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

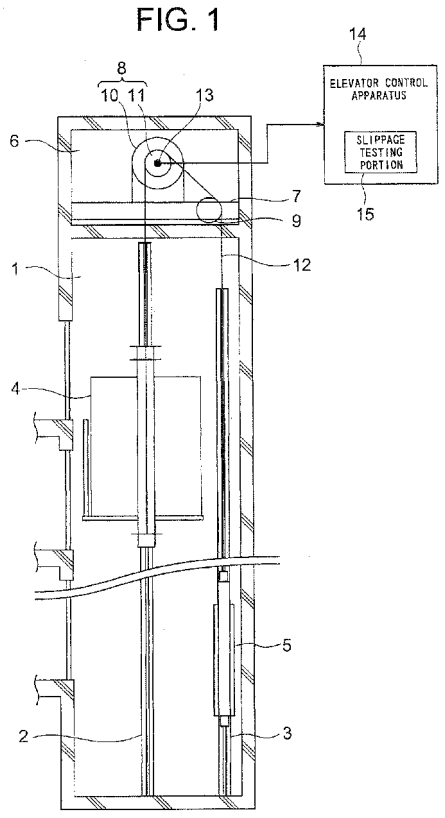
(72) Inventor: **MITSUI, Atsushi**
Tokyo 100-8310 (JP)

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

(54) ELEVATOR DEVICE

(57) In an elevator apparatus, a car is suspended by a main rope on a first side of a sheave, and a counterweight is suspended by the main rope on a second side of the sheave. A rotation detector generates a signal that corresponds to rotation of the sheave. A slippage testing portion operates the car through a round trip for a predetermined distance, and tests for slippage between the sheave and the main rope based on a difference between a signal from the rotation detector during ascent and a signal from the rotation detector during descent.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a traction elevator apparatus in which a car and a counterweight are suspended by a main rope.

BACKGROUND ART

[0002] In conventional traction elevator apparatuses, an undercut groove that has a width that is less than that of a sheave groove that is disposed on an outer circumferential surface of a sheave is disposed on a bottom portion of the sheave groove, thereby ensuring required frictional force against a main rope. When a car is moving, minute slippage between the main rope and the sheave, i.e., creep, arises due to differences in tension between the main rope on a car side and on a counterweight side, abrading the sheave groove. As abrasion of this kind progresses, more slippage arises between the main rope and the sheave, and abrasion of the sheave groove progresses further.

[0003] In answer to this, in conventional elevator apparatuses, a rotation detector that generates a signal that corresponds to movement of the main rope is disposed in addition to a rotation detector that generates a signal that corresponds to rotation of the sheave, and slippage of the main rope relative to the sheave is determined by comparing the signals from the two rotation detectors (see Patent Literature 1, for example).

[0004] [Patent Literature 1]
Japanese Patent Laid-Open No. SHO 62-205973 (Gazette)

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0005] In conventional slippage detecting methods such as that described above, since it is necessary to add a rotation detector that detects the movement of the main rope, application to existing elevator apparatuses may not be possible due to installation space problems.

[0006] The present invention aims to solve the above problems and an object of the present invention is to provide an elevator apparatus that can test for slippage of a main rope relative to a sheave using a simple configuration.

MEANS FOR SOLVING THE PROBLEM

[0007] In order to achieve the above object, according to one aspect of the present invention, there is provided an elevator apparatus including: a hoisting machine that has a sheave; a main rope that is wound around the sheave; a car that is suspended by the main rope on a first side of the sheave; a counterweight that is suspended by the main rope on a second side of the sheave; a rotation detector that generates a signal that corresponds to rotation of the sheave; and a slippage testing portion that operates the car through a round trip for a predetermined distance, and that tests for slippage between the sheave and the main rope based on a difference between a signal from the rotation detector during ascent and a signal from the rotation detector during descent.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Figure 1 is a structural diagram that shows an elevator apparatus according to Embodiment 1 of the present invention;
Figure 2 is a partial cross section of a sheave from Figure 1;
Figure 3 is a cross section that shows a state in which abrasion of a sheave groove from Figure 2 has progressed;
Figure 4 is an explanatory diagram that schematically shows changes in tension of main ropes that pass through the sheave when a car from Figure 1 is ascending; and
Figure 5 is an explanatory diagram that schematically shows changes in tension of the main ropes that pass through the sheave when the car from Figure 1 is descending.

BEST MODE FOR CARRYING OUT THE INVENTION

[0009] A preferred embodiment of the present invention will now be explained with reference to the drawings.

Embodiment 1

[0010] Figure 1 is a structural diagram that shows an elevator apparatus according to Embodiment 1 of the present invention. In the figure, a pair of car guide rails 2 and a pair of counterweight guide rails 3 are installed inside a hoistway 1. A car 4 is raised and lowered inside the hoistway 1 along the car guide rails 2. A counterweight 5 is raised and lowered inside the hoistway 1 along the counterweight guide rails 3.

[0011] A machine room 6 is disposed in an upper portion of the hoistway 1. A machine base 7 is installed inside the machine room 6. A hoisting machine 8 and a deflecting sheave 9 are supported by the machine base 7. The hoisting machine 8 has a hoisting machine main body 10 and a sheave 11. Included in the hoisting machine main body 10 are: a motor that rotates the sheave 11; and a brake that brakes rotation of the sheave 11.

[0012] A plurality of main ropes 12 (only one is shown in the figures) are wound around the sheave 11 and the deflecting sheave 9. First end portions of the main ropes 12 are connected to an upper portion of the car 4. Second end portions of the main ropes 12 are connected to an

upper portion of the counterweight 5. The car 4 and the counterweight 5 are suspended inside the hoistway 1 by the main ropes 12, and are raised and lowered by the hoisting machine 8.

[0013] A rotation detector that generates a signal that corresponds to the rotation of the sheave 11 (a speed detector) 13 is disposed on the hoisting machine 8. An encoder that generates pulse signals that corresponds to the rotation of the sheave 11, for example, can be used as the rotation detector 13.

[0014] The signal from the rotation detector 13 is input into an elevator control apparatus 14 that controls running of the car 4, i.e., driving of the hoisting machine 8. The elevator control apparatus 14 computes the speed and distance traveled by the car 4 based on the signal from the rotation detector 13. A slippage testing portion 15 that tests for the presence or absence of slippage of the main ropes 12 relative to the sheave 11 is disposed on the elevator control apparatus 14. The elevator control apparatus 14 has a computer that has a storage portion, an arithmetic processing portion, and a signal input/output portion. Functions of the slippage testing portion 15 can be implemented by the computer, for example.

[0015] Figure 2 is a partial cross section of the sheave 11 from Figure 1. A plurality of sheave grooves 11a into which the main ropes 12 are inserted are disposed on an outer circumferential surface of the sheave 11. Undercut grooves 11b that have smaller widths than the sheave grooves 11a are disposed on bottom portions of the sheave grooves 11a. The sheave grooves 11 a are abraded over time by contact with the main ropes 12. Figure 3 is a cross section that shows a state in which abrasion of the sheave groove 11a from Figure 2 has progressed.

[0016] Next, a slippage testing method used by the slippage testing portion 15 will be explained. Figures 4 and 5 are explanatory diagrams that schematically show changes in tension of the main ropes 12 that pass through the sheave 11, Figure 4 representing when the car 4 from Figure 1 is ascending, and Figure 5 representing when the car 4 from Figure 1 is descending.

[0017] Traction elevator apparatuses are designed so as to satisfy:

$T1/T2 > e^{\mu k\theta}$, when T1 > T2, and

T2/T1 when T1 < T2,

where T1 is tension on a side near the car 4, T2 is tension on a side near the counterweight 5, θ is a contact angle of the main ropes 12 on the sheave 11, μ is a coefficient of friction between the main ropes 12 and the sheave 11, and k is a shape coefficient of the sheave grooves 11a.

[0018] In the sheave 11 on which traction acts, tension changes exponentially from T2 to T1, or from T1 to T2, within the limit angle $\theta 1$ required to operate without generating slippage between the main ropes 12 and the sheave 11. Tension does not change in a zone of difference between the actual contact angle θ and $\theta 1$, in which traction acts to change tension, i.e., $\theta - \theta 1$. In addition, this region where tension does not change is known to be always present on the side that is being raised irrespective of the magnitude of the tension.

[0019] When the car 4 is raised, since the tension of the main ropes 12 changes from T1 to T2 within angle $\theta 1$, if the distance traveled by the sheave 11 is integrated on an exit side of the main ropes 12 (the side near the counterweight 5), it can be seen that the main ropes 12 drift toward the counterweight 5 (extend) due to tension differential extension δ of the main ropes 12, proportionately reducing the distance traveled by the sheave 11.

[0020] Conversely, when the car 4 is lowered by an identical distance, i.e., when the counterweight 5 is raised, if the distance traveled by the sheave 11 is integrated at identical positions, it can be seen that drift of the main ropes 12 relative to the sheave 11 does not arise since the tension of the main ropes 12 barely changes on the raised side (the side near the counterweight 5). Here, the tension differential extension δ of the main ropes 12 is given by $\delta = (T2 - T1) \times L/(E \times A)$, where L is the length the main ropes 12 move along the sheave 11, E is the elastic modulus of the main ropes 12, and A is the cross-sectional area of the main ropes 12.

[0021] If the distance traveled by the sheave 11 is integrated on an entry side of the main ropes 12 (a side near the car 4) when the car 4 is raised, positional drift does not occur between the sheave 11 and the main ropes 12 since tension of the main ropes 12 does not change on the entry side. In contrast to that, when the car 4 is lowered by an identical distance, since the tension of the main ropes 12 changes from T2 to T1 within angle $\theta 1$, the main ropes 12 drift toward the counterweight 5 due to tension differential contraction δ of the main ropes 12.

[0022] In other words, the main ropes 12 and the sheave 11 drift by an identical amount in each direction whichever side is considered, and the amount of drift between the sheave 11 and the main ropes 12 when one round trip is made is the tension differential extension δ of the main ropes 12. From the above, drift between the sheave 11 and the main ropes 12, i.e., creep, can be calculated by measuring cumulative rotational speed of the sheave 11 when the car 4 is driven up and down by a given distance and calculating differences in the measured values.

[0023] Only drift due to creep occurs as described above while abrasion of the sheave grooves 11a has not progressed, and sufficient traction capacity is being maintained, but as the abrasion of the sheave grooves 11a progresses and the traction capacity decreases, slippage between the sheave 11 and the main ropes 12 occurs, increasing drift between the sheave 11 and the main ropes 12.

[0024] When slippage occurs in this manner, if the exit side of the main ropes 12 is considered when the car 4

is raised with no load on board the car 4, for example, the distance traveled by the sheave 11 relative to the distance traveled by the main ropes 12 is even smaller. For this reason, when the car 4 is lowered, the car 4 cannot be moved to a predetermined position unless the distance traveled by the sheave 11 is increased by an amount proportionate to the slippage. In other words, a rotation pulse integrated value of the sheave 11 during descent is even greater than a rotation pulse integrated value of the sheave 11 during ascent.

[0025] Traction capacity rarely suddenly decreases significantly, usually decreasing gradually over a long period of use due to the sheave grooves 11a being abraded, or the main ropes 12 being abraded and deteriorating, etc. For this reason, it is not necessary for verification of traction capacity, i.e., verification of the presence or absence of slippage, to be performed constantly, and it need only be performed regularly, for example, making use of a time period during which the elevator apparatus is not used (at night, for example).

[0026] When verifying the traction capacity, first verify that passengers and freight are not on board the car 4 (an unloaded state), make the car 4 perform a round trip for a preset distance, and find integrated values for the encoder pulse values during ascent and descent. Then, compare the difference between the integrated value during ascent and the integrated value during descent with a preset slippage tolerance value, and execute processing in response to the compared result.

[0027] For example, if slippage that exceeds the slippage tolerance value is detected, a slippage detection signal is transmitted to a remote elevator monitoring switchboard to let it be known that inspection of the sheave 11 and the main ropes 12 is required. If slippage is even greater, and is determined to be at a level at which normal operation is impossible, operation of the elevator apparatus is stopped.

[0028] If the distance traveled by the car 4 when the slippage test is performed is large, the percentage that is occupied by creep due to the difference in tension will be large even if slippage occurs. For this reason, it is preferable to make the distance traveled by the car 4 when the slippage test is performed a minimum distance for accelerating to a predetermined speed, then decelerating and stopping. In other words, when performing a slippage test, it is preferable for the slippage testing portion 15 to run the car 4 through a speed pattern in which constant speed traveling time is significantly shorter than accelerating and decelerating time. It is even more preferable to minimize, i.e., completely eliminate, the constant speed traveling time, enabling slippage detecting precision to be improved even further.

[0029] In an elevator apparatus of this kind, because a car 4 is operated through a round trip for a predetermined distance, and slippage between a sheave 11 and main ropes 12 is tested by a slippage testing portion 15 based on a difference in a signal from a rotation detector 13 during ascent and a signal from the rotation detector 13 during descent, apparatus or software is required for pulse integration, but slippage can be tested using a simple configuration without having to dispose another rotation detector that would require separate space.

[0030] Because the slippage testing portion 15 performs the slippage test after the car 4 is confirmed to be in an unloaded state, slippage can be detected precisely under stable conditions.

In addition, because the slippage testing portion 15 runs the car 4 through a speed pattern in which constant speed traveling time is shorter than accelerating and decelerating time when performing the slippage test, slippage detecting precision can be improved.

[0031] Moreover, in the above example, the slippage testing portion 15 is disposed on the elevator control apparatus 14, but the slippage testing portion 15 may also be disposed on another apparatus such as safety monitoring apparatus, etc., or may also be an independent apparatus, for example.

The main ropes 12 may be ropes that have circular cross sections, or may also be belts.

Moreover, in the above example, an elevator apparatus using a one-to-one (1:1) roping method is shown, but is not limited thereto, and for example, the present invention can also be applied to an elevator apparatus using a two-to-one (2:1) roping method.

Claims

1. An elevator apparatus comprising:

a hoisting machine that has a sheave;
a main rope that is wound around the sheave;
a car that is suspended by the main rope on a first side of the sheave;
a counterweight that is suspended by the main rope on a second side of the sheave;
a rotation detector that generates a signal that corresponds to rotation of the sheave; and
a slippage testing portion that operates the car through a round trip for a predetermined distance, and that tests for slippage between the sheave and the main rope based on a difference between a signal from the rotation detector during ascent and a signal from the rotation detector during descent.

2. An elevator apparatus according to Claim 1, wherein the slippage testing portion performs a slippage test after confirming that the car is in an unloaded state.

3. An elevator apparatus according to Claim 1, wherein the slippage testing portion runs the car through a speed pattern in which constant speed traveling time is shorter than accelerating and decelerating time when performing a slippage test.

FIG. 1

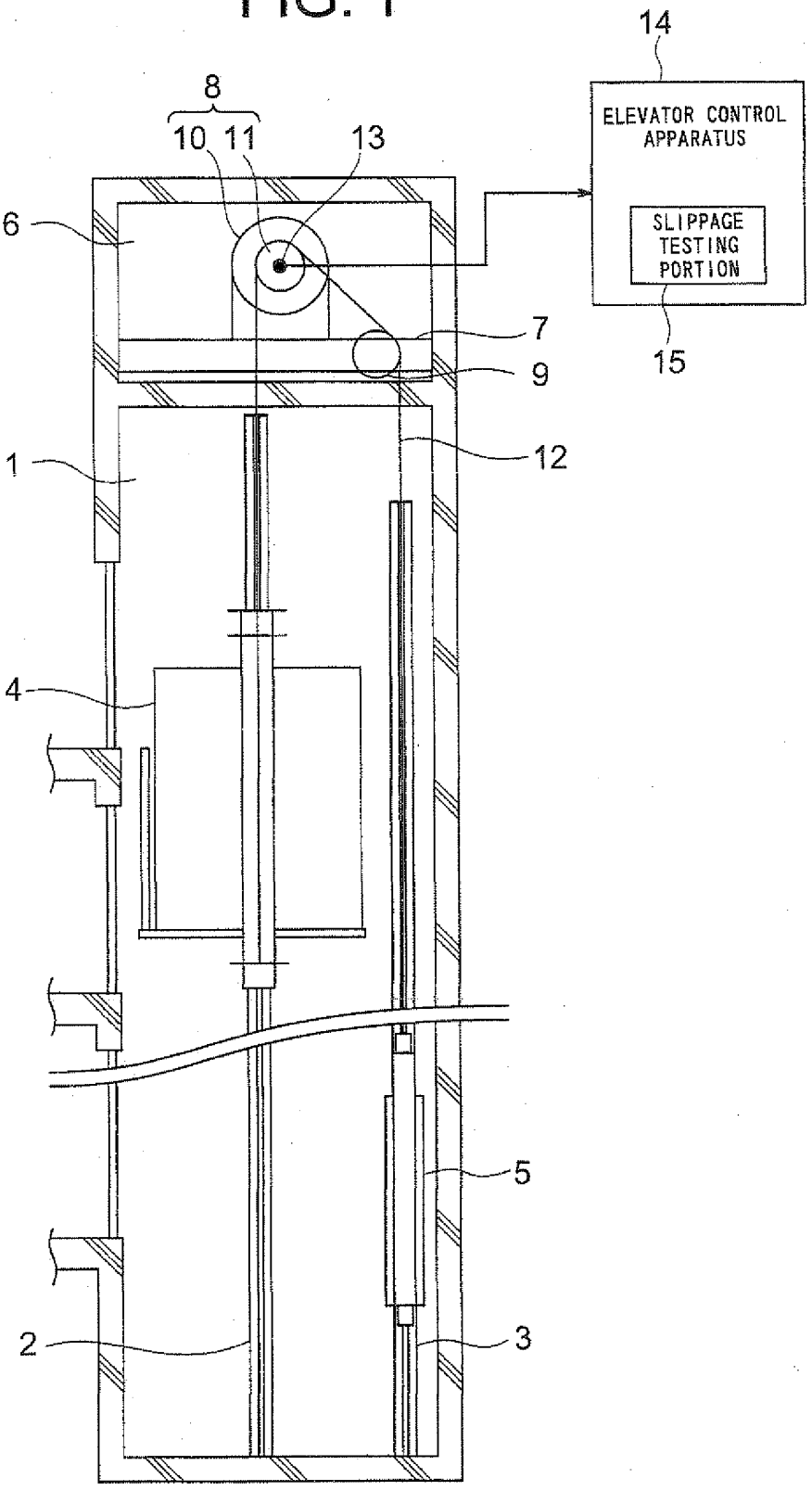

14
ELEVATOR CONTROL APPARATUS
SLIPPAGE TESTING PORTION
15
8
10
11
13
6
7
9
12
1
4
5
2
3

FIG. 2

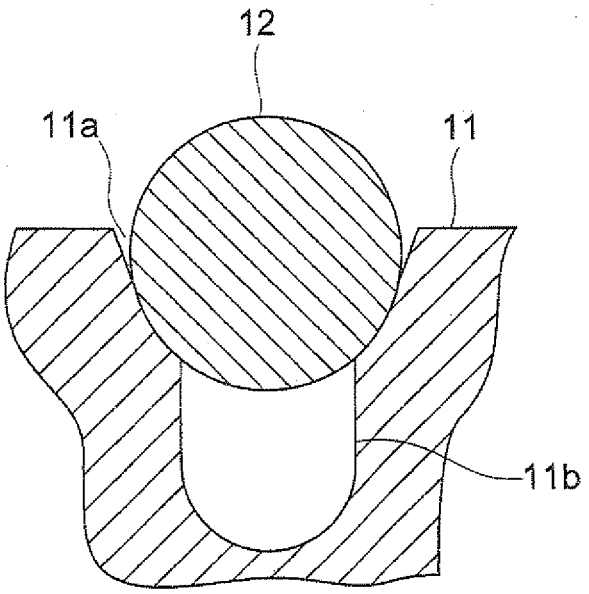


FIG. 3

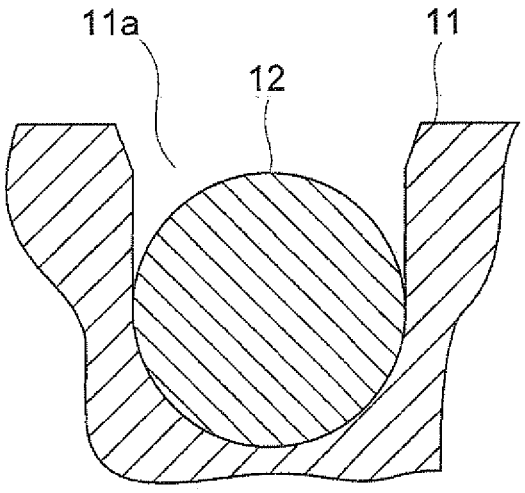


FIG. 4

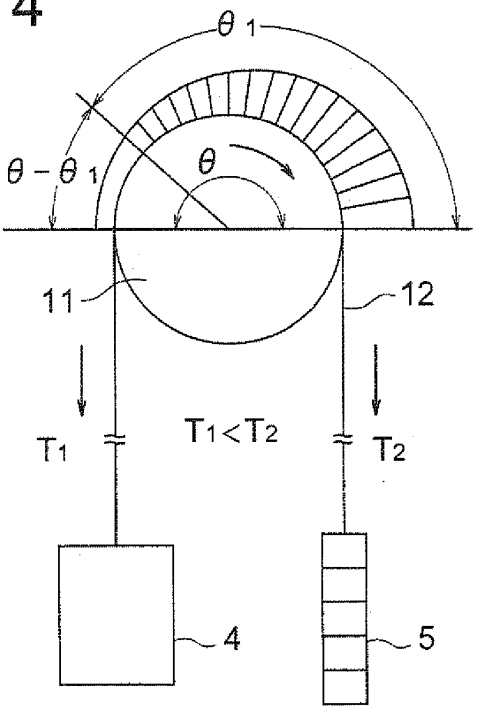
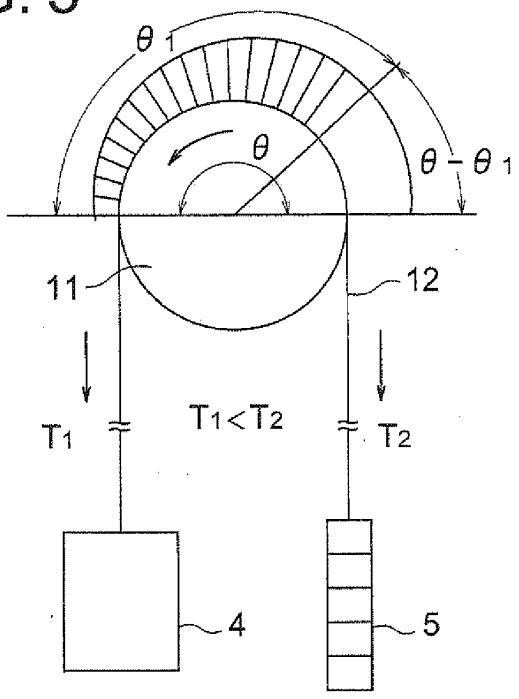


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/052101

A. CLASSIFICATION OF SUBJECT MATTER
B66B7/12(2006.01)i, *B66B5/02*(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)
B66B7/12, B66B5/02

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 1996-2008
Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

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 2007-153547 A (Hitachi Building Systems Co., Ltd.), 21 June, 2007 (21.06.07), (Family: none)	1-3

☐ 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	Date of mailing of the international search report
28 October, 2008 (28.10.08)	04 November, 2008 (04.11.08)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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REFERENCES CITED IN THE DESCRIPTION

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