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

(11) EP 1 739 047 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
03.01.2007 Bulletin 2007/01

(21) Application number: **05728716.1**

(22) Date of filing: **05.04.2005**

(51) Int Cl.:
B66B 11/02 *(2006.01)* ***B66B 1/06*** *(2006.01)*

(86) International application number:
PCT/JP2005/006666

(87) International publication number:
WO 2005/097655 (20.10.2005 Gazette 2005/42)

(84) Designated Contracting States:
DE FI

(30) Priority: **06.04.2004 JP 2004111943**

(71) Applicant: **Toshiba Elevator Kabushiki Kaisha**
Shinagawa-ku,
Tokyo 141-0001 (JP)

(72) Inventors:
- **KAIDA, Yuuichiro, c/o Fuchu Complex**
Fuchu-shi, Tokyo 183-0043 (JP)
- **HIRAI, Masaaki, c/o Fuchu Complex**
Fuchu-shi, Tokyo 183-0043 (JP)

(74) Representative: **Kramer - Barske - Schmidtchen**
European Patent Attorneys
Patenta
Radeckestrasse 43
81245 München (DE)

(54) DAMPING DEVICE OF ELEVATOR

(57) A vibration damping device for an elevator can improve the ride comfort of an elevator cage included in the elevator by efficiently damping the vibration of the elevator cage. The vibration damping device uses a filtering means for reducing the gains of vibrations of frequencies outside a frequency band including the low natural frequency of vibration insulating means elastically supporting the elevator cage. Thus, the ride comfort of the elevator cage can be improved by concentratedly using a movable weight and a driving means for damping vibrations caused by the vibration of a low natural frequency of the vibration isolating means.

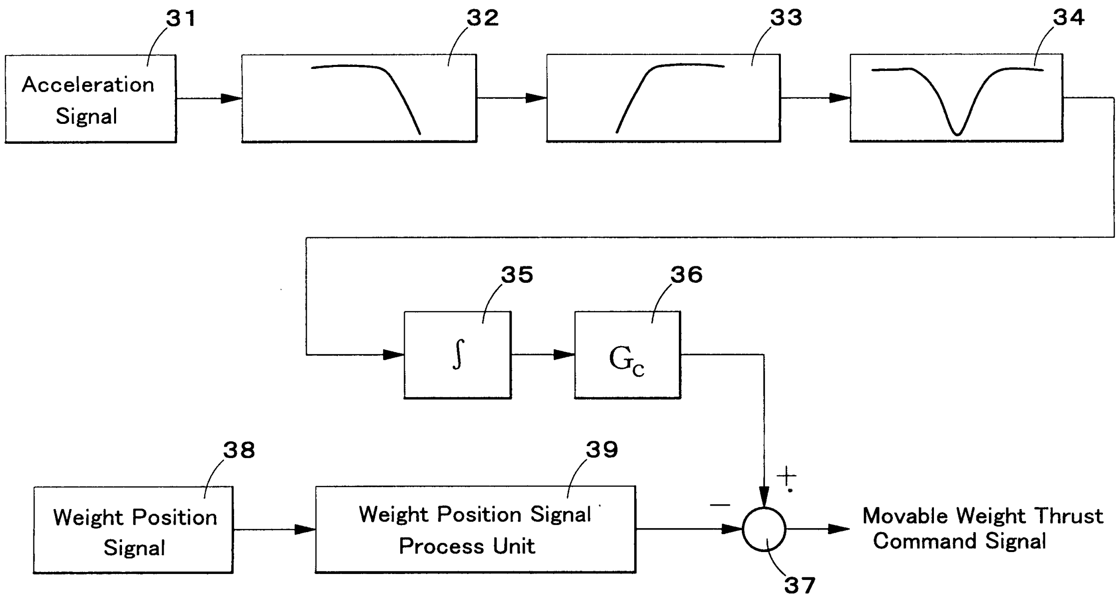

FIG.3

EP 1 739 047 A1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a vibration damping device including a movable weight movably supported on an elevator cage and capable of being driven for movement to damp the vibration of the elevator cage. More specifically, the present invention relates to techniques for improving a vibration damping device for efficiently damping the vibration of an elevator cage.

Description of the Related Art

[0002] Referring to Fig. 7, a cage assembly 1 for an elevator has an elevator cage 4 supported on a cage frame 2 via vibration insulating members 3. A main rope 5 suspended from a hoist, not shown, is connected to the cage frame 3 via a vibration insulating member 6 to move the cage assembly 1 vertically in an elevator shaft 7. Guide rollers 9 are supported on the four corners of the cage frame 2 via vibration insulating members 8. The guide rollers 9 roll on a right guide rail 10R and a left guide rail 10L attached vertically to walls 7a defining the elevator shaft 7 to guide the cage assembly 1 for vertical movement.

[0003] Since the guide rails 10R and 10L warp slightly, when the cage assembly 1 moves vertically in the elevator shaft 7, lateral vibratory force acts through the guide rollers 9 to the cage assembly 1. The vibratory force can be attenuated to some extent by the vibration insulating members 8 and the vibration insulating members 3 while the vibratory force is being transmitted to the elevator cage 4, but elevator cage 4 cannot be completely insulated from the vibratory force. Installation and adjustment of the guide rails 10R and 10L requires considerable man-hours for straightening the guide rails 10R and 10L. Although increase in the speed of the vertical movement of the elevator cage 4 requires higher precision in installing the guide rails 10R and 10L, there is limit to the accuracy of installation work. A vibration damping device for damping lateral vibrations of the elevator cage 4 to improve ride comfort is proposed in, for example, JP 5-310386 A.

[0004] A vibration damping device 12 shown in Fig. 7 fastened to the bottom of the elevator cage 4 includes a ball screw 14, a drive motor 13 for rotating the ball screw 14 in opposite directions, a movable weight 15 engaged with the ball screw 14 for movement in opposite directions along the axis of the ball screw 14, an accelerometer 16 fixed to the elevator cage 4 and a controller 17 for controlling the drive motor 13 on the basis of a signal provided by the accelerometer 16. Ride comfort can be improved by counteracting vibrations of the elevator cage 4 by inertial forces produced by forcibly displacing the movable weight 15.

[0005] The signal provided by the accelerometer 16 included in the foregoing known vibration damping device 12 includes a signal component representing the vibration of the building caused by wind. Consequently, the controller 17 inevitably drives the movable weight 15 to counteract the vibration of the building. However, the frequency of the vibration of a flexible, high-rise building is as low as 5 Hz or below and the displacement is on the order of several hundreds millimeters. Therefore, the movable weight 15 needs to have a very large mass and the stroke of the movable weight 15 needs to be very long and, consequently, the size of the vibration damping device 12 become large. From the viewpoint of aseismic design, the displacement of the elevator cage 4 relative to the guide rails 10R and 10L is several millimeters. The vibration of the building is outside a range with which the vibration damping device is expected to cope and does not need to cope with, because the building itself is vibrating.

[0006] Vibrations of the elevator cage 4 to be damped to improve ride comfort are those of low natural frequencies of the vibration insulating members 8 and the vibration insulating members 3 interposed between the cage frame 2 and the elevator cage 4. Unnecessary widening of the frequency range of vibrations to be damped by the vibration damping device 12 entails the enlargement of the vibration damping device 12 and the reduction of the efficiency of damping vibrations of frequencies in a frequency band to be damped.

[0007] If the harmonic vibrations of the drive motor 13 of the vibration damping device 12 is transmitted to the elevator cage 4, the ride comfort of the elevator cage will be deteriorated. Moreover, if the movable component, such as the ball screw 14, is contaminated with foreign matters, the vibration damping device 12 will be deteriorated and unable to operate smoothly, and the damping effect of the vibration damping device 12 will be reduced.

SUMMARY OF THE INVENTION

[0008] Accordingly, it is an object of the present invention to solve those problems in the related art and to provide a vibration damping device capable of efficiently damping vibrations of an elevator cage to improve the ride comfort of the elevator cage for an elevator.

[0009] To this end, a vibration damping device in a first aspect of the present invention for an elevator including an elevator cage, a cage frame supporting the elevator cage, guide means combined with the cage frame to guide the cage frame in cooperation with guide rails installed in an elevator shaft and first vibration insulating means interposed between the guide means and the cage frame, combined with the elevator cage to damp the vibration of the elevator cage includes: a movable weight movably supported on the elevator cage; a driving means for displacing the movable weight; a vibration measuring means for measuring the vibration of the elevator cage; filtering means capable of transmitting signals representing vibrations of frequencies in a frequency band including the low natural frequency of the first vibration insulating means included in a signal provided by the vibration measuring means; and a control means for controlling the operation of the driving means on the basis of the signals transmitted by the filtering means. A combination of a low-pass filter and a high-pass filter may be used as the filtering means.

[0010] That is, the vibration damping device in the first aspect of the present invention for an elevator uses the filtering means for transmitting only the signals representing vibrations of frequencies in the frequency band including the low natural frequency of the first vibration insulating means included in a signal provided by the vibration measuring means, such as an accelerometer or, in other words, this vibration damping device uses the filtering means for reducing the gains of vibrations of frequencies outside the frequency band including the low natural frequency of the first vibration insulating means. Thus, the effect of the movable weight and the driving means can be concentratedly used for damping the vibration of the cage frame relative to the guide rails caused by the vibration of a low natural frequency of the first vibration insulating means. Therefore, the damping ability of the movable weight and the driving means can be limited to build the vibration damping device in small, lightweight construction. Consequently, elevator cage has a smaller total mass and power necessary for driving the driving means can be reduced.

[0011] A vibration damping device in a second aspect of the present invention for an elevator including an elevator cage, a cage frame supporting the elevator cage and a second vibration insulating means interposed between the elevator cage and the cage frame, combined with the elevator cage to damp the vibration of the elevator cage, said vibration damping device includes: a movable weight movably supported on the elevator cage; a driving means for displacing the movable weight; a vibration measuring means for measuring the vibration of the elevator cage; a filtering means capable of transmitting signals representing vibrations of frequencies in a frequency band including the low natural frequency of the second vibration insulating means included in a signal provided by the vibration measuring means; and a control means for controlling the operation of the driving means on the basis of the signals transmitted by the filtering means. The filtering means may include, in combination, a low-pass filter and a high-pass filter.

[0012] That is, the vibration damping device in the second aspect of the present invention for an elevator uses the filtering means for transmitting only the signals representing vibrations of frequencies in the frequency band including the low natural frequency of the second vibration insulating means included in a signal provided by the vibration measuring means, such as an accelerometer or, in other words, this vibration damping device uses the filtering means for reducing the gains of vibrations of frequencies outside the frequency band including the low natural frequency of the second vibration insulating means. Thus the effect of the movable weight and the driving means can be concentratedly used for damping the vibration of the cage frame relative to the cage frame caused by the vibration of a low natural frequency of the second vibration insulating means. Therefore, the damping ability of the movable weight and the driving means can be limited to build the vibration damping device in small, lightweight construction. Consequently, elevator cage has a smaller mass and power necessary for driving the driving means can be reduced.

[0013] A vibration damping device in a third aspect of the present invention combined with an elevator cage to damp the vibration of the elevator cage includes: a movable weight movably supported on the elevator cage; a driving means for displacing the movable weight; a vibration measuring means for measuring the vibration of the elevator cage; a filtering means capable of attenuating a signal representing the vibration of low natural frequency of a building in which the elevator is installed included in a signal provided by the vibration measuring means; and a control means for controlling the operation of the driving means on the basis of signals transmitted by the filtering means. The filtering means may include a notch filter or in combination, a low-pass filter and a high-pass filter.

[0014] The vibration damping device in the third aspect of the present invention for an elevator uses the filtering means for attenuating a signal representing the vibration of low natural frequency of a building in which the elevator is installed included in a signal provided by the vibration measuring means or, in other words, this vibration damping device uses the filtering means for reducing the gains of vibrations of low natural frequencies of the building. Thus the driving means does not need to operate for damping the component vibration of the low natural frequency of the building included in the vibration of the elevator cage, the stroke of the movable weight may be short and the movable weight may have a small weight. Therefore, the vibration damping device can be formed in small construction and power necessary for driving the driving means can be reduced.

[0015] In each of the vibration damping devices in the first to the third aspect of the present invention, at least the movable weight and the driving means may be held on the elevator cage via a third vibration insulating means. Thus the propagations of high-frequency vibrations generated by the driving means and such to the elevator cage can be prevented and noise in the elevator cage can be reduced to improve ride comfort.

[0016] Each of the vibration damping devices in the first to the third aspect of the present invention may further include an enclosing means detachably attached to the elevator cage to enclose at least the movable weight and the driving means. Thus precision moving parts included in the driving means can be prevented from contamination with dust and propagation of high-frequency vibrations generated by the driving means and such through air can be prevented. To inspect the vibration damping device, only the enclosing means needs to be removed and the heavy vibration damping device does not need to be removed from the elevator cage, which simplifies maintenance work.

[0017] Each of the vibration damping devices in the first to the third aspect of the present invention may further include a frequency analyzing arithmetic unit capable of processing the frequencies of the signal provided by the vibration measuring means by a frequency analysis process and of calculating the low natural frequency of the building in which the elevator is installed, and a display for displaying the low natural frequency of the building calculated by the frequency analyzing arithmetic unit. Thus the natural frequency of the building can be known by directly giving the signal provided by the vibration measuring means to the control means without passing the signal through the filtering means and processing the signal by the frequency analyzing arithmetic unit and displaying the calculated frequency by the display. Therefore, an additional measuring means for determining the natural frequency of the building is not necessary. Since the natural frequency of the building can be directly known, the control means can be adjusted for an optimum operation and vibration damping can be satisfactorily achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 is a side elevation of an elevator equipped with a vibration damping device according to the present invention.

Fig. 2 is an enlarged side elevation of the vibration damping device shown in Fig. 1.

Fig. 3 is a block diagram of assistance in explaining the operation of a controller shown in Fig. 2.

Fig. 4 is a gain diagram showing the characteristic of filters.

Figs. 5(a) and 5(b) are a front elevation and a side elevation, respectively, of a cover included in the vibration damping device.

Fig. 6 is a block diagram of assistance in explaining the operation of the controller.

Fig. 7 is a side elevation of an elevator equipped with a known vibration damping device.

DESCRIPTION OF THE PREFERRED EMBODIENTS

[0019] Vibration damping devices embodying the present invention will be described with reference to Figs. 1 to 6. In the following description, the same parts are denoted by the same reference characters and the duplicate description of those parts will be omitted.

[0020] The construction of an elevator to which a vibration damping device in a first embodiment according to the present invention is applied will be described with reference to Fig. 1.

[0021] A cage assembly 1 has an elevator cage 4 supported on a cage frame 2 via vibration insulating members (second vibration insulating members) 3. A main rope 5 suspended from a hoist, not shown, is connected to the cage frame 3 via a vibration insulating member 6 to move the cage assembly 1 vertically in an elevator shaft 7. Guide rollers 9 are supported on the four corners of the cage frame 2 via vibration insulating members (first vibration insulating members) 8. The guide rollers 9 roll on a right guide rail 10R and a left guide rail 10L attached vertically to walls 7a defining the elevator shaft 7 to guide the cage assembly 1 for vertical movement. A vibration damping device 20 is disposed in a bottom part of the elevator cage 4 to improve ride comfort by attenuating the lateral vibration of the elevator cage 4.

[0022] Referring to Fig. 2, the vibration damping device 20 includes stationary members 21 fixed to the bottom surface of the elevator cage 4, and a frame 23 supported on vibration insulating members (third vibration insulating members) 22 mounted on the stationary members 21. A threaded rod 24 is extended horizontally between vertical side members 23a and 23b of the frame 23. The threaded rod 24 is supported rotatably on the vertical side members 23a and 23b. A drive motor 25 is mounted on the right, vertical side wall 23b, as viewed in Fig. 2, and is operatively connected to the threaded rod 24 to rotate the threaded rod 24 in opposite directions. A threaded movable weight 26 is engaged with the threaded rod 24. The threaded rod 24 is rotated to move the movable weight 24 in horizontal directions as viewed in Fig. 2. An accelerometer (vibration measuring means) 27 is installed in the elevator cage 4. The accelerometer 27 measures the vibration of the elevator cage 4 and gives a signal to a controller 28.

[0023] The controller 28 processes an acceleration signal 31 received from the accelerometer 27 via a low-pass filter 32, a high-pass filter 33, a notch filter 34, an integrator 35 and an amplifier 36 as shown typically in Fig. 3. The processed acceleration signal is given to an adder 37. A weight position signal process unit 39 processes a weight position signal 38 provided by a weight position sensor, not shown, and gives the processed weight position signal to the adder 37. Then, the adder 37 gives a movable weight thrust command signal to the drive motor 25. Although the filters (filtering means) are connected in series in Fig. 3, filters of different types may be connected in parallel when necessary.

[0024] Fig. 4 is a gain diagram showing the respective cutoff characteristics 41, 42 and 43 of the low-pass filter, the high-pass filter and the notch filter. As obvious from the gain diagram, the gain of a component representing the low natural frequency of a building in which the elevator is installed included in the signal provided by the accelerometer 27 is reduced. Gains of frequency bands other than a frequency band including the low natural frequencies of the first vibration insulating means 8 and the second vibration insulating means 3 are reduced.

[0025] The acceleration signal 31 filtered by the notch filter 34 of the vibration damping device 20 in this embodiment does not contain a component corresponding to the low natural frequency of the building in which the elevator is installed. Thus the controller 28 does not need to control the drive motor 25 so as to damp the component corresponding to the low natural frequency of the building included in the vibration of the elevator cage 4. Therefore, the stroke of the movable weight 26 may be short, the vibration damping device 20 can be formed in a small size and power necessary for driving the drive motor 25 can be reduced.

[0026] The acceleration signal 31 filtered by the low-pass filter 32 and the high-pass filter 33 of the vibration damping device 20 in this embodiment mainly contain a component corresponding to the frequency of vibration attributable to the vibration isolating members (first vibration isolating members) 8 interposed between the guide rails 10R and 10L and the cage frame 2 and a component corresponding to the frequency of the vibration of the cage frame 2 attributable to the natural frequency of the vibration insulating members (second vibration insulating members) 3. The movable weight 26 and the drive motor 25 can be concentratedly used for damping the vibration of the elevator cage 4. Therefore, the movable weight 26 and the drive motor 25 may be small and lightweight. Consequently, the mass of the elevator cage 4 can be reduced and power necessary for driving the drive motor 25 can be reduced.

[0027] Fig. 5 shows a case (enclosing means) 50 for enclosing the vibration damping device 20. The case 50 includes a box-shaped body 51 attached to the bottom surface of the elevator case 4 and surrounding the vibration damping device 20, and a lid 52 detachably attached to the open lower end of the body. The lid 52 is fastened to the body with bolts 53.

[0028] Thus the contamination of the precision movable parts included in the threaded rod 24 and the drive motor 25 with dust and the propagation of high-frequency vibrations generated by the drive motor 25 and such through air into the interior of the elevator cage 4 can be prevented. To inspect the vibration damping device 20, only the lid 52 needs to be removed and the heavy vibration damping device 20 does not need to be removed from the elevator cage, which simplifies maintenance work.

[0029] Fig. 6 shows the function of the vibration damping device 20. An acceleration signal 61 provided by the accelerometer 27 attached to the elevator cage 4 is given directly to a frequency analyzing unit 62 included in the controller 28 without being filtered by the filters. Then, the frequency analyzing unit 62 processes the acceleration signal 61 to calculate the natural frequency of the building in which the elevator is installed and a display 63 displays the natural frequency of the building.

[0030] Thus any other measuring device for determining the natural frequency of the building is not necessary and the setting of the controller 28 can be adjusted at site so that the controller 28 can achieve an optimum operation according to the natural frequency of the building. Consequently, a satisfactory vibration damping operation can be achieved.

Claims

1. A vibration damping device for an elevator including an elevator cage, a cage frame supporting the elevator cage, guide means combined with the cage frame to guide the cage frame in cooperation with guide rails installed in an elevator shaft and first vibration insulating means interposed between the guide means and the cage frame, combined with the elevator cage to damp the vibration of the elevator cage, said vibration damping device comprising:

   a movable weight movably supported on the elevator cage;
   a driving means for displacing the movable weight;
   a vibration measuring means for measuring the vibration of the elevator cage;
   filtering means capable of transmitting signals representing vibrations of frequencies in a frequency band including the low natural frequency of the first vibration insulating means included in a signal provided by the vibration measuring means; and
   a control means for controlling the operation of the driving means on the basis of the signals transmitted by the filtering means.

2. A vibration damping device for an elevator including an elevator cage, a cage frame supporting the elevator cage and a second vibration insulating means interposed between the elevator cage and the cage frame, combined with the elevator cage to damp the vibration of the elevator cage, said vibration damping device comprising:

   a movable weight movably supported on the elevator cage;
   a driving means for displacing the movable weight;
   a vibration measuring means for measuring the vibration of the elevator cage;
   a filtering means capable of transmitting signals representing vibrations of frequencies in a frequency band including the low natural frequency of the second vibration insulating means included in a signal provided by the vibration measuring means; and
   a control means for controlling the operation of the driving means on the basis of the signals transmitted by the filtering means.

3. A vibration damping device combined with an elevator cage to damp the vibration of the elevator cage, said vibration damping device comprising:

a movable weight movably supported on the elevator cage;
a driving means for displacing the movable weight;
a vibration measuring means for measuring the vibration of the elevator cage;
a filtering means capable of attenuating a signal representing the vibration of low natural frequency of a building in which the elevator is installed included in a signal provided by the vibration measuring means; and
a control means for controlling the operation of the driving means on the basis of signals transmitted by the filtering means.

4. The vibration damping device according to any one of claims 1 to 3, wherein at least the movable weight and the driving means are held on the elevator cage by a third vibration insulating means.

5. The vibration damping device according to any one of claims 1 to 3 further comprising an enclosing means detachably attached to the elevator cage to enclose at least the movable weight and the driving means.

6. The vibration damping device according to any one of claims 1 to 3 further comprising:

a frequency analyzing arithmetic unit capable of processing a signal provided by the vibration measuring means by a frequency analysis process and of calculating the low natural frequency of the building in which the elevator is installed; and
a display for displaying the low natural frequency of the building calculated by the frequency analyzing arithmetic unit.

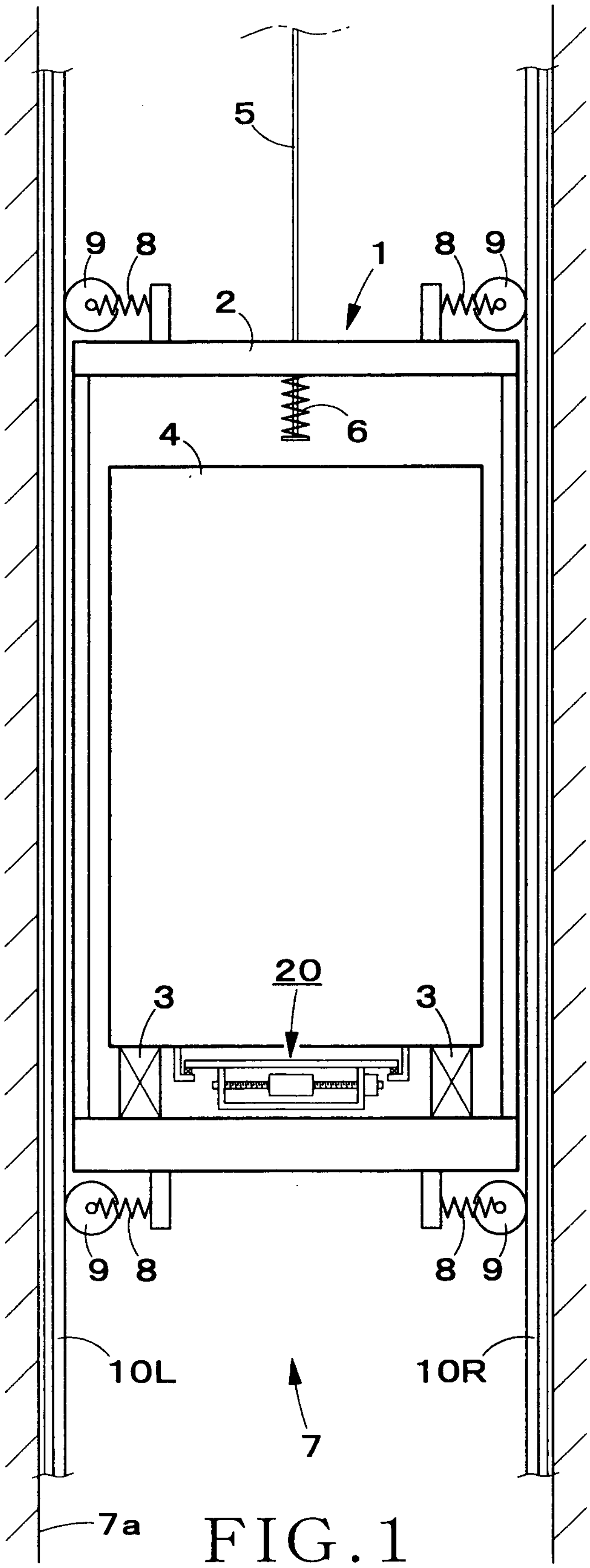

FIG.1

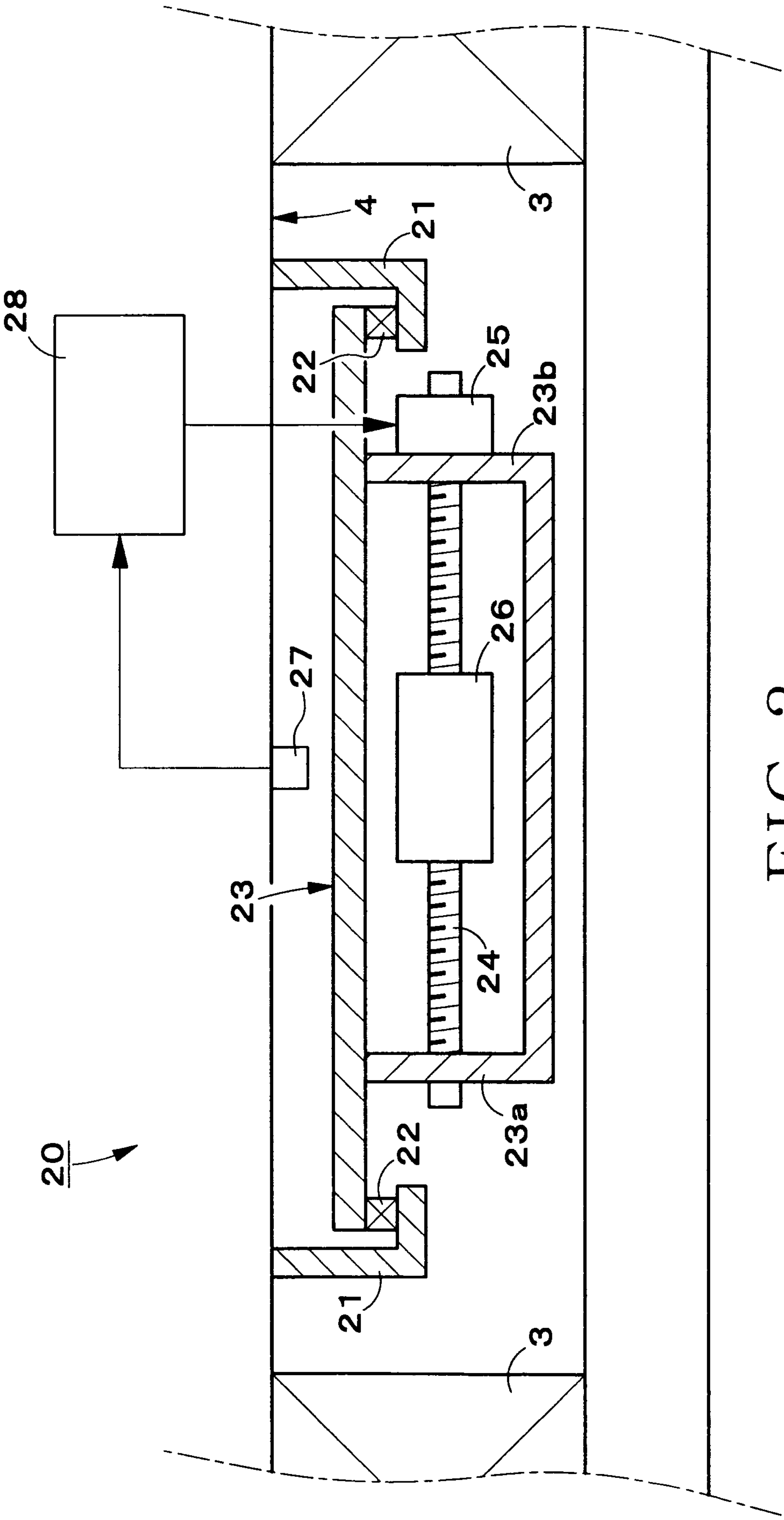

FIG. 2

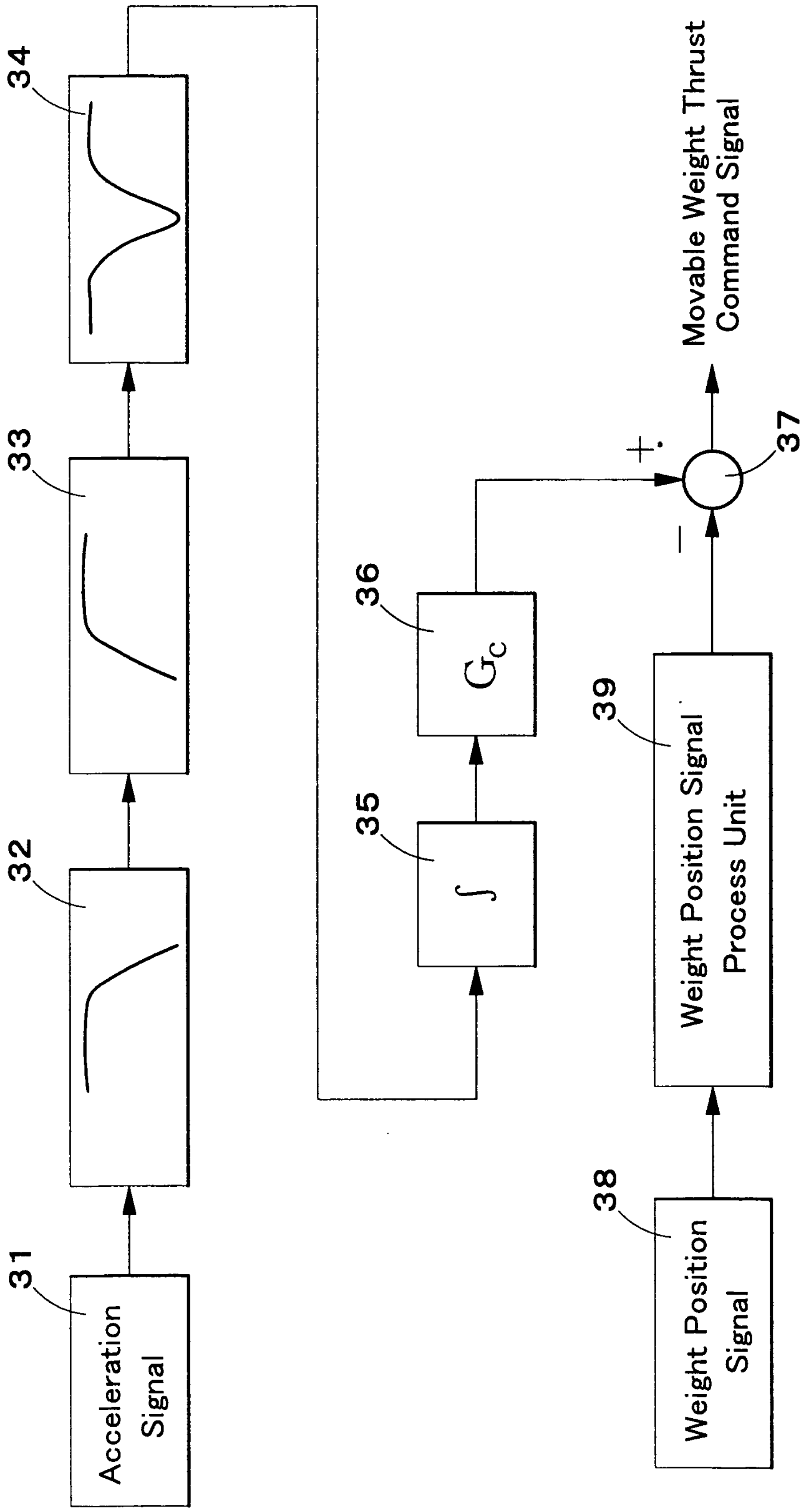
31
Acceleration Signal
32
33
34
35
∫
36
Gc
37
+
−
Movable Weight Thrust Command Signal
38
Weight Position Signal
39
Weight Position Signal Process Unit

FIG. 3

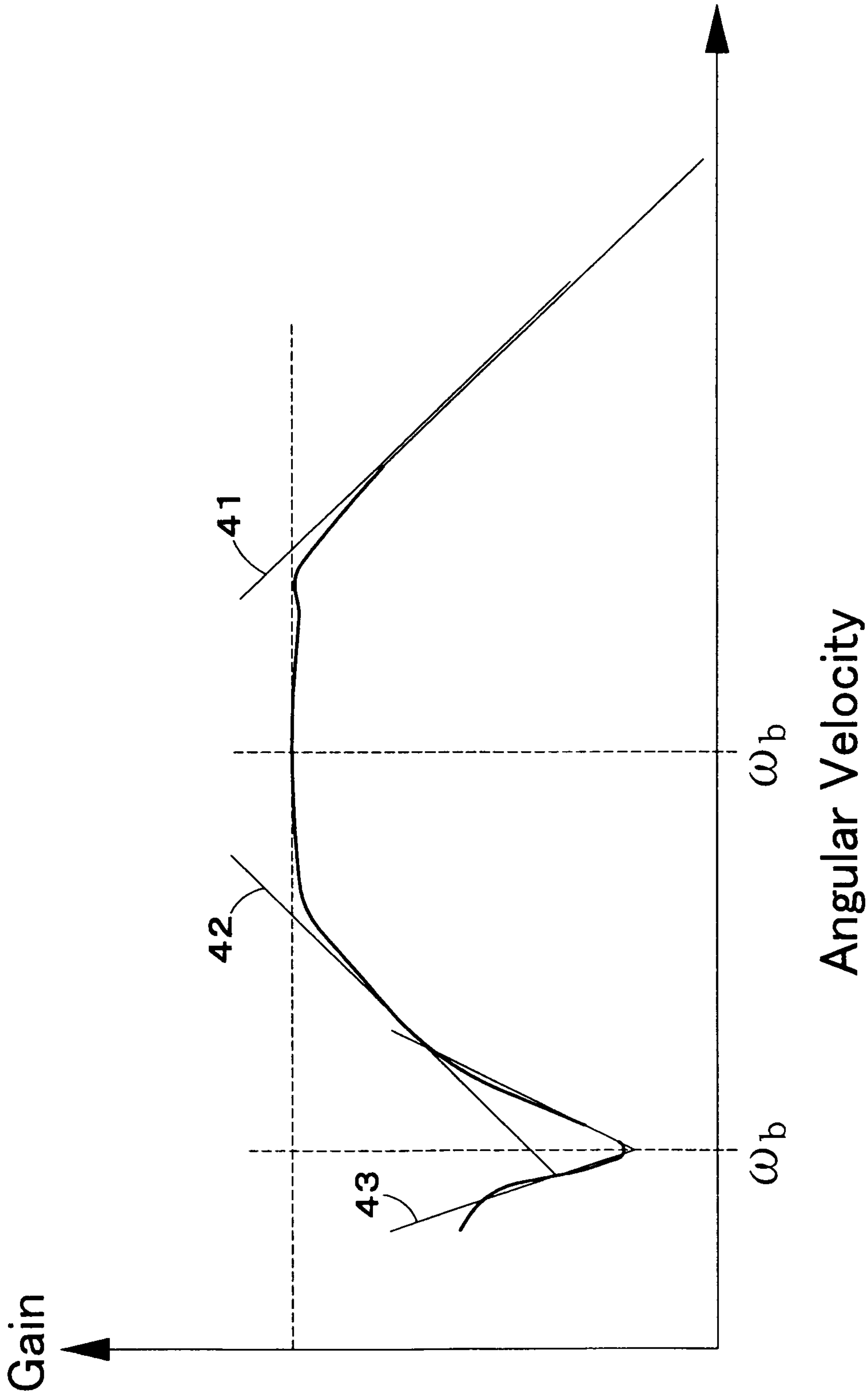

FIG.4

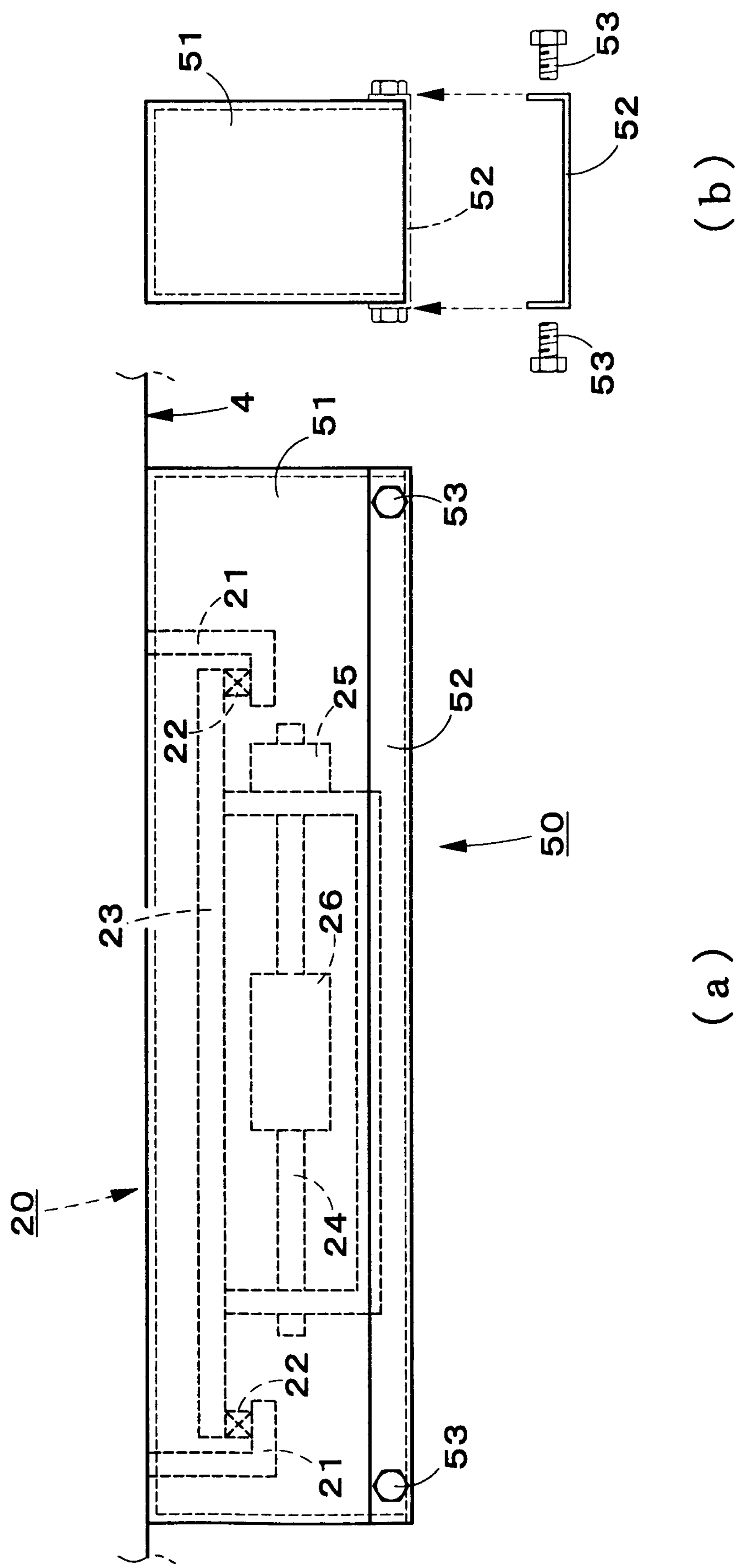

FIG.5

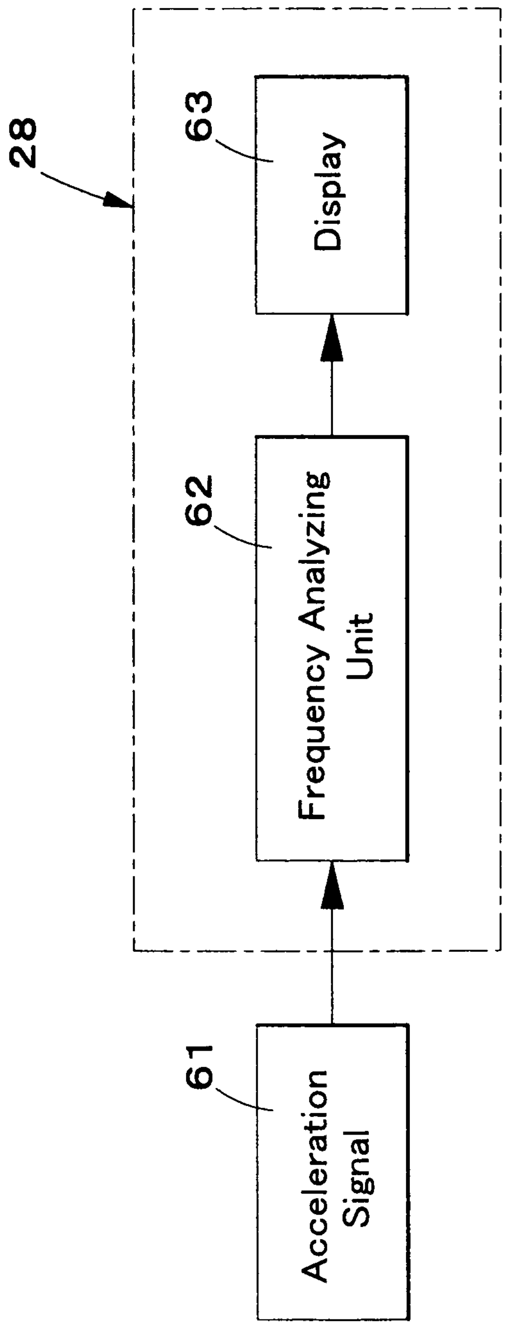
28
63
Display
62
Frequency Analyzing Unit
61
Acceleration Signal

FIG.6

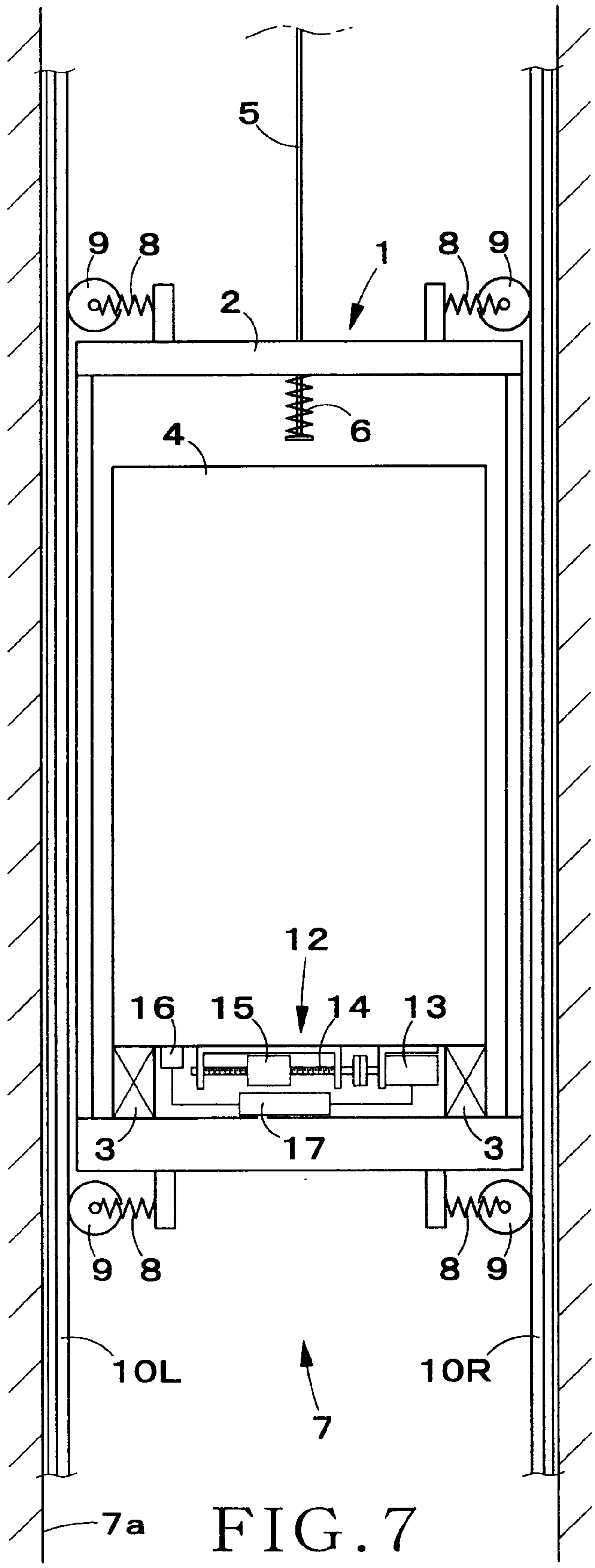

FIG.7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/006666

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B66B11/02, B66B1/06

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

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	1996-2005
Kokai Jitsuyo Shinan Koho	1971-2005	Toroku Jitsuyo Shinan Koho	1994-2005

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.
X	JP 11-116166 A (Toshiba Corp.), 27 April, 1999 (27.04.99), Par. Nos. [0028] to [0035], [0043] to [0047]; Figs. 1 to 2, 7 to 9, 13 (Family: none)	1-6
A	JP 9-110341 A (Toshiba Corp.), 28 April, 1997 (28.04.97), Claims; Figs. 1 to 13 (Family: none)	1-6

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"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
19 July, 2005 (19.07.05)

Date of mailing of the international search report
02 August, 2005 (02.08.05)

Name and mailing address of the ISA/
Japanese Patent Office

Facsimile No.

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2004)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 5310386 A **[0003]**