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(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

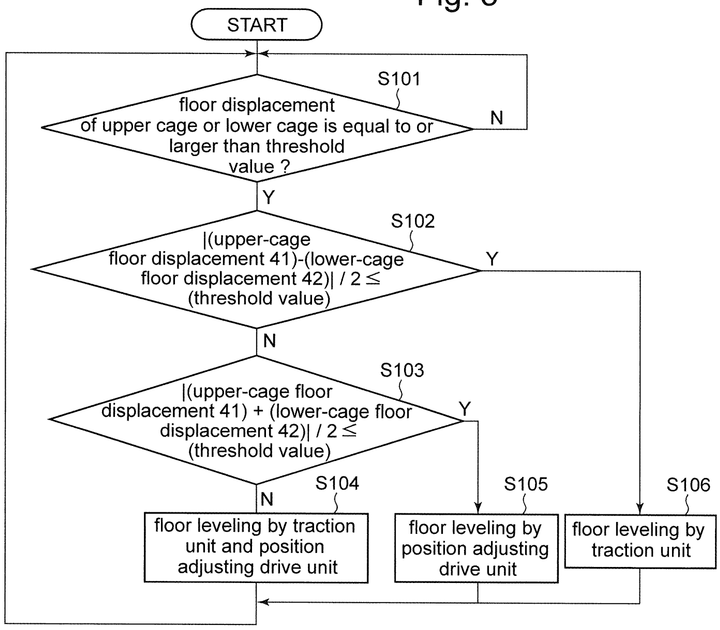
(72) Inventor: **KOKETSU, Masahiko**
Tokyo 100-8310 (JP)

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

(54) DOUBLE DECK ELEVATOR

(57) There is provided a double deck elevator that is capable of adjusting floor displacement levels of the upper and lower cages to reduce the floor level difference by selecting either the main frame or the upper and lower cages or both to be moved depending on conditions of the respective floor displacement levels of the upper and lower cages. In order to implement the present invention, the double deck elevator according to the present invention compares whether at least one of cage-doorway floor-displacement levels detected by upper- and lower-cages' detection sensors is equal to or larger than a threshold value; performs calculations, when either floor-displacement level is determined to be equal to or larger than the threshold value, by substituting the respective floor displacement levels of the two upper and lower cages successively into a plurality of conditions for correcting the floor displacement levels; and selects, when a relevant condition among the plurality of conditions holds true from the calculation result, either the main traction unit or the cage-position adjusting drive unit or both of the main traction unit and the cage-position adjusting drive unit to be actuated, according to the relevant condition.

Fig. 3



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Description

Technical Field

[0001] The present invention relates to a double deck elevator that has an inter-cage distance adjusting mechanism for adjusting the distance between the upper and lower cages.

Background Art

[0002] Recent years have seen increasing development in height and capacity of buildings. Elevators installed in such buildings need to convey many passengers at one time. However, since increase in the number of elevators installed reduces floor spaces in the building, a double deck elevator, which is capable of conveying many passengers using one shaft, is employed particularly as a shuttle elevator traveling directly to upper floors from a main floor. Generally, inter-story heights are different between upper floors and a main floor in many cases. Accordingly, there has been proposed a double deck elevator that is adjustable for such inter-story heights.

[0003] A conventional art for a double deck elevator adjustable for inter-story heights is such that the upper and lower cages are disposed inside the main frame and wound around with ropes; the positions of the upper and lower cages are moved in mutually opposite directions by actuating a cage-position adjusting drive unit provided in the car, which allows adjustment for inter-story heights (refer to Patent Document **1**, for example).

[0004] In addition, in order to correct a floor displacement occurring between the cage floors and landing floors due to getting on and off of passengers after the car arrives and stops at a destination floor, there has been proposed a double deck elevator that performs a floor leveling operation for the upper and lower cages simultaneously using a method of adjusting by an inter-cage distance adjusting unit the positions of the upper and lower cages on the basis of a value calculated from variations of ratios of loads in the cages (refer to Patent Document **2**, for example).

Prior Art Document

Patent Documents

[0005]

Patent Document **1**: JP 2007-331871 A (paragraphs [0024], [0025], and **FIG. 1**)
Patent Document **2**: JP 2002-338154 A (paragraphs [0027] through [0029], and **FIG. 2**)

Summary of the Invention

Problem that the Invention is to Solve

[0006] However, in the floor-height adjustable double-deck elevator described in Patent Document **1**, since the upper and lower cages are ganged to move together, a landing level displacement tends to occur, raising a problem that a floor level difference is highly likely to occur at landing or at getting on and off of passengers after landing.

[0007] In Patent Document **2**, a floor leveling operation is performed simultaneously for the upper and lower cages by an inter-cage distance adjusting unit, based on the premise that floor displacement levels of the upper and lower cages due to getting on and off of passengers when the car arrives at a landing floor are substantially the same in the opposite directions. However, in actuality, under the influence of rubber isolators provided under the cage floors, floor displacements of the upper and lower cages happen to occur in the same direction and/or at different levels, raising a problem that it is difficult to reduce the floor displacement levels of the upper and lower cages to zero in a system in which the upper and lower cages are ganged to move together.

[0008] The present invention aims at providing a double deck elevator that is capable of adjusting floor displacement levels of the upper and lower cages to reduce the floor level differences by selecting either the main frame or the upper and lower cages or both to be moved, depending on conditions of the respective floor-displacement levels of the upper and lower cages.

Means for Solving the Problems

[0009] A double deck elevator according to the present invention includes a main traction unit for actuating a main frame to travel up and down in a hoistway of a building; two upper and lower cages disposed inside the main frame; a cage-position adjusting drive unit provided to a top portion of the main frame and having a position adjusting drive sheave around which ropes suspending the respective two upper and lower cages from the main frame are wound, for varying a distance between the cages by moving inside the main frame the cages vertically in mutually opposite directions by rotating the position adjusting drive sheave; a determination means for making determination by comparing whether at least one of cage-doorway floor-displacement levels detected by cages' detection sensors provided to the respective cages is equal to or larger than a floor-displacement-level threshold value that is stored beforehand in a storage means and is a reference for whether or not the floor displacement level to be corrected; a calculation means for performing calculations by substituting respective floor displacement levels of the two upper and lower cages successively into a plurality of conditions for correcting the floor displacement levels when the determination means determines that at least one of the cage-doorway floor-displacement levels is equal to or larger than the threshold value; and a selection means for selecting, when a relevant condition among the plurality of conditions holds true from a calculation result of the calculation means, either the main traction unit or the cage-position adjusting drive unit or both of the main traction unit and the cage-position adjusting drive unit to be actuated, according to the relevant condition.

Advantages of the Invention

[0010] According to a double deck elevator of the present invention, an advantageous effect is brought about that floor displacement levels of the upper and lower cages can be adjusted to reduce the floor level differences by selecting either the main frame or the upper and lower cages or both to be moved, depending on conditions of the respective floor displacement levels of the upper and lower cages.

Brief Description of the Drawings

[0011]

FIG. 1 is a schematic view illustrating a configuration of a double deck elevator according to an embodiment **1** of the present invention;
FIG. 2 is a functional block diagram showing a function of a floor leveling control unit according to the embodiment **1** of the present invention;
FIG. 3 is a flowchart showing an operation of the double deck elevator, according to the embodiment **1** of the present invention;
FIG. 4 shows examples explaining floor leveling performed using a main frame by actuating a main traction unit, according to the embodiment **1** of the present invention;
FIG. 5 shows examples explaining floor leveling performed using the upper and lower cages by actuating a cage-position adjusting drive unit, according to the embodiment **1** of the present invention;
FIG. 6 shows an example explaining floor leveling performed by actuating the main traction unit and the cage-position adjusting drive unit, according to the embodiment **1** of the present invention;
FIG. 7 is a flowchart showing an operation of a double deck elevator according to an embodiment **2** of the present invention;
FIG. 8 shows examples explaining floor leveling performed by actuating the main traction unit and the cage-position adjusting drive unit, according to the embodiment **2** of the present invention;
FIG. 9 is a functional block diagram showing a function of a floor leveling control unit according to an embodiment **3** of the present invention; and
FIG. 10 is a flowchart showing an operation of a double deck elevator according to the embodiment **3** of the present invention.

Best Mode for Carrying Out the Invention

[0012] Hereinafter, embodiments for carrying out the present invention will be described with reference to the drawings.

Embodiment **1**

[0013] A double deck elevator according to an embodiment **1** of the invention will be described. First of all, a configuration of the double deck elevator is described.

[0014] **FIG. 1** is a schematic view illustrating a configuration of the double deck elevator according to the embodiment **1** of the present invention. Referring to **FIG. 1,** a main traction unit **20** having a main traction sheave **21** coupled thereto is installed at the top of an elevator hoistway, for driving an elevator car unit **50;** a deflection pulley **22** is disposed near the main traction unit **20,** for keeping the elevator car unit **50** and a counterweight **25** from contact with each other; a main cable **23** consisting of a plurality of ropes in a bundle is wound around the main traction sheave **21** and the deflection pulley **22,** and at one end of main cable **23** the elevator car unit **50** is suspended and at the other end thereof the counterweight **25** is suspended; the elevator car unit **50** and the counterweight **25** are suspended by the main cable **23** in a 1:1 roping arrangement and travel up and down in the hoistway by the traction force of the main traction unit **20.** Here, the 1:1 roping arrangement refers to such a roping configuration that a speed ratio between the main cable **23** and the elevator car unit **50** is 1:1.

[0015] A main frame **24** of the elevator car unit **50** is made up of a pair of vertical beams **1,** a top beam **2,** a middle beam **4** and a bottom beam **3,** and is provided with a pair of upper-cage guide rails (not shown) and a pair of lower-cage guide rails (not shown). The top beam **2** is fixed horizontally between the top ends of the vertical beams **1.** The middle beam **4** is fixed horizontally between the middle portions of the pair of vertical beams **1.** The bottom beam **3** is fixed horizontally between the bottom ends of the vertical beams **1.** The upper-cage guide rails and the lower-cage guide rails both are fixed inside the main frame **24** and in parallel with the vertical beams 1, for respectively guiding an upper cage **26** and a lower cage **28** moving up and down relative to the main frame **2.**

[0016] The main frame **24** has vertically separated spaces. In the upper space, i.e., between the top frame **2** and the middle beam **4,** the upper cage **26** is disposed, and in the lower space, i.e., between the middle beam **4** and the bottom beam **3,** the lower cage **28** is disposed. The upper cage **26** and the lower cage **28** are up-and-down movable along the upper-cage guide rails and the lower-cage guide rails, respectively.

[0017] The upper cage **26** and the lower cage **28** have suspending pulleys **27, 29** at their bottoms, for suspending the respective cages. A plurality of ropes **30, 33** for respectively suspending the two upper and lower cages from the main frame are wound around the suspending pulleys. One end of the rope **30** for the upper cage is secured to a securing member **31** provided to the top beam **2** at the top portion of the main frame, and the other end is wound around a position adjusting drive sheave **32** of a cage-position adjusting drive unit **5.** Likewise, one end of the rope **33** for the lower cage is secured to a securing member **34** provided to the middle portion of the main frame, and the other end is wound around the position adjusting drive sheave **32** of the cage-position adjusting drive unit **5.** The cage-position adjusting drive unit 5 is secured to a bottom portion of the top beam **2,** i.e., an upper portion of the main frame **24,** for adjusting the distance between the upper cage **26** and the lower cage **28** by moving both of them vertically in mutually opposite directions inside the main frame **24.** Further, the cage-position adjusting drive unit **5,** which has the position adjusting drive sheave **32,** is disposed so as to align the rotation axis of the position adjusting drive sheave **32** to be in parallel with the widthwise direction of the upper cage **26.**

[0018] The upper-cage rope **30** and the lower-cage rope **33** are formed of one continuous rope, and the continuous other ends of the upper-cage rope **30** and the lower-cage ropes **33** are wound, for example, approximately one and a half turns around the position adjusting drive sheave **32.** The upper and lower cages are suspended with a roping arrangement of 2:1 and ganged to move together by actuating the cage-position adjusting drive unit **5.** Note that a 2:1 roping arrangement refers to such a roping arrangement that the speed ratio between the main cable **23** and the car unit **50** is 2:1. In addition, the upper-cage rope **30** and the lower-cage rope **33** may be formed of separate ropes. In that case, the upper-cage rope **30** and the lower-cage rope **33** should be wound in the clockwise direction and the counterclockwise direction around the position adjusting drive sheave **32,** and their respective other ends may be secured to an upper portion of the middle beam **4.**

[0019] Designated at **35** are buffers for the upper cage and at **36** are buffers for the lower cage, for absorbing shock of the cages. The upper and lower cages **36, 38** are provided with detection sensors for detecting cage-doorway floor displacements occurring when or after landing. Designated at **37** is an upper cage's detection sensor that is provided to the upper cage and capable of detecting a floor displacement level **41** by sensing a relative position to a plate **38** placed in the hoistway. Likewise, a lower cage's detection sensor **39** is provided to the lower cage and capable of detecting a floor displacement level **42** of the lower-cage doorway by sensing a relative position to a plate **40** placed in the hoistway. On a top portion of the main frame **24,** a floor leveling control unit **12** is provided that sends a floor-leveling operation instruction based on the floor displacement levels **41, 42** detected by the upper cage's detection sensor **37** and the lower cage's detection sensor **39** to the main traction unit **20,** the cage-position adjusting drive unit **5,** or both. Note that a reference numeral **6** indicates an inter-story height between contiguous upper and lower floors.

[0020] Next, the operation will be described. The car unit **50** (the main frame **24**) and the counterweight **25** travel up and down in the hoistway by drive force by the main traction unit **20.** While the upper cage **26** and the lower cage **28** land vertically contiguous landing floors at the same time, since inter-story heights of a building are in some cases not exactly constant but different depending on floors, in such case, the upper cage **26** and the lower cage **28** is moved up and down relative to the main frame **24** by the cage-position adjusting drive unit **5** so that the distance between the cages is adjusted in accordance with an inter-story height. Specifically, when the upper cage **26** moves downwardly, the lower cage **28** moves upwardly and the distance between both reduces; conversely, when the upper cage **26** moves upwardly, the lower cage **28** moves downwardly and the distance between both increases. That is, the absolute value of movement amounts of the upper and lower cages by the cage-position adjusting drive unit **5** are substantially the same. Ordinarily, inter-story heights for the cages to be moved are memorized in advance, whereby the distance between the upper and lower cages is adjusted before arrival, and then the main frame **24** travels to a landing floor.

[0021] **FIG. 2** is a functional block diagram showing a function of the floor leveling control unit according to the embodiment **1** of the present invention. In **FIG. 2,** the upper cage's detection sensor **37** and the lower cage's detection sensor **39** are the detection sensors provided to the upper and lower cages **36, 38,** respectively, for detecting floor displacement levels. The position of the plate **38** is determined so that when the position of the upper cage's detection sensor **37** coincides with that of the plate **38** placed in the hoistway, the floor displacement level becomes zero. Likewise, the position of the plate **40** is determined so that when the position of the lower cage's detection sensor **39** coincides with that of the plate **40,** the floor displacement level becomes zero. Note that it is assumed that upward displacement of a cage from its reference position is expressed as positive, and downward displacement is expressed as negative.

[0022] The floor leveling control unit **12** provided on the top portion of the main frame **24** performs floor leveling, i.e., corrects a floor displacement by adjusting the positions of the upper and lower cages **26, 28** so that floor level differences occurring between landing floors and the upper and lower cages **26, 28** become within a threshold value or zero. The floor leveling control unit **12** includes a floor-displacement level recognition and determination means **7,** a conditional expression calculating means **8,** a storage means **9,** a floor-leveling operation selecting and calculating means **10,** and a floor-leveling operation instruction means **11.**

[0023] The floor-displacement level recognition and determination means (determination means) **7** recognizes the floor displacement levels **41, 42** detected by the upper cage's detection sensor **37** and the lower cage's detection sensor **39,** and determines whether a floor displacement level of the upper cage **26** or the lower cage **28** is equal to or larger than the floor-displacement-level threshold value that is a reference for whether or not to perform floor leveling. The storage means **9** stores in advance the threshold value, which is used in the comparison when the floor-displacement level recognition and determination means **7** determines whether a floor displacement level of the upper cage **26** or the lower cage **28** is equal to or larger than the floor-displacement level threshold value, and also stores conditional expressions for determining whether the main traction unit **20** or the cage-position adjusting drive unit **5** or both is/are to be actuated and mathematical expressions for determining a floor leveling amount. The conditional expression calculating means (calculation means) **8,** when the floor-displacement level recognition and determination means **7** determines that at least one of floor displacement levels of the upper and lower cages **26, 28** is equal to or larger than the threshold value, performs calculations by substituting the floor displacement levels of the upper and lower cages **26, 28** successively into the plurality of conditional expressions stored in the storage means **9.** When the calculation result of the conditional expression calculating means **8** meets a relevant condition among the plurality of conditional expressions, the floor-leveling operation selecting and calculating means (selection means) **10** selects, according to the relevant condition, either the main traction unit **20** or the cage-position adjusting drive unit **5** or both to be actuated, and calculates based on the floor-leveling amount determining mathematical expressions stored in the storage means **9** how many millimeters either the main traction unit **20** or the cage-position adjusting drive unit **5** or both is/are to be moved. The floor-leveling operation instruction means **11** outputs, according to the selection and calculation result of the floor-leveling operation selecting and calculating means **10,** an actuation instruction to the main traction unit **20** or the cage-position adjusting drive unit 5 or both.

[0024] An after-landing operation of the double deck elevator according to the above embodiment **1** will be described. **FIG. 3** is a flowchart showing the operation of the double deck elevator according to the embodiment **1** of the present invention. As described above, before the elevator car unit **50** arrives at a landing floor, the distance between the upper and low cages is adjusted and then the main frame **24** travels to the landing floor. However, due to getting on and off of passengers after the car unit **50** stops, a floor displacement occurs between the upper cage **26** and its landing floor and/or between the lower cage **28** and its landing floor. At this time, because of influences such as of distortion of rubber-isolators provided under the upper and lower cage floors for preventing the cages from vibration due to a passenger load or of temporary stretch of the upper and lower cage ropes **30, 33** due to a passenger load, the floor displacements of the upper cage **26** and the lower cage may occur in the same direction as well as in the reverse direction.

[0025] As shown in **FIGS. 1** through **3,** the upper cage's detection sensor **37** detects the doorway floor displacement **41** occurring in getting on and off of passengers after the upper cage **26** has landed. Likewise, the upper cage's detection sensor **39** detects the doorway floor displacement **42** occurring in getting on and off of passengers after the upper cage **28** has landed. Then, the floor-displacement level recognition and determination means **7** recognizes the floor displacements **41, 42** input from the upper cage's detection sensor **37** and the lower cage's detection sensor **39.** Further, the floor-displacement level recognition and determination means **7** compares the floor displacements **41, 42** with the threshold value stored in the storage means **9,** to determine whether at least one displacement of the upper cage **26** and the lower cage **28** is equal to or larger than the threshold value (**S101**). If the displacement is equal to or larger than the threshold value, the process proceeds to **S102** and the subsequent steps and calculations are made by substituting the floor displacement levels of the two upper and lower cages successively into the plurality of conditional expressions stored in the storage means **9.** On the other hand, if the displacement is smaller than the threshold value, the later steps are not executed.

[0026] In **S102,** the conditional expression calculating means **8** substitutes the floor displacement levels **41, 42** into a conditional floor-displacement expression stored in the storage means **9:** | (upper-cage floor displacement level **41**) - (lower-cage floor displacement level **42**)| / **2** ≤ (threshold value), to determine whether the conditional expression holds true. Then, if the conditional expression holds true, the process proceeds to **S106.** Conversely, if the conditional expression does not hold true, the process proceeds to **S103.**

[0027] In **S106,** according to the conditional expression validity determined by the conditional calculation means **8,** the main traction unit **20** (the main frame **24**) is selected to be actuated. As for the actuation amount, i.e., the floor-leveling amount, using a mathematical expression stored in the storage means 9: (main-frame floor leveling amount) = - ((upper-cage floor displacement level **41**) + (lower-cage floor displacement level **42**)) / 2, the floor-leveling amount is calculated by substituting the upper-cage floor displacement level **41** and the lower-cage floor displacement level **42** into the mathematical expression. Then, the floor-leveling operation instruction means **11** outputs to the main traction unit **20** an actuation instruction to actuate the main traction unit **20** by the calculated floor-leveling amount, and the main traction unit **20** performs the floor leveling in accordance with the instruction.

[0028] Specific examples are described here with reference to **FIG. 4. FIG. 4** shows examples explaining the floor leveling performed using a main frame by actuating the main traction unit, according to the embodiment **1** of the present invention. First, the threshold value stored in the storage means **9,** for necessity or non-necessity of performing the floor leveling, is assumed to be 5 mm for example. In that case, the floor leveling is performed when the upper-cage floor displacement level **41** or the lower-cage floor displacement level **42** is equal to or larger than 5 mm, or equal to or smaller than -5 mm. When |(upper-cage floor displacement level **41**) - (lower-cage floor displacement level **42**)| / **2** ≤ (threshold value (5 mm)), the main frame is moved. Here, substituting an upper-cage floor displacement level of 8 mm and a lower-cage floor displacement level of 4 mm into the mathematical expression: (main-frame floor leveling amounts) = - ((upper-cage floor displacement level **41**) + (lower-cage floor displacement level **42**)) / 2 yields -6 mm. Accordingly, the main frame (the main traction unit **20**) is moved by -6 mm. Thereby, the upper-cage floor displacement **41** becomes 2 mm and the lower-cage floor displacement **42** becomes -2 mm, so that the upper and lower doorways are leveled within the threshold value of 5 mm. Likewise, when the upper-cage floor displacement **41** is 3 mm and the lower-cage floor displacement **42** is 7 mm, movement of the main frame by 5 mm brings the upper-cage floor displacement **41** to become -2 mm and the lower-cage floor displacement **42** to become 2 mm, so that the upper and lower doorways are leveled within the threshold value. In this way, movement of the main frame **24** alone can level the upper- and lower- cage floors within the threshold value.

[0029] Proceeding to **S103,** the conditional expression calculating means **8** then substitutes the floor displacement levels **41, 42** into a conditional floor-displacement expression stored in the storage means **9**: |(upper-cage floor displacement level **42**) + (lower-cage floor displacement level **44**) | / **2** ≤ (threshold value), to determine the conditional expression holds true. If the conditional expression holds true, the process proceeds to **S105.** Conversely, if the conditional expression does not hold true, the process proceeds to **S104.**

[0030] In **S105,** based on the conditional expression validity determined by the conditional calculation means **8,** the position adjusting drive unit **5** (the upper and lower cages **26, 28**) is selected to be actuated. As for the floor leveling amounts, i.e., the actuation amount, using mathematical expressions stored in the storage means **9:** (upper-cage floor leveling amount) = ((lower-cage floor displacement level **42**) - (upper-cage floor displacement level **41**)) / 2 and (lower-cage floor leveling amount) = ((upper-cage floor displacement level **41**) - (lower-cage floor displacement level **42**)) / 2, the floor-leveling amounts are calculated by substituting the upper-cage floor displacement level **41** and the lower-cage floor displacement level **42** into the mathematical expressions, respectively. Then, the floor-leveling operation instruction means **11** outputs to the position adjusting drive unit **5** an actuation instruction to actuate the position adjusting drive unit **5** by the calculated floor-leveling amount, and the position adjusting drive unit **5** performs the floor leveling in accordance with the instruction.

[0031] Specific examples are described here with reference to **FIG. 5. FIG. 5** shows examples explaining the floor leveling performed using the upper and lower cages by actuating the cage-position adjusting drive unit **5,** according to the embodiment **1** of the present invention. First, the threshold value stored in the storage means **9,** for necessity or non-necessity of performing the floor leveling, is assumed to be 5 mm for example. In that case, the floor leveling is performed when the upper-cage floor displacement level **41** or the lower-cage floor displacement level **42** is equal to or larger than 5 mm, or equal to or smaller than -5 mm. When |(upper-cage floor displacement level **41**) + (lower-cage floor displacement level **42**)| / 2 ≤ (threshold value (5 mm)), the upper and lower cages are moved. For example, when the upper-cage floor displacement is 5 mm and the lower-cage floor displacement **42** is -7 mm, the upper cage is moved by -6 mm and the lower cage, by **6** mm. Thereby, the upper-cage floor displacement **41** becomes -1 mm and the lower-cage floor displacement **42** becomes 1 mm, so that the upper and lower doorways are leveled within the threshold value. In this way, actuation of the cage-position adjusting drive unit 5 alone can level the upper- and lower- cage floors within the threshold value.

[0032] In a case of not meeting the conditions of **S102** and **S103** (i.e., in a case where conditional floor-displacement expressions stored in the storage means **9**: |(upper-cage floor displacement level **41**) + (lower-cage floor displacement level **42**)| / 2 > (threshold value) and |(upper-cage floor displacement level **41**) - (lower-cage floor displacement level **42**)| / **2** > (threshold value) hold true, the process proceeds to **S104** and the main traction unit **20** and the position adjusting drive unit **5** are selected to be actuated. As for the floor leveling amounts, i.e., the actuation amounts, by substituting the upper-cage floor displacement level **41** and the lower-cage floor displacement level **42** into the following mathematical expressions stored in the storage means **9,** a floor-leveling amount by the main frame **24** is calculated using the mathematical expression: (upper-cage floor leveling amount) = - ((lower-cage floor displacement level **42**) + (upper-cage floor displacement level **41**)) / **2**; and floor-leveling amounts by the upper and lower cages **26, 28** are calculated using the respective mathematical expressions: (upper-cage floor leveling amount) = ((lower-cage floor displacement level **42**) - (upper-cage floor displacement level **41**)) / **2** and (lower-cage floor leveling amount) = ((upper-cage floor displacement level **41**) - (lower-cage floor displacement level **42**)) / **2.** Then, the floor-leveling operation instruction means **11** outputs, to both of the main traction unit **20** and the position adjusting drive unit **5,** actuation instructions to actuate them by the respective calculated floor-leveling amounts for the main frame and the upper and lower cages, and the main traction unit **20** and the position adjusting drive unit 5 perform the floor leveling in accordance with the instructions.

[0033] A specific example is described here with reference to **FIG. 6. FIG. 6** shows an example explaining the floor leveling performed by the main traction unit and the cage-position adjusting drive unit, according to the embodiment 1 of the present invention. First, the threshold value stored in the storage means **9,** for performing the floor leveling, is assumed to be 5 mm for example. In that case, the floor leveling is performed when the upper-cage floor displacement level **41** or the lower-cage floor displacement level **42** is equal to or larger than 5 mm, or equal to or smaller than -5 mm. For example, when the upper-cage floor displacement level is 3 mm and the lower-cage floor displacement level **42** is **15** mm, the main frame is moved by **-6** mm and the upper and the lower cages are moved by 3 mm and -3 mm, respectively, so that the upper-cage floor displacement **41** becomes 0 mm and the lower-cage floor displacement **42** becomes 0 mm. In this way, the upper- and lower-doorway floor displacement levels can be 0 mm.

[0034] According to the embodiment **1** of the present invention, by selecting a mode of the floor leveling depending on upper- and lower-cage floor displacement levels, the upper- and lower-cage floor displacement levels can be suppressed within a threshold value even when passengers are getting on and off during the open states of the doors, thus achieving an optimal floor leveling of the upper and lower cages.

[0035] The above describes a correction of floor displacements occurring in getting on and off of passengers after the car unit **50** arrives at a landing floor. However, similar floor leveling can be applied not only to the correction but also to a correction of floor displacements occurring when the car unit **50** arrives at a landing floor. In addition, while the above corrections are implemented in accordance with microcomputer software, the corrections using addition and subtraction calculations and threshold comparison can be implemented not only by software but also by providing circuitry such as an adder circuit and a subtracter circuit.

Embodiment **2**

[0036] Next, a double deck elevator according to an embodiment **2** will be described. Note that the same configuration and operation as those of the embodiment **1** are appropriately omitted.

[0037] **FIG. 7** is a flowchart showing an operation of a double deck elevator according to the embodiment **2** of the present invention. In **FIGS. 2** and **7,** the floor-displacement level recognition and determination means **7** recognizes the floor displacement levels **41, 42** input from the upper cage's detection sensor **37** and the lower cage's detection sensor **39.** Then, floor-displacement level recognition and determination means **7** compares the floor displacement levels **41, 42** with the threshold value stored in the storage means **9,** to determine whether a floor displacement has occurred to at least one of the upper cage **26** and the lower cage **28** (S110).

[0038] After that, when a signal is input from a car wheelchair-button call registration unit (not shown) that registers an action on a wheelchair button panel provided in the cages or from a hall wheelchair-button call registration unit (not shown) that registers an action on a wheelchair button panel provided at landing floors, the floor-displacement level recognition and determination means **7** determines the signal as a special condition in **S111** and advances the process to **S104,** so that floor leveling is performed by the main traction unit **20** and the position adjusting drive unit **5.** This is because the floor leveling for a cage whose wheelchair button panel is pressed needs to be zero in order to prevent a wheelchair user from tripping on the floor level difference when utilizing the elevator. On the other hand, when the signal is not input to the floor-displacement level recognition and determination means **7** from a car wheelchair-button call registration unit or a hall wheelchair-button call registration unit, the floor-displacement level recognition and determination means **7** determines that there is no special condition and advances the process to **S102.**

[0039] Proceeding to **S102,** the floor-displacement level recognition and determination means **7** determines whether at least one floor-displacement level of the upper cage **26** and the lower cage **28** is equal to or larger than the threshold value (**S101**). Since the later steps are the same as those in the embodiment **1,** description thereof is omitted.

[0040] Specific examples are described here with reference to **FIG. 8. FIG. 8** shows examples explaining the floor leveling performed by the main traction unit and the cage-position adjusting drive unit, according to the embodiment **2** of the present invention. In the figure, when a floor displacement occurs, the floor leveling is performed. For example, when the special condition holds, such as press of a wheelchair button panel (not shown) in a cage or at a landing floor, the floor leveling is performed by both of the main frame and the upper and lower cages, which is similar to **FIG. 6.** When the upper-cage floor displacement level is 8 mm and the lower-cage floor displacement level **42** is 4 mm, the main frame is moved by -6 mm and the upper and lower cages are moved by **-2** mm and 2 mm, respectively. Likewise, when the upper-cage floor displacement level is 3 mm and the lower-cage floor displacement level **42** is 7 mm, the main frame is moved by -5 mm and the upper and lower cages are moved by -2 mm and 2 mm, respectively.

[0041] In this way, the upper-cage floor displacement level **41** becomes 0 mm and the lower-cage floor displacement level **42** becomes 0 mm, i.e., both of the upper- and lower-doorway floor-displacement levels become 0 mm. According to the embodiment **2** of the present invention, the distance between the upper- and the lower-cage floors can be thus adjusted to be equal to the interstory height **6** between landing floors, thereby achieving enhancement in safety of elevator users.

Embodiment **3**

[0042] Next, a double deck elevator according to an embodiment **3** will be described. Note that the same configuration and operation as those of the embodiments **1** and **2** are appropriately omitted.

[0043] **FIG. 9** is a functional block diagram showing a function of a floor leveling control unit according to the embodiment **3** of the present invention, and **FIG. 10** is a flowchart showing an operation of a double deck elevator according to the embodiment 3 of the present invention. Referring to **FIGS. 2, 9** and **10,** the floor-displacement level recognition and determination means **7** recognizes the floor displacement levels **41, 42** input from the upper cage's detection sensor **37** and the lower cage's detection sensor **39.** Then, the floor-displacement level recognition and determination means **7** compares the floor displacement levels **41, 42** with the floor-displacement-level threshold value stored in the storage means **9,** to determine whether at least one of the floor displacement level **41** occurring to the upper cage **26** and the floor displacement level **42** occurring to the lower cage **28** is equal to or larger than the threshold value (**S101**). When either level is equal to or larger than the threshold value, the process proceeds to **S112,** and when smaller than the threshold value, the later steps are not executed.

[0044] In **S112,** an abnormality detection means **43** provided to the floor leveling control unit **12** counts the number of facts that the floor-displacement level recognition and determination means **7** determines that at least one of a floor displacement level **41** occurring to the upper cage **26** and a floor displacement level **42** occurring to the lower cage **28** is equal to or larger than the threshold value, to determine whether the number is equal to or more than a predetermined count (for example, five counts or more) within a certain period of time. As a result, if the facts are repeated for the predetermined count, the abnormality detection means **43** determines that there occurs an abnormal condition such as stretch of the upper- and lower- cage ropes **30, 33** due to long-term deterioration or slippage of the upper- and lower- cage ropes **30, 33** due to an imbalance state generated by extremely uneven loads between the upper and lower cages, and notifies the external of the abnormality to urge inspection by maintenance staff.

[0045] According to the embodiment **3** of the present invention, it is possible to determine an abnormal condition such as stretch of the upper- and lower- cage ropes due to long-term deterioration or rope slippage due to load imbalance between the upper and lower cages, thereby ensuring enhancement in safety of elevator users.

[0046] It should be noted that when relative floor-leveling speeds of the upper and lower cages **26, 28** with respect to the main frame **24** become a certain value or larger, the floor leveling operation can be aborted. For example, assuming as ***A*** an upper-cage movement speed detected by a speed detector for control (not shown) provided to the cage-position adjusting drive unit **5** and as ***B*** a main-frame movement speed detected by a speed detector provided to the main traction unit **20,** a movement speed ***C = A + B*** expresses a relative speed of the upper cage with respect to a landing floor when a floor displacement level is corrected. When the speed ***C*** > an abnormal speed level, the floor leveling is aborted. In this way, a relative floor-leveling speed can be determined to be in an abnormal condition, thereby ensuring safety.

Reference Numerals

[0047]

1:	vertical beams
2:	top beam
3:	bottom beam
4:	middle beam
5:	cage-position adjusting drive unit
6:	inter-story height
7:	floor-displacement level recognition and determination means
8:	conditional expression calculating means
9:	storage means
10:	floor-leveling operation selecting and calculating means
11:	floor-leveling operation instruction means
12:	floor leveling control unit
20:	main traction unit
21:	main traction sheave
22:	deflection pulley
23:	main cable
24:	main frame
25:	counterweight
26:	upper cage
27, 29:	suspending pulley
28:	lower cage

30, 33 rope

31, 34: securing member

32: position adjusting drive sheave

35, 36: buffer

37: upper cage's detection sensor

38, 40: plate

39: lower cage's detection sensor

41, 42: floor displacement level

43: abnormality detection means

50: car unit

Claims

1. A double deck elevator comprising:

a main traction unit for actuating a main frame to travel up and down in a hoistway of a building;
two upper and lower cages disposed inside the main frame;
a cage-position adjusting drive unit provided to a top portion of the main frame and having a position adjusting drive sheave around which ropes suspending the respective two upper and lower cages from the main frame are wound, for varying a distance between the cages by moving inside the main frame the cages vertically in mutually opposite directions by rotating the position adjusting drive sheave;
a determination means for making determination by comparing whether at least one of cage-doorway floor-displacement levels detected by cages' detection sensors provided to the respective cages is equal to or larger than a floor-displacement-level threshold value that is stored beforehand in a storage means and is a reference for whether or not the floor displacement level to be corrected;
a calculation means for performing calculations by substituting respective floor displacement levels of the two upper and lower cages successively into a plurality of conditions for correcting the floor displacement levels when the determination means determines that at least one of the cage-doorway floor-displacement levels is equal to or larger than the threshold value; and
a selection means for selecting, when a relevant condition among the plurality of conditions holds true from a calculation result of the calculation means, either the main traction unit or the cage-position adjusting drive unit or both of the main traction unit and the cage-position adjusting drive unit to be actuated, according to the relevant condition.

2. The double deck elevator of claim 1, wherein when among the plurality of conditions, a condition of |(upper-cage floor displacement level) - (lower-cage floor displacement level) / 2 ≤ (threshold value) holds true, the selection means selects the main traction unit to be actuated.

3. The double deck elevator of claim 1, wherein when among the plurality of conditions, a condition of |(upper-cage floor displacement level) + (lower-cage floor displacement level)| / 2 ≤ (threshold value) holds true, the selection means selects the cage-position adjusting drive unit to be actuated.

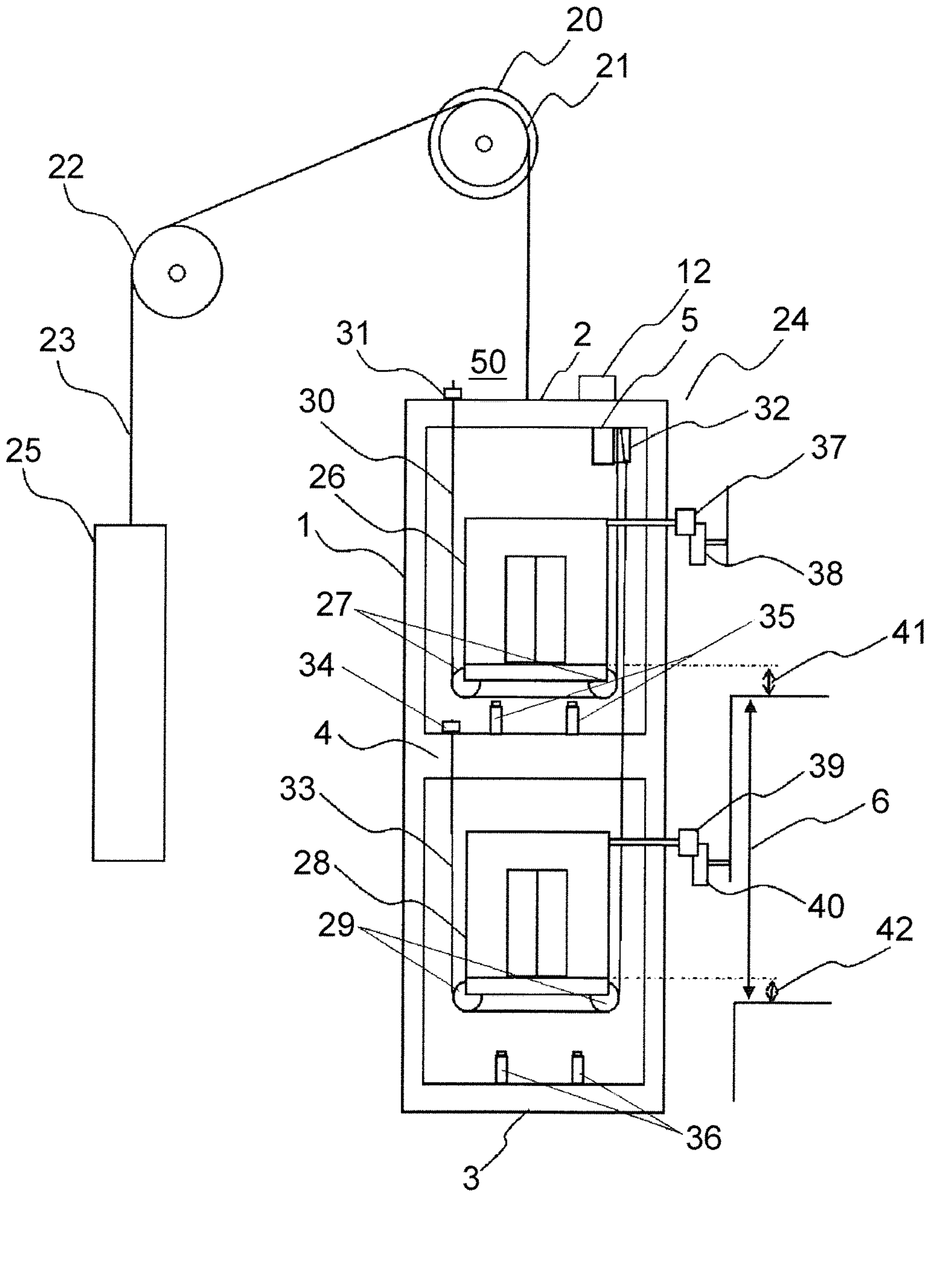
4. The double deck elevator of claim 1, wherein when among the plurality of conditions, conditions of |(upper-cage floor displacement level) + (lower-cage floor displacement level)| / 2 > (threshold value) and |(upper-cage floor displacement level) - (lower-cage floor displacement level)| / 2 > (threshold value) hold true, the selection means selects the main traction unit and the cage-position adjusting drive unit to be actuated.

5. The double deck elevator of claim **1,** wherein when the determination means receives a signal from a car wheelchair-button call registration unit that registers an action to a wheelchair button panel provided in the cages or from a hall wheelchair-button call registration unit that registers an action to a wheelchair button panel provided at landing floors, the selection means selects the main traction unit and the cage-position adjusting drive unit to be actuated.

6. The double deck elevator of claim **1,** further comprising:

an abnormality detection means for counting the number of determinations made by the determination means that at least one of cage-doorway floor-displacement levels is equal to or larger than the threshold value, wherein the abnormality detection means, when it determines that the number is equal to or more than a predetermined count within a certain period of time, notifies an external of an abnormality.

Fig. 1


20
21
22
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25
12
5
24
31
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2
30
32
37
26
1
38
27
35
41
34
4
39
33
6
28
40
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42
36
3

Fig. 2

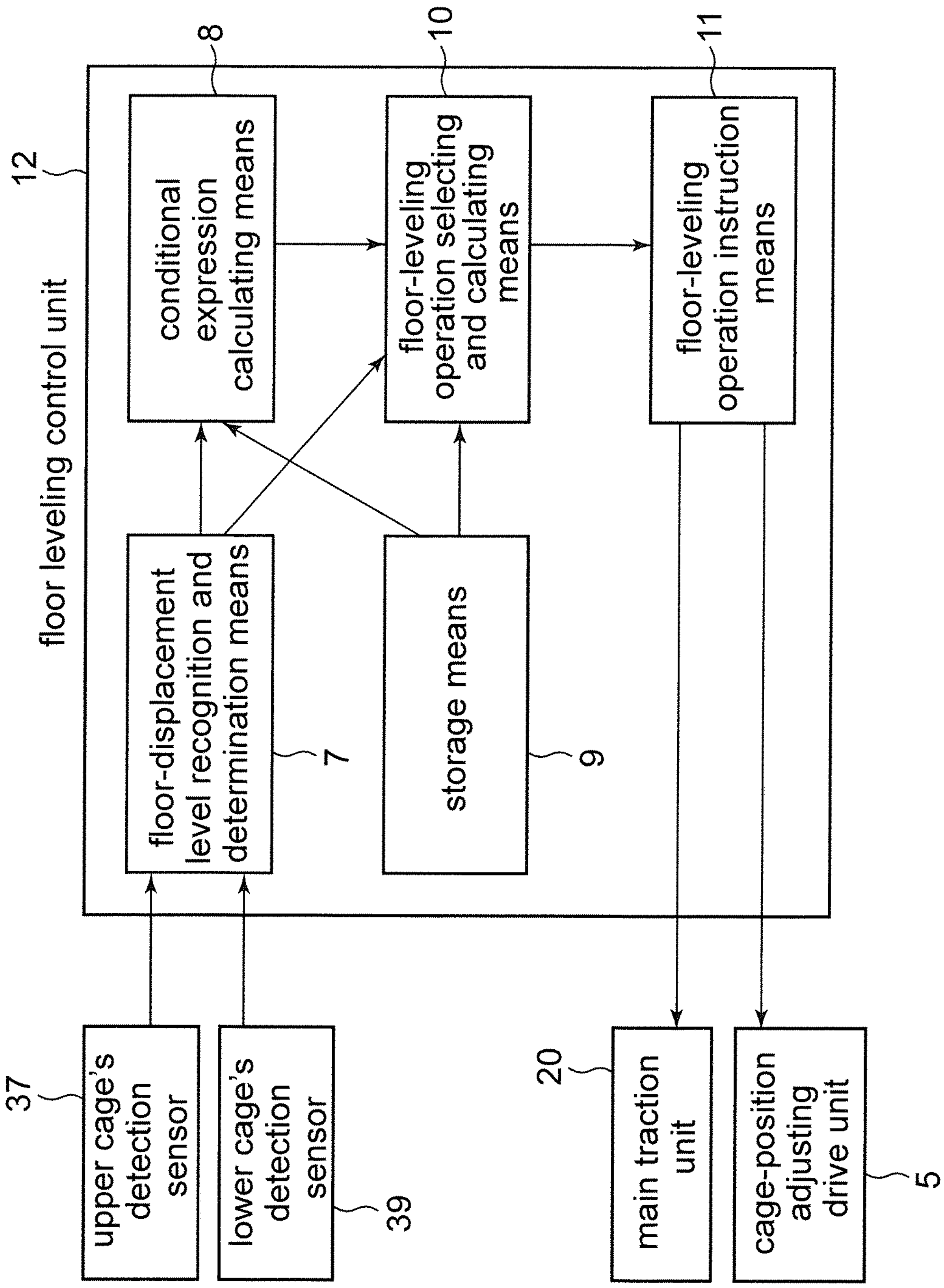

floor leveling control unit
12
conditional expression calculating means
8
floor-leveling operation selecting and calculating means
10
floor-leveling operation instruction means
11
floor-displacement level recognition and determination means
7
storage means
9
upper cage's detection sensor
37
lower cage's detection sensor
39
main traction unit
20
cage-position adjusting drive unit
5

Fig. 3

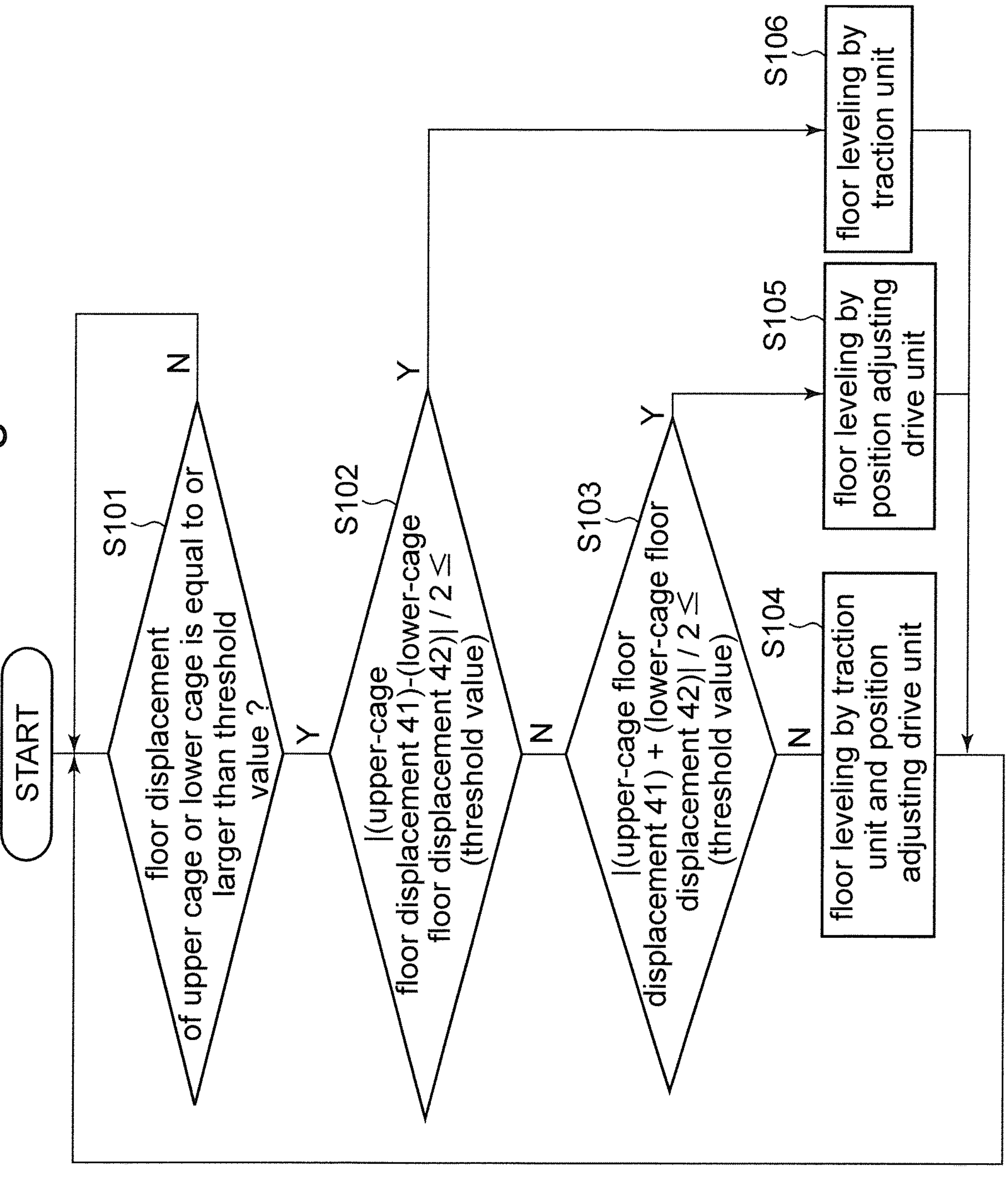

START
S101
floor displacement of upper cage or lower cage is equal to or larger than threshold value ?
N
Y
S102
|(upper-cage floor displacement 41)-(lower-cage floor displacement 42)| / 2 ≤ (threshold value)
Y
N
S103
|(upper-cage floor displacement 41) + (lower-cage floor displacement 42)| / 2 ≤ (threshold value)
Y
N
S104
floor leveling by traction unit and position adjusting drive unit
S105
floor leveling by position adjusting drive unit
S106
floor leveling by traction unit

Fig. 4

example: threshold value of 5 mm

|(upper-cage floor displacement 41)-(lower-cage floor displacement 42)| / 2 ≤ (threshold value)

upper-cage floor displacement 41	lower-cage floor displacement 42	threshold value	floor leveling operation
8mm	4mm	5mm	move main frame by -6 mm
3mm	7mm	5mm	move main frame by -5 mm

Fig. 5

example: threshold value of 5 mm

|(upper-cage floor displacement 41) + (lower-cage floor displacement 42)| / 2 ≤(threshold value)

upper-cage floor displacement 41	lower-cage floor displacement 42	threshold value	floor leveling operation
5mm	-7mm	5mm	move upper cage by -6 mm move lower cage by 6 mm
-3mm	7mm	5mm	move upper cage by 5 mm move lower cage by -5 mm

Fig. 6

example: threshold value of 5 mm

|(upper-cage floor displacement 41) + (lower-cage floor displacement 42)| / 2 > (threshold value) and
|(upper-cage floor displacement 41)-(lower-cage floor displacement 42)| / 2 > (threshold value)

upper-cage floor displacement 41	lower-cage floor displacement 42	threshold value	floor leveling operation
3mm	15mm	5mm	move main frame by -9 mm move upper cage by 6 mm move lower cage by -6 mm

Fig. 7

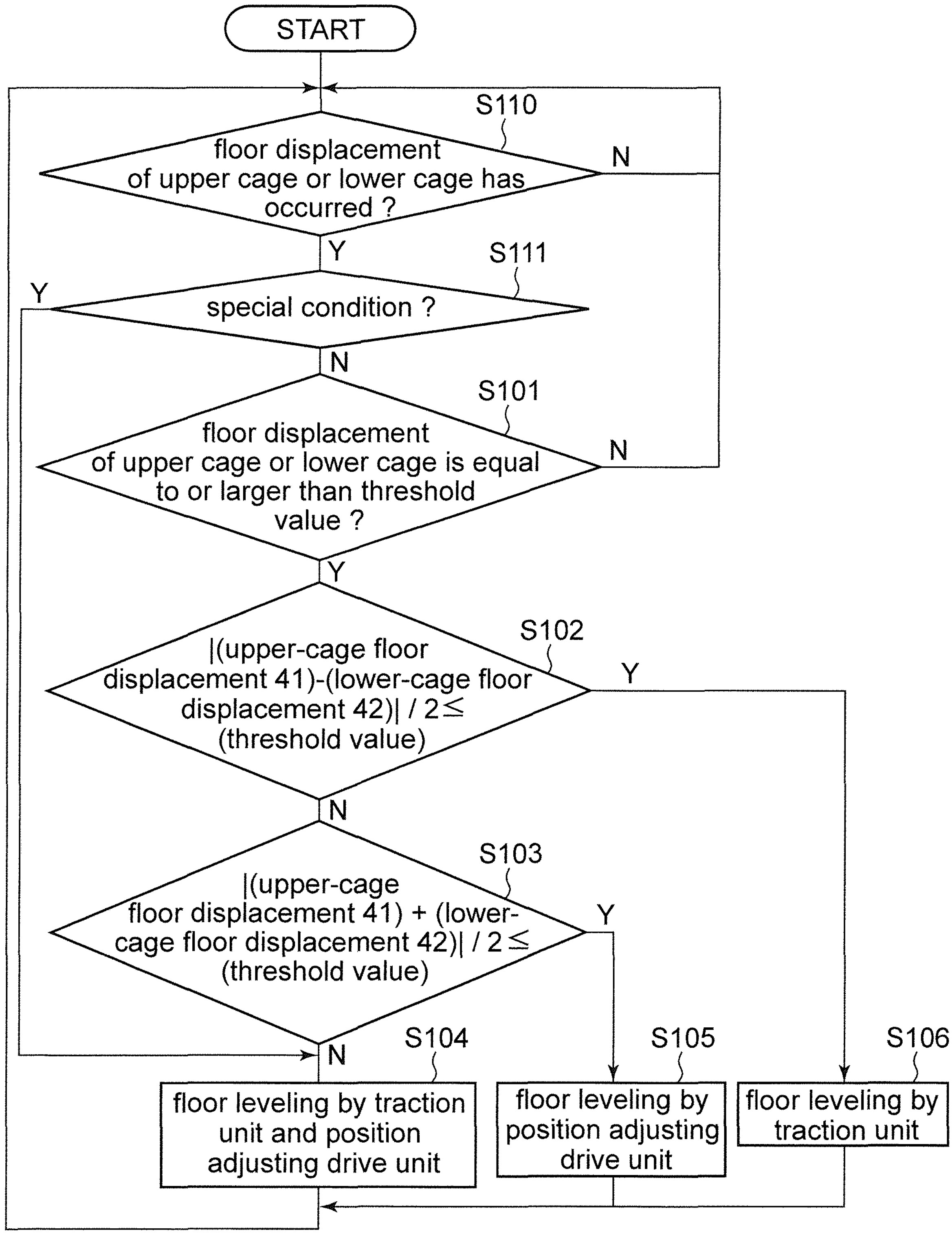

START
S110
floor displacement of upper cage or lower cage has occurred ?
N
Y
S111
special condition ?
Y
N
S101
floor displacement of upper cage or lower cage is equal to or larger than threshold value ?
N
Y
S102
|(upper-cage floor displacement 41)-(lower-cage floor displacement 42)| / 2≤ (threshold value)
Y
N
S103
|(upper-cage floor displacement 41) + (lower-cage floor displacement 42)| / 2≤ (threshold value)
Y
N
S104
floor leveling by traction unit and position adjusting drive unit
S105
floor leveling by position adjusting drive unit
S106
floor leveling by traction unit

Fig. 8

example: special condition

upper-cage floor displacement 41	lower-cage floor displacement 42	floor leveling operation
8mm	4mm	move main frame by -6 mm move upper cage by -2 mm move lower cage by 2 mm
3mm	7mm	move main frame by -5 mm move upper cage by -2 mm move lower cage by 2 mm

Fig. 9

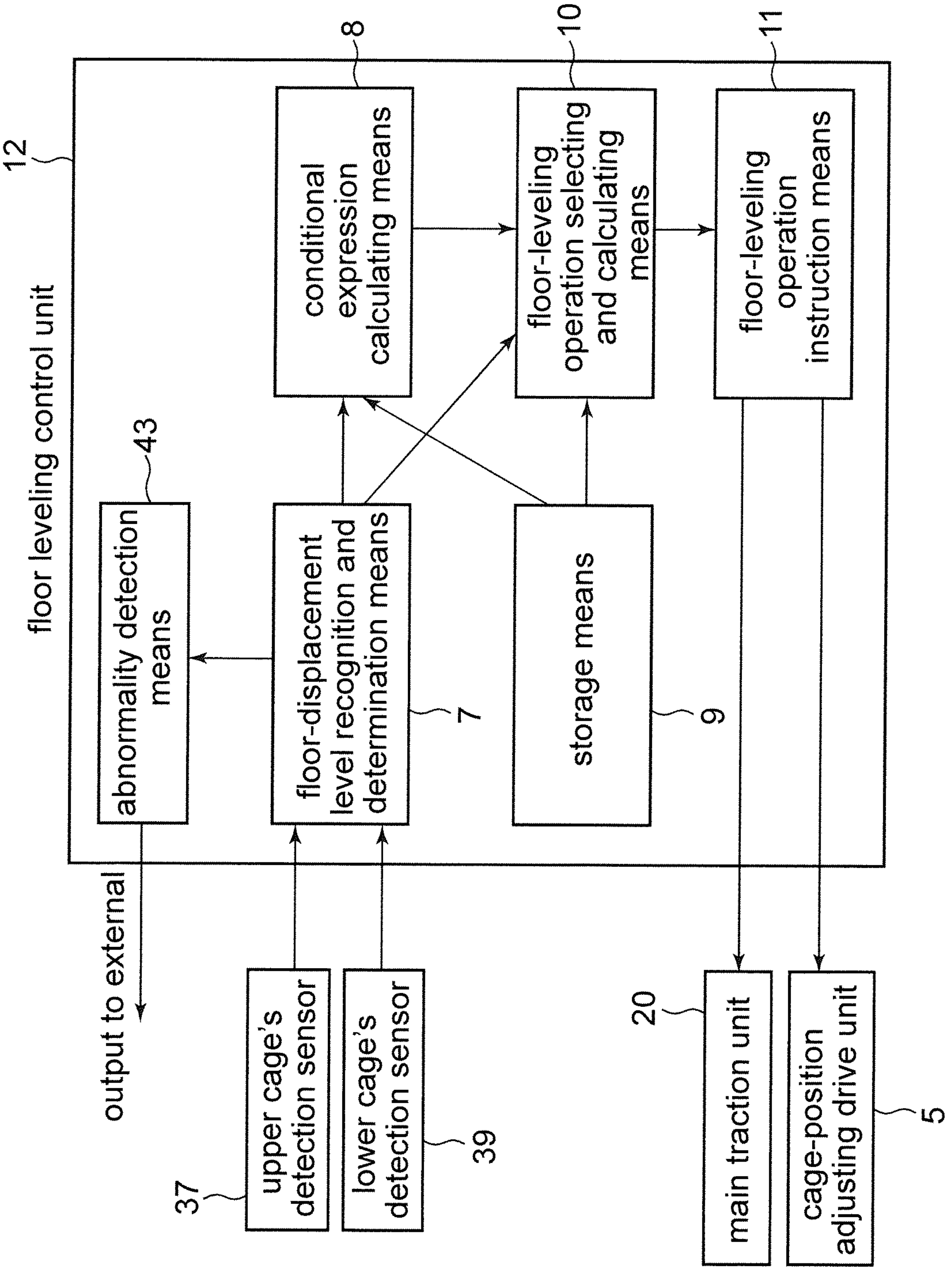
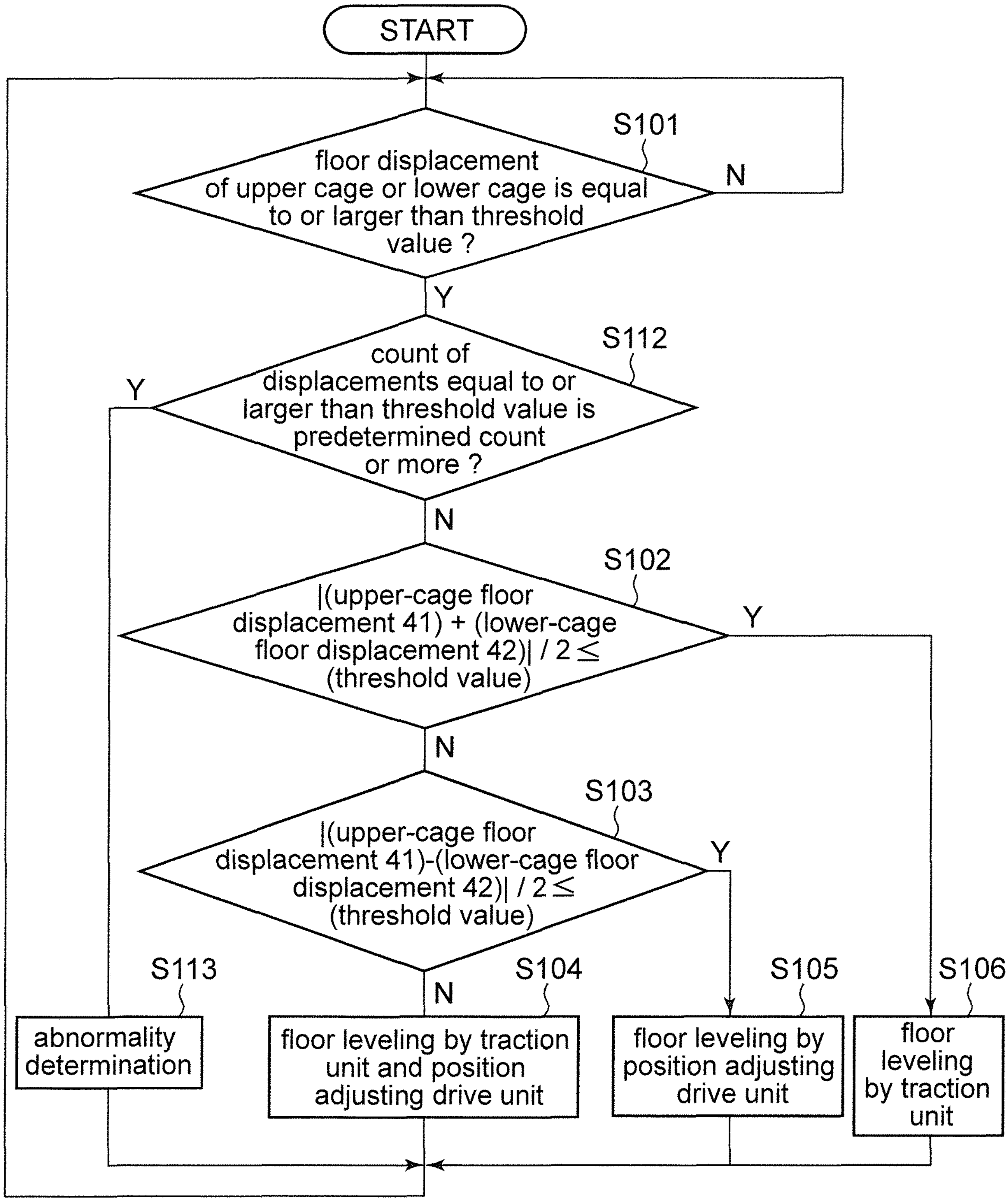

floor leveling control unit
12
abnormality detection means
43
floor-displacement level recognition and determination means
7
conditional expression calculating means
8
storage means
9
floor-leveling operation selecting and calculating means
10
floor-leveling operation instruction means
11
output to external
upper cage's detection sensor
37
lower cage's detection sensor
39
main traction unit
20
cage-position adjusting drive unit
5

Fig. 10


START
S101
floor displacement of upper cage or lower cage is equal to or larger than threshold value ?
N
Y
S112
count of displacements equal to or larger than threshold value is predetermined count or more ?
Y
N
S102
|(upper-cage floor displacement 41) + (lower-cage floor displacement 42)| / 2 ≤ (threshold value)
Y
N
S103
|(upper-cage floor displacement 41)-(lower-cage floor displacement 42)| / 2 ≤ (threshold value)
Y
N
S113
abnormality determination
S104
floor leveling by traction unit and position adjusting drive unit
S105
floor leveling by position adjusting drive unit
S106
floor leveling by traction unit

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/001808

A. CLASSIFICATION OF SUBJECT MATTER
B66B1/06(2006.01)i, *B66B1/42*(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)
B66B1/06, B66B1/42

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	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2005-145696 A (Mitsubishi Electric Corp.), 09 June 2005 (09.06.2005), claims 1 to 2 (Family: none)	1-6
A	JP 2004-67286 A (Toshiba Elevator and Building Systems Corp.), 04 March 2004 (04.03.2004), paragraphs [0059] to [0070] (Family: none)	1
A	JP 2002-87716 A (Toshiba Corp.), 27 March 2002 (27.03.2002), paragraphs [0011], [0032] (Family: none)	2

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 July, 2011 (04.07.11)	12 July, 2011 (12.07.11)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/001808

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 9-202553 A (Toshiba Corp.), 05 August 1997 (05.08.1997), paragraphs [0036] to [0042] (Family: none)	5
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 147125/1976(Laid-open No. 64470/1978) (Mitsubishi Electric Corp.), 31 May 1978 (31.05.1978), claims (Family: none)	6

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2002338154 A **[0005]**