; and a first electromagnet that acts against the first brake spring so as to separate the first brake shoe from the first brake wheel 10. A first electromagnetic coil is disposed on the first electromagnet.

[0012] The second hoisting machine 5 has: a second drive sheave 12; a second motor 13 that rotates the second drive sheave 12; a second brake wheel 14 that is rotated together with the second drive sheave 12; and a second braking apparatus 15 that brakes rotation of the second brake wheel 14 and the second drive sheave 12.

[0013] The second braking apparatus 15 has: a second brake shoe that can be placed in contact with and separated from the second brake wheel 14; a second brake spring that presses the second brake shoe against the second brake wheel 14; and a second electromagnet that acts against the second brake spring so as to separate the second brake shoe from the second brake wheel 14. A second electromagnetic coil is disposed on

the second electromagnet.

[0014] The first main rope 6 is wound around the first drive sheave 8. The second main rope 7 is wound around the second drive sheave 12. Brake disks, or brake drums, etc., can be used as the first and second brake wheels 10 and 14, for example.

[0015] A first speed detector 16 is disposed on the first motor 9. A signal from the first speed detector 16 is input into a first brake controlling means 17. The first brake controlling means 17 controls the first braking apparatus 11 based on the signal from the first speed detector 16. Specifically, the first brake controlling means 17 energizes and de-energizes the first electromagnetic coil of the first braking apparatus 11 in response to the signal from the first speed detector 16.

[0016] A second speed detector 18 is disposed on the second motor 13. A signal from the second speed detector 18 is input into a second brake controlling means 19. The second brake controlling means 19 controls the second braking apparatus 15 based on the signal from the second speed detector 18. Specifically, the second brake controlling means 19 energizes and de-energizes the second electromagnetic coil of the second braking apparatus 15 in response to the signal from the second speed detector 18.

[0017] Figure 2 is a graph that shows time variations of rotational speed, deceleration, an energizing command to an electromagnetic coil, and current in the electromagnetic coil during emergency braking of one of the hoisting machines 4 and 5 from Figure 1.

[0018] If a command to make the car 1 stop urgently (an emergency stop command) is generated, electric current to the motors 9 and 13 is interrupted and the electromagnetic coils of the braking apparatuses 11 and 15 are also de-energized. If deceleration γ exceeds a predetermined value (threshold value) γ_0 at time T1, the brake controlling means 17 and 19 switch on energizing commands to the electromagnetic coils. Thus, braking force from the braking apparatuses 11 and 15 is reduced, reducing deceleration γ .

[0019] If deceleration γ is subsequently lower than the predetermined value γ_0 at time T2, the brake controlling means 17 and 19 switch off the energizing commands to the electromagnetic coils. Thus, the braking force from the braking apparatuses 11 and 15 is increased, increasing the deceleration γ .

[0020] The first and second brake controlling means 17 and 19 execute such switching on and off as energizing commands independently from each other until time T3 when the first and second hoisting machines 4 and 5 stop. Thus, the first and second hoisting machines 4 and 5 are decelerated and stopped at a rate of deceleration close to the predetermined deceleration γ_0 .

[0021] In an elevator apparatus of this kind, because the brake controlling means 17 and 19 detect the state of rotation of the respective hoisting machines 4 and 5, i.e., deceleration, during emergency braking, and control the braking force from the respective braking apparatus-

es 11 and 15 in response to the detected deceleration, the hoisting machines 4 and 5 can be decelerated and stopped more appropriately during emergency braking.

Embodiment 2

[0022] Next, Figure 3 is a structural diagram that shows an elevator apparatus according to Embodiment 2 of the present invention. In the figure, an emergency stop detecting means 20 is connected to first and second brake controlling means 17 and 19. The emergency stop detecting means 20 detects generation of an emergency stop command, and activates control of the braking forces from the first and second brake controlling means 17 and 19 synchronously. The rest of the configuration is similar to that of Embodiment 1.

[0023] In an elevator apparatus of this kind, because activation of control action of the braking forces from the first and second brake controlling means 17 and 19 is synchronized by the emergency stop detecting means 20, differences in tension between the first and second main ropes 6 and 7 can be reduced, enabling damage to the main ropes 6 and 7 to be prevented.

Embodiment 3

[0024] Next, Embodiment 3 of the present invention will be explained. In Embodiment 2, deceleration of the hoisting machines 4 and 5 was detected by the brake controlling means 17 and 19, but in Embodiment 3, rotational speed of the hoisting machines 4 and 5 is detected. Specifically, the brake controlling means 17 and 19 generate control target speeds for deceleration at a predetermined rate of deceleration using the rotational speeds of the respective hoisting machines 4 and 5 during emergency stop command generation as initial values, and control the braking force from the braking apparatuses 11 and 15 of the respective hoisting machines 4 and 5 in such a way that the rotational speeds of the respective hoisting machines 4 and 5 follow the control target speeds. The rest of the configuration is similar to that of Embodiment 2.

[0025] Figure 4 is a graph that shows time variations of rotational speed, an energizing command to an electromagnetic coil, and current in the electromagnetic coil during emergency braking of one of the hoisting machines 4 and 5 from Figure 3. In the figure, time T1 is the time at which the generation of the emergency stop command is detected, and the rotational speed of the hoisting machines 4 and 5 at that time is V0. The brake controlling means 17 and 19 perform the following calculations, where $\pm V1$ are upper and lower limit values of control speed, γ is a predetermined rate of deceleration, and t is elapsed time from time T1:

[0026]

$$V2(t) = (V0 + V1) - \gamma \times t \dots (1)$$

$$V3(t) = (V0 - V1) - \gamma \times t \dots (2)$$

Expression 1 above is a control target speed pattern that constitutes an upper limit, and Expression 2 is a control target speed pattern that constitutes a lower limit.

[0027] The brake controlling means 17 and 19 compare the rotational speeds V(t) of the hoisting machines 4 and 5 at that time and the control target speed pattern, and energize the electromagnetic coils if V(t) is less than or equal to V3(t). If V(t) is greater than or equal to V2(t), the electromagnetic coils are de-energized. By controlling the braking apparatuses 11 and 15 using an algorithm of this kind, the hoisting machines 4 and 5 can be decelerated and stopped at a deceleration in a vicinity of the predetermined rate of deceleration γ .

[0028] Thus, the hoisting machines 4 and 5 can also be decelerated and stopped during emergency braking more appropriately by controlling braking force in response to rotational speeds of the hoisting machines 4 and 5 instead of deceleration.

Embodiment 4

[0029] Next, Figure 5 is a structural diagram that shows an elevator apparatus according to Embodiment 4 of the present invention. In the figure, braking apparatuses 11 and 15 are controlled by a shared brake controlling means 21. The brake controlling means 21 detects deceleration of the second hoisting machine 5 during emergency braking, and controls braking force from the first and second braking apparatuses 11 and 15 in response to the detected deceleration. The specific method for controlling the braking force is similar to that of Embodiment 1.

[0030] In an elevator apparatus of this kind, because the brake controlling means 21 detects deceleration of the second hoisting machine 5 during emergency braking, and controls the braking force from the braking apparatuses 11 and 15 in response to the detected deceleration, the hoisting machines 4 and 5 can be decelerated and stopped more appropriately during emergency braking. Because one brake controlling means 21 is used for the first and second hoisting machines 4 and 5, the number of brake controlling means 21 and speed detectors 18 can be reduced, thereby enabling costs to be reduced.

[0031] Moreover, in Embodiment 4, the braking forces from the braking apparatuses 11 and 15 are controlled by detecting deceleration of the second hoisting machine 5, but the braking forces from the braking apparatuses 11 and 15 may also be controlled in response to the rotational speed of the second hoisting machine 5, as shown in Embodiment 3.

Embodiment 5

[0032] Next, Figure 6 is a structural diagram that shows an elevator apparatus according to Embodiment 5 of the present invention. In the figure, braking apparatuses 11 and 15 are controlled by a shared brake controlling means 22. The brake controlling means 22 detects deceleration that constitutes a running state of a car 1 during emergency braking, and controls braking force from the first and second braking apparatuses 11 and 15 in response to the detected deceleration. The specific method for controlling the braking force is similar to that of Embodiment 1.

[0033] The brake controlling means 22 detects the deceleration of the car 1 based on a signal from a speed detector 23 that generates a signal that corresponds to the speed of the car 1. The speed detector 23 can be disposed on a speed governor 24, for example. In addition, a counterweight is divided into: a first counterweight 2a that is suspended by a first main rope 6; and a second counterweight 2b that is suspended by a second main rope 7.

[0034] In an elevator apparatus of this kind, because the brake controlling means 22 detects deceleration of the car 1 during emergency braking, and controls the braking force from the braking apparatuses 11 and 15 in response to the detected deceleration, the hoisting machines 4 and 5 can be decelerated and stopped more appropriately during emergency braking.

[0035] Moreover, in Embodiment 5, the braking forces from the braking apparatuses 11 and 15 are controlled by detecting deceleration of the car 1, but the braking forces from the braking apparatuses 11 and 15 may also be controlled in response to a running speed of the car 1 that constitutes a running state of the car 1. In that case, the brake controlling means 22 generates a control target speed for deceleration at a predetermined rate of deceleration using the running speed of the car 1 during emergency stop command generation as an initial value, and controls the braking force from the braking apparatuses 11 and 15 in such a way that the running speed of the car 1 follows the control target speed.

Embodiment 6

[0036] Next, Figure 7 is a structural diagram that shows an elevator apparatus according to Embodiment 6 of the present invention. In the figure, braking apparatuses 11 and 15 are controlled by a shared brake controlling means 21. A braking control stopping means (a switch) 25 is disposed between the brake controlling means 21 and the first braking apparatus 11.

[0037] An emergency stop detecting means 26 is connected to the brake controlling means 21 and the braking control stopping means 25. The emergency stop detecting means 26 detects generation of an emergency stop command, and activates control of the braking force from the brake controlling means 21, and immediately acti-

vates braking by disconnecting the first braking apparatus 11 from the brake controlling means 21. During emergency braking, the brake controlling means 21 controls braking force from the second braking apparatus 15 that is subject to control such that deceleration of the second hoisting machine 5 that is subject to control is at predetermined rate of deceleration.

[0038] In an elevator apparatus of this kind, because braking is immediately activated during emergency braking by disconnecting the first braking apparatus 11 from the brake controlling means 21, the car 1 can be stopped more reliably by the braking apparatus 11 even if a fault has occurred in the control of the braking force by the brake controlling means 21. In other words, in Embodiment 6, a method in which the hoisting machine 4 is immediately made to perform a braking action while controlling deceleration of the hoisting machine 5 has been chosen as an appropriate decelerating and stopping method for the hoisting machines 4 and 5 during emergency braking. Consequently, using a control method of this kind, the hoisting machines 4 and 5 can be decelerated and stopped more appropriately during emergency braking.

Embodiment 7

[0039] Next, Figure 8 is a structural diagram that shows an elevator apparatus according to Embodiment 7 of the present invention. Embodiment 7 is a combination of Embodiments 5 and 6. Specifically, a braking control stopping means 25 is disposed between a brake controlling means 22 according to Embodiment 5 and a first braking apparatus 11, and is configured such that the first braking apparatus 11 is disconnected from the brake controlling means 22 by the emergency stop detecting means 26 during emergency braking.

[0040] The hoisting machines 4 and 5 can also be decelerated and stopped more appropriately during emergency braking by an elevator apparatus of this kind.

[0041] Moreover, the brake controlling means can be configured using a circuit that includes a microcomputer, for example.

In the above examples, two hoisting machines were used, but three or more hoisting machines may also be used.

In addition, the generation of the emergency stop command may also be detected using a signal from an elevator control apparatus, or may also be independently detected by a brake controlling means. Approach or contact of a brake shoe toward or with a brake wheel, for example, may also be detected to determine whether an emergency stop command has been generated. It may also be determined that the emergency stop command has been generated if an electric current value of an electromagnetic coil of a braking apparatus is less than a predetermined value despite the speed of the car being greater than or equal to a predetermined value.

In the above examples, deceleration or speed was de-

tected using a signal from a speed detector that is disposed on a hoisting machine or a speed governor, but a signal from a car speed sensor that is disposed on a car or a hoistway may also be used.

The brake controlling means may perform both braking control during normal operation and braking control during emergency stop command generation, or may also perform only braking control during the emergency stop command generation. In the latter case, braking control during normal operation can be performed by a running controlling means, and a brake controlling means that is independent from the running controlling means can be used.

Claims

1. An elevator apparatus comprising:

a plurality of hoisting machines that have respective braking apparatuses;
a car that is raised and lowered by the hoisting machines; and
a plurality of brake controlling means that control the respective braking apparatuses individually, wherein the respective brake controlling means detect states of rotation of the respective hoisting machines during emergency braking, and control braking forces from the respective braking apparatuses in response to the detected states of rotation.

2. An elevator apparatus according to Claim 1, further comprising an emergency stop detecting means that detects generation of an emergency stop command, and synchronously activates control of the braking forces by the brake controlling means.

3. An elevator apparatus according to Claim 1, wherein:

the respective brake controlling means generate control target speeds for deceleration at a predetermined rate of deceleration using rotational speeds of the respective hoisting machines during emergency stop command generation as initial values, and control braking forces from the braking apparatuses of the respective hoisting machines such that rotational speeds of the respective hoisting machines follow the control target speeds.

4. An elevator apparatus comprising:

a plurality of hoisting machines that have respective braking apparatuses;
a car that is raised and lowered by the hoisting machines; and
a brake controlling means that controls the brak-

ing apparatuses,

wherein the brake controlling means detects a state of rotation of any one of the hoisting machines during emergency braking, and controls braking forces from at least two of the braking apparatuses of the hoisting machines in response to the detected state of rotation.

5. An elevator apparatus according to Claim 4, wherein:

the brake controlling means generates a control target speed for deceleration at a predetermined rate of deceleration using a rotational speed of the hoisting machine that is subject to detection during emergency stop command generation as an initial value, and controls braking forces from the braking apparatuses of the hoisting machines that are subject to control such that rotational speeds of the respective hoisting machines that are subject to control follow the control target speed.

6. An elevator apparatus comprising:

a plurality of hoisting machines that have respective braking apparatuses;
a car that is raised and lowered by the hoisting machines; and
a brake controlling means that controls the braking apparatuses, wherein the brake controlling means detects a running state of the car during emergency braking, and controls braking forces from at least two of the braking apparatuses of the hoisting machines in response to the detected running state.

7. An elevator apparatus according to Claim 6, wherein:

the brake controlling means generates a control target speed for deceleration at a predetermined rate of deceleration using a running speed of the car during emergency stop command generation as an initial value, and controls braking forces from the braking apparatuses of the hoisting machines that are subject to control such that the running speed of the car follows the control target speed.

8. An elevator apparatus comprising:

a plurality of hoisting machines that have respective braking apparatuses;
a car that is raised and lowered by the hoisting machines;
a brake controlling means that controls the braking apparatuses; and
an emergency stop detecting means that detects generation of an emergency stop com-

mand,

wherein:

the emergency stop detecting means immediately makes the braking apparatus of at least one of the hoisting machines perform a braking action by disconnection from the brake controlling means when generation of an emergency stop command is detected; and
the brake controlling means controls a braking force from the braking apparatus of at least one of the hoisting machines that is subject to control during emergency braking such that deceleration of the hoisting machine that is subject to control is at a predetermined rate of deceleration.

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FIG. 1

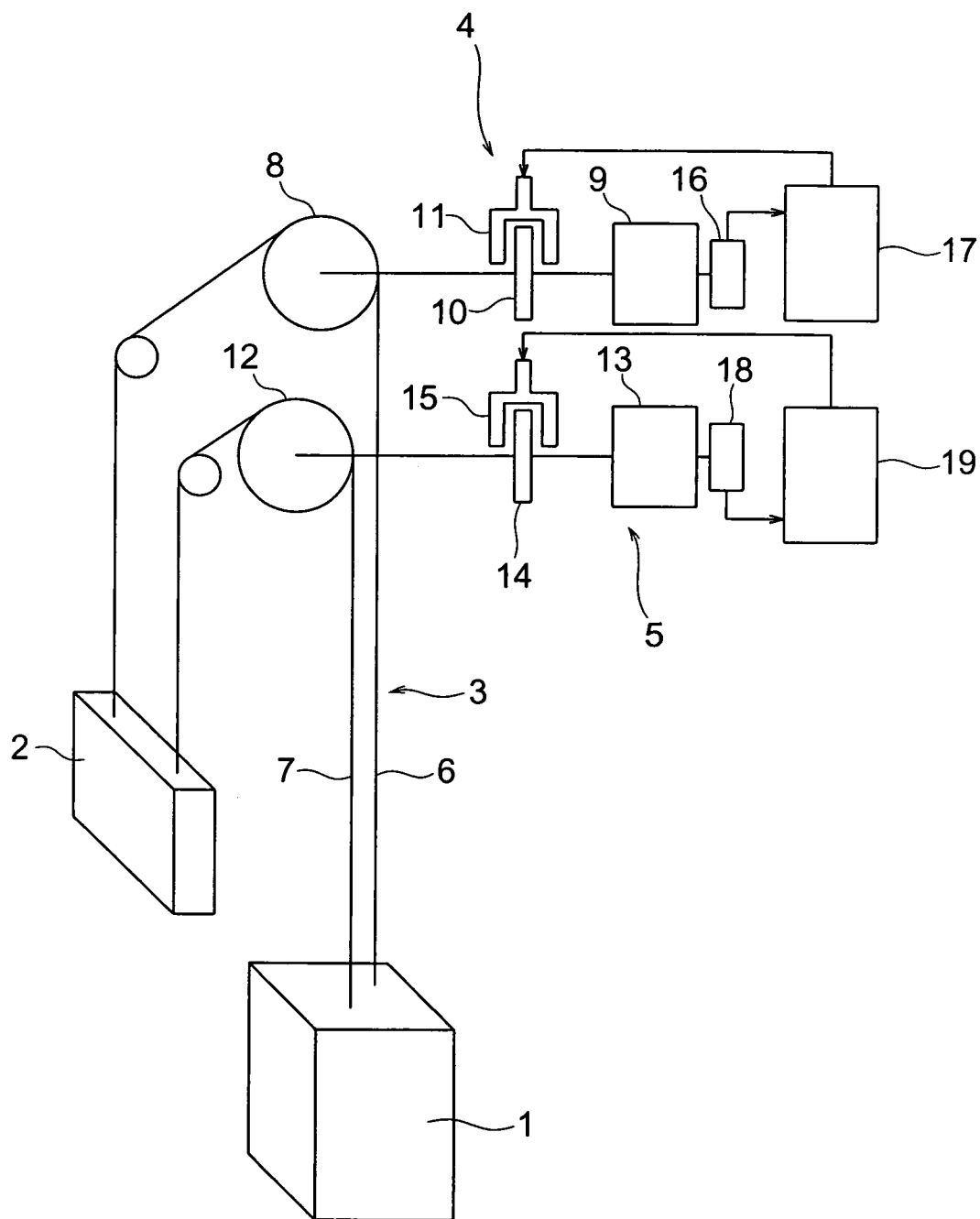


FIG. 2

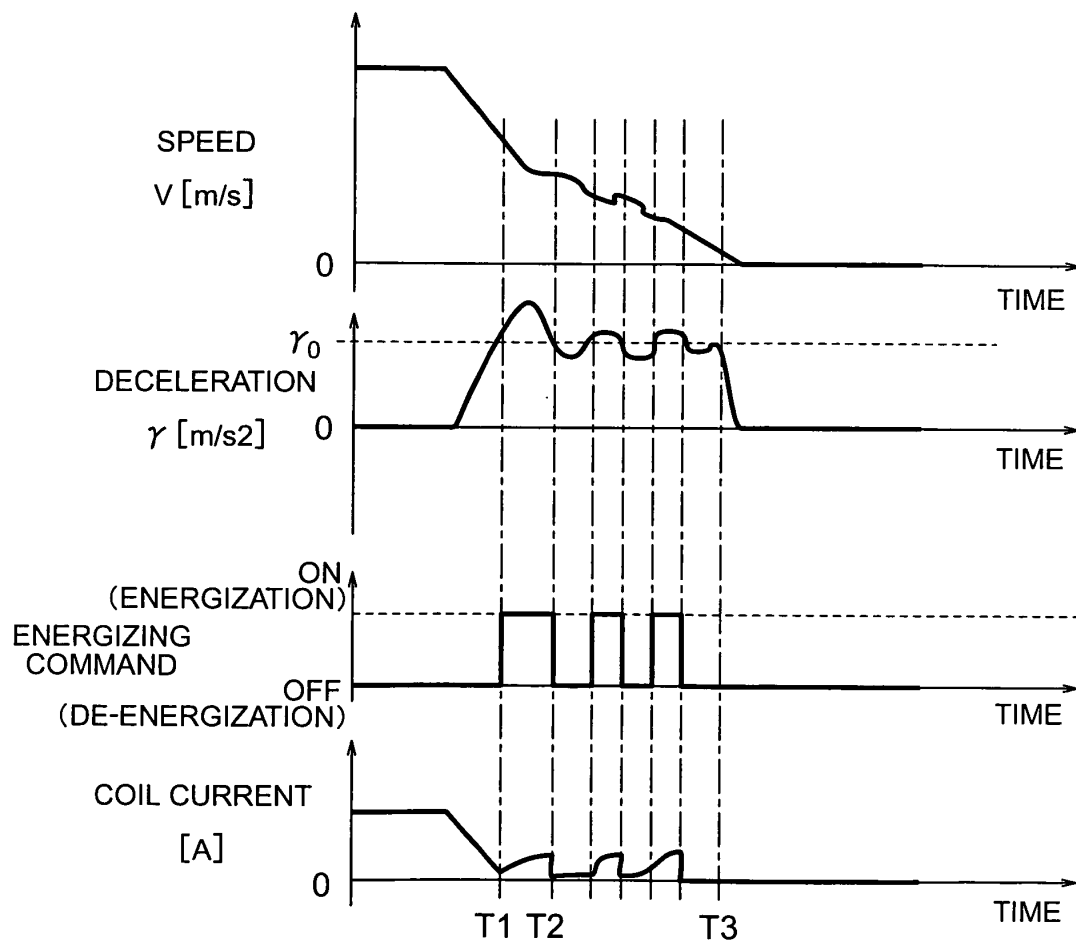


FIG. 3

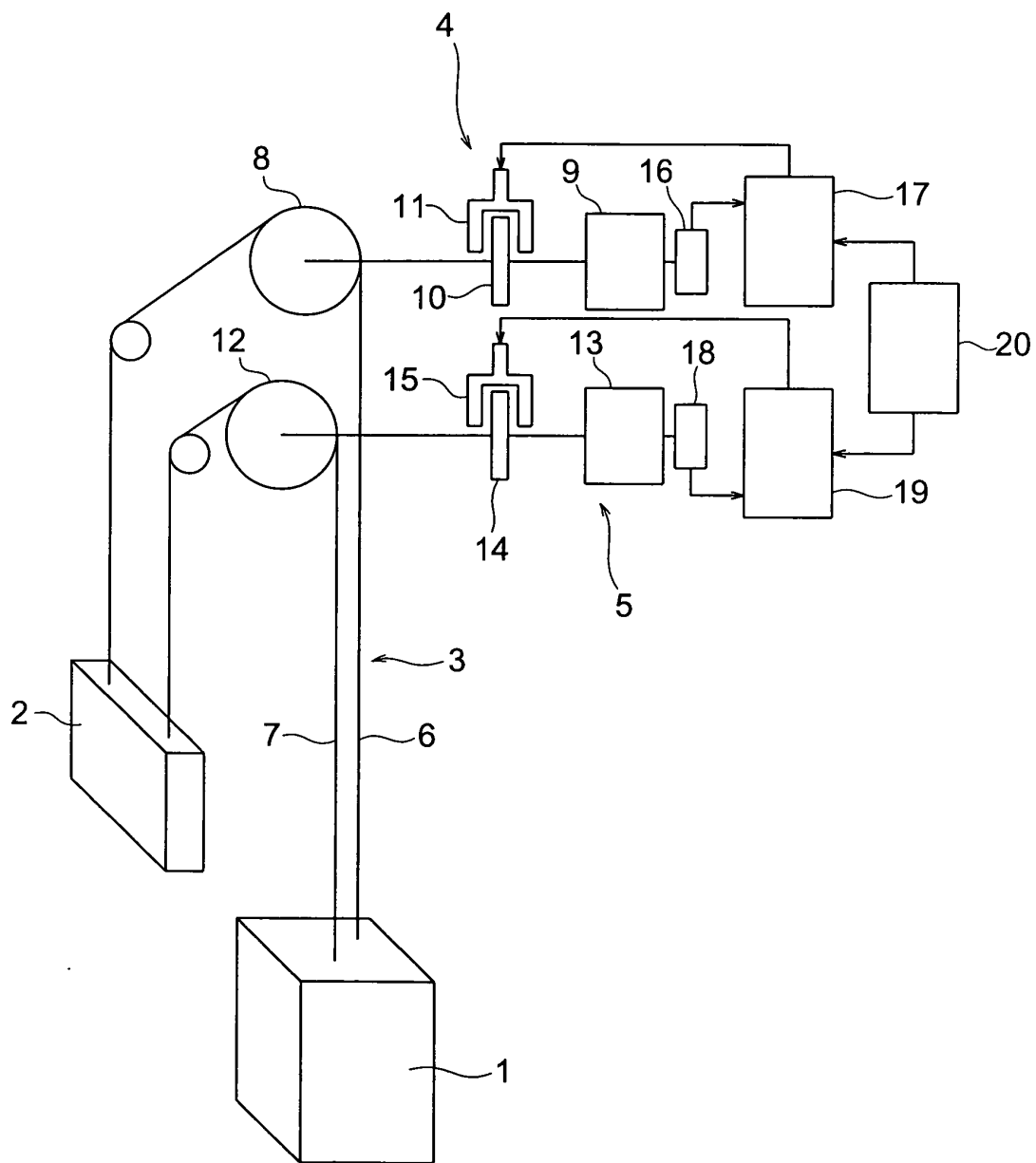


FIG. 4

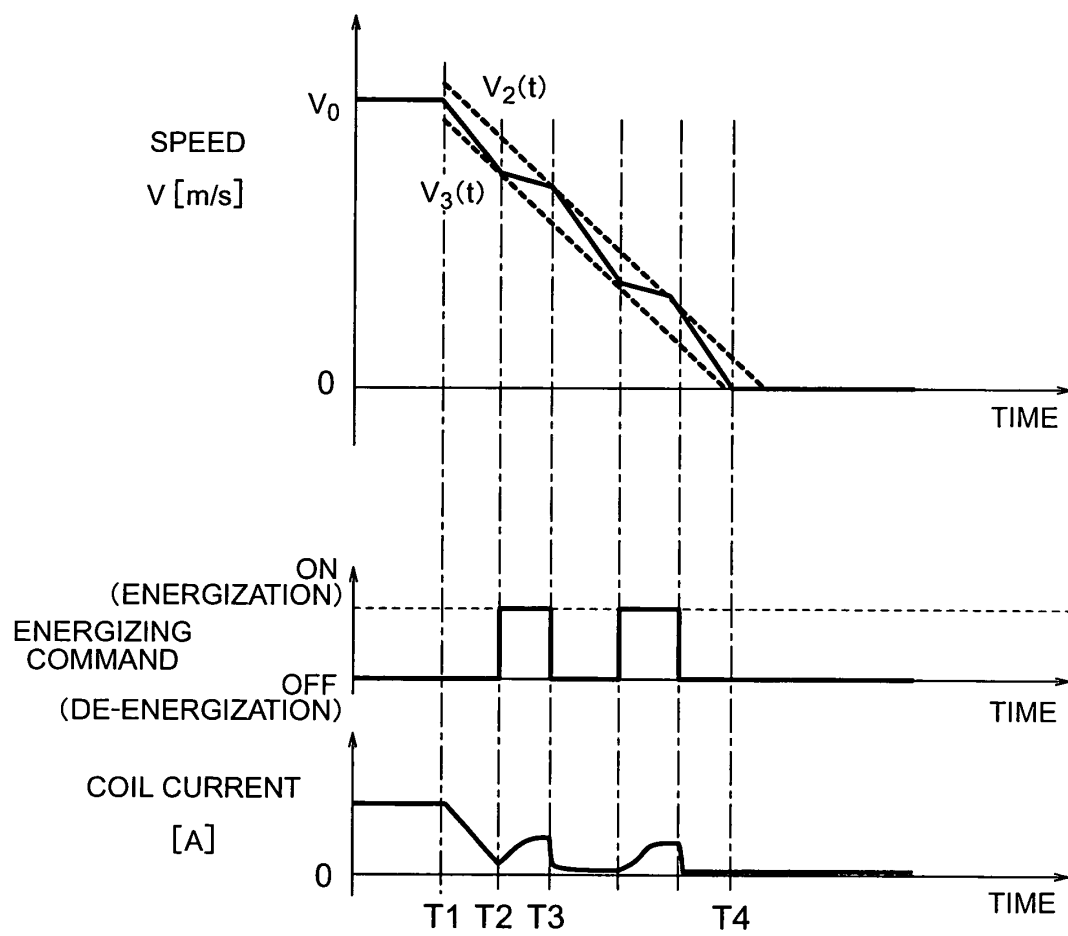


FIG. 5

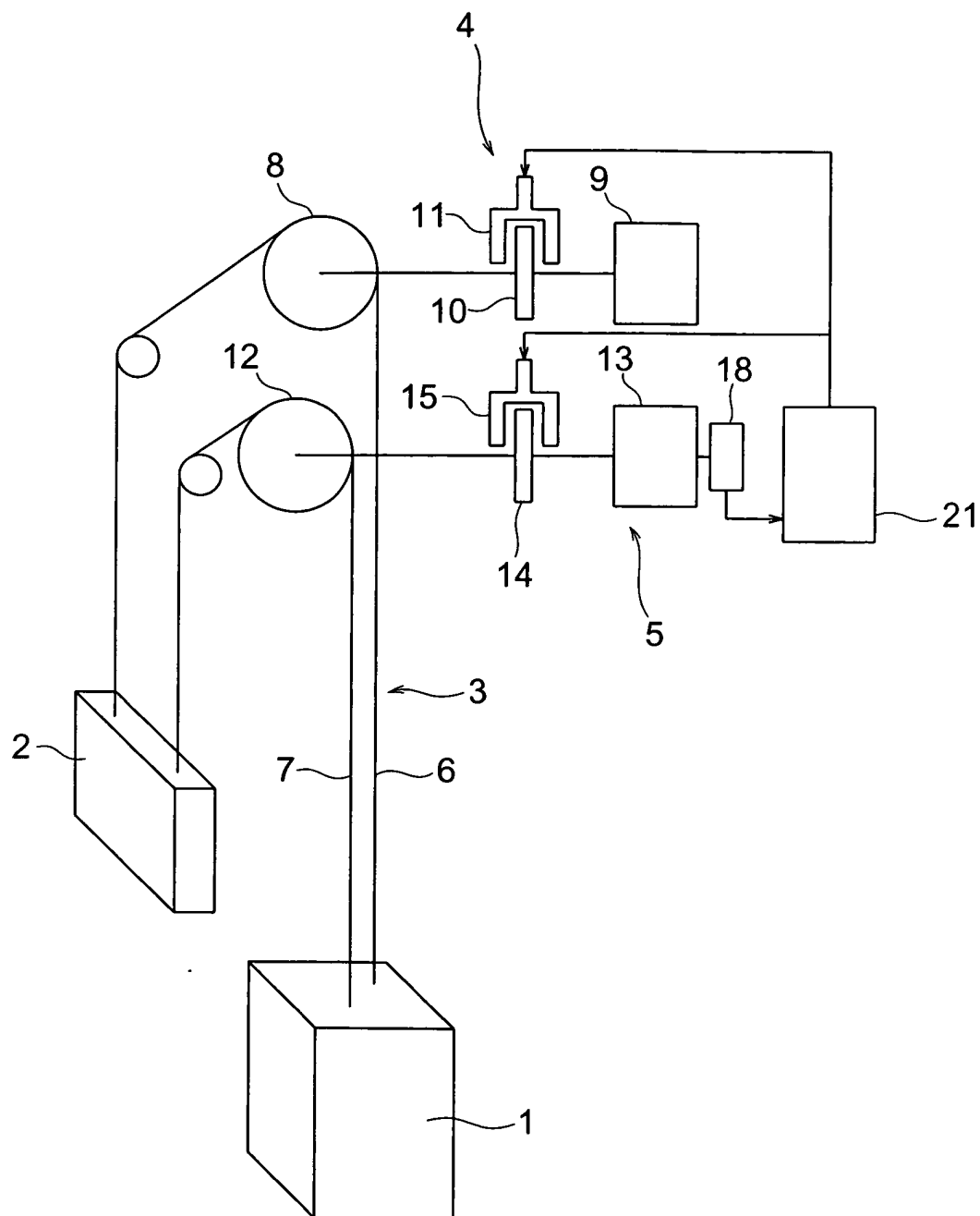


FIG. 6

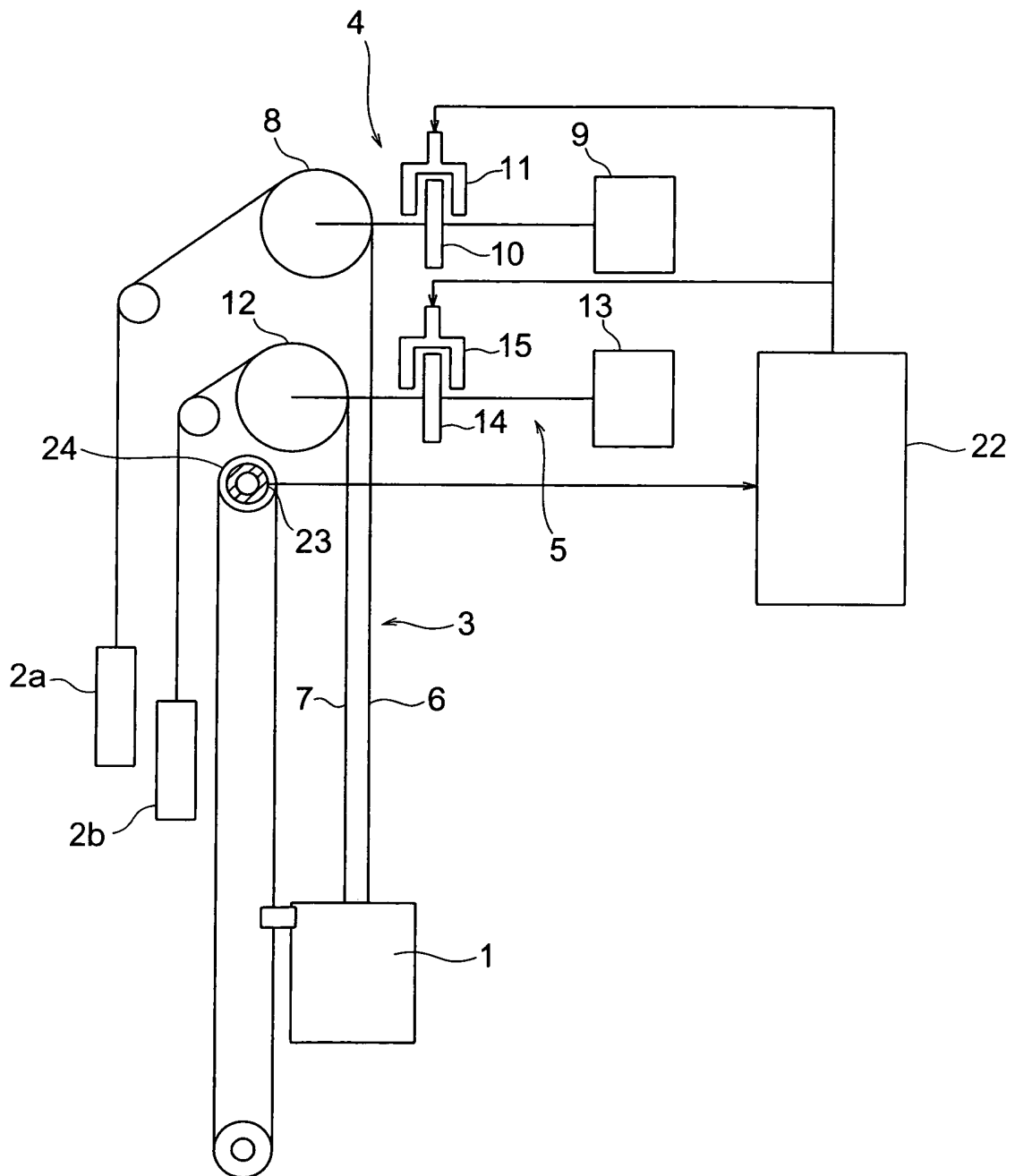


FIG. 7

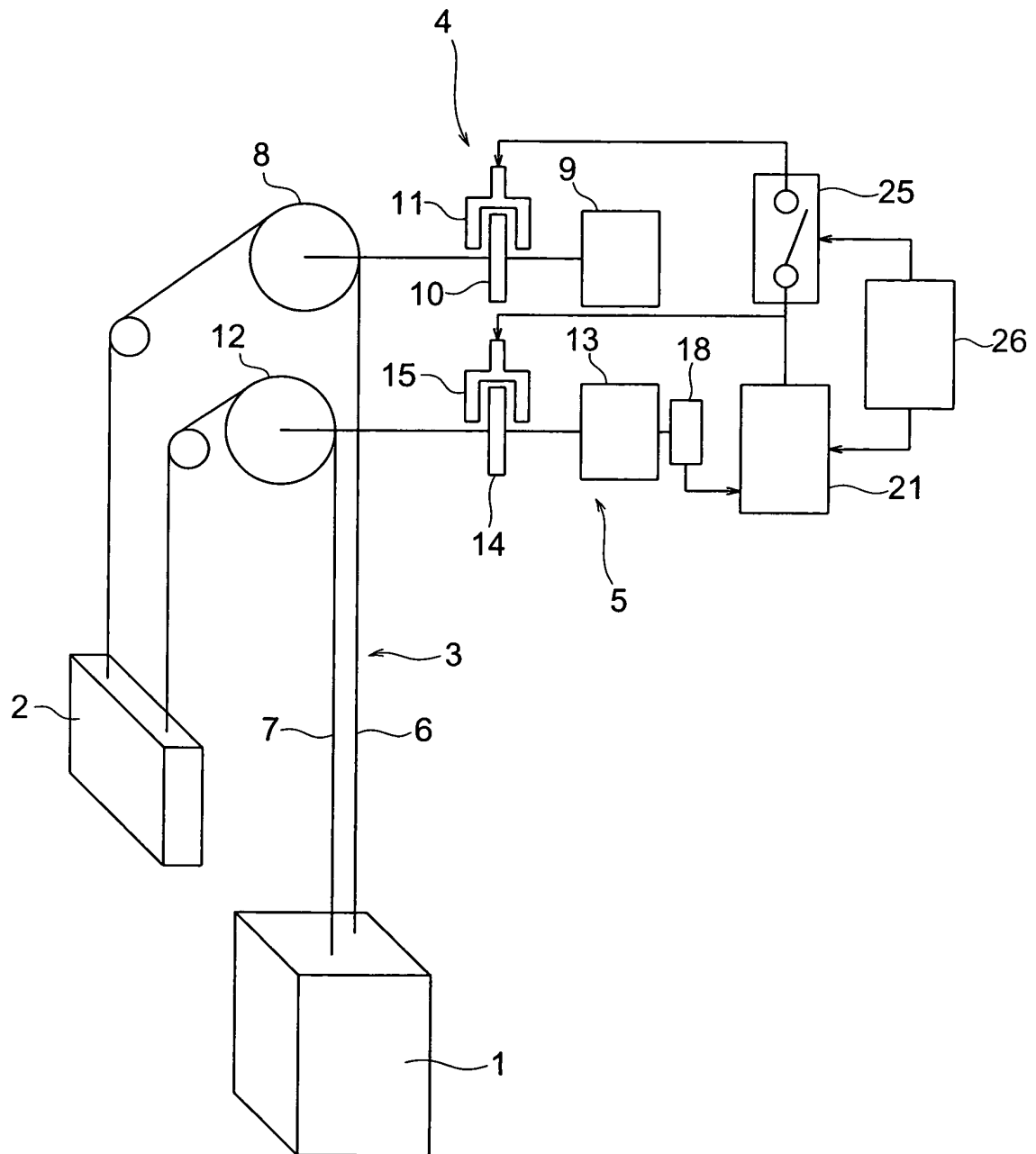
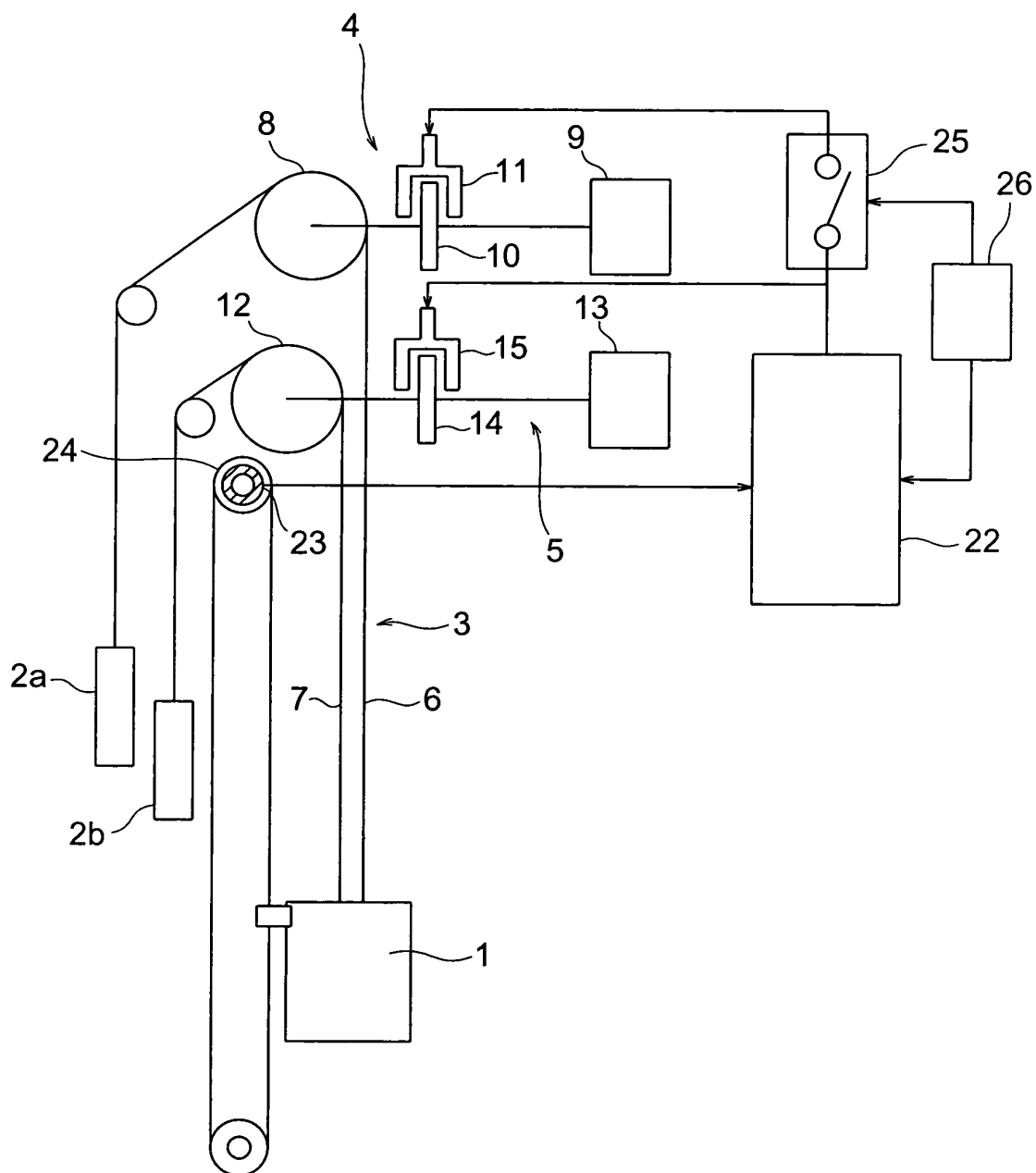


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/324210

A. CLASSIFICATION OF SUBJECT MATTER

B66B1/32(2006.01)i, B66B5/02(2006.01)i, B66B7/06(2006.01)i, B66B11/08(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B66B1/00-B66B11/08

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO 2006/92967 A1 (Mitsubishi Electric Corp.), 08 September, 2006 (08.09.06), Par. Nos. [0038] to [0044]; Figs. 6 to 8 (Family: none)	1-7 8
Y A	JP 2006-168978 A (Hitachi, Ltd.), 29 June, 2006 (29.06.06), Par. Nos. [0035], [0055] (Family: none)	1-5 8
Y A	JP 2002-3095 A (Mitsubishi Electric Corp.), 09 January, 2002 (09.01.02), Par. Nos. [0039] to [0043]; Figs. 9 to 10 (Family: none)	3, 5, 7 8

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

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Date of the actual completion of the international search
09 July, 2007 (09.07.07)Date of mailing of the international search report
17 July, 2007 (17.07.07)Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/324210

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 8-198542 A (Otis Elevator Co.), 06 August, 1996 (06.08.96), Par. Nos. [0009] to [0020]; Figs. 1 to 4 (Family: none)	6-7 8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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