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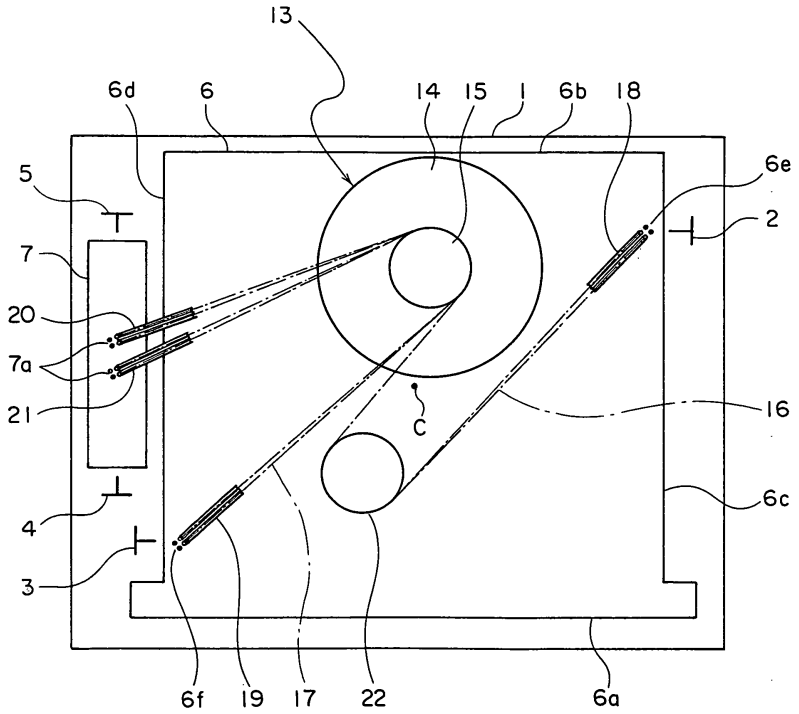
(54) **ELEVATOR DEVICE**

(57) In an elevator apparatus, a driving machine is disposed in an upper portion inside a hoistway such that a rotating shaft of a drive sheave is vertical. A car suspension portion that is connected to a main rope is disposed on an upper portion of the car. A car return sheave for directing the main rope to the car suspension portion is disposed in an upper portion of the hoistway. The drive sheave and the car return sheave are disposed inside a region of the car when viewed from above.

FIG. 1

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to an elevator apparatus in which a driving machine is disposed in an upper portion inside a hoistway.

### BACKGROUND ART

**[0002]** In conventional elevator apparatuses, first and second rope connecting portions are disposed on lower portions of two sides of a car. A driving machine that raises and lowers the car is disposed in an upper portion inside the hoistway. A main rope group that is wound around a drive sheave of the driving machine includes: a first main rope that is connected to the first rope connecting portion; and a second rope that is connected to the second rope connecting portion (see Patent Document 1, for example).

**[0003]** Patent Document 1: WO 03/074409

### DISCLOSURE OF THE INVENTION

### PROBLEM TO BE SOLVED BY THE INVENTION

**[0004]** In conventional elevator apparatuses such as that described above, because the first and second rope connecting portions are disposed on lower portions of the side surfaces of the car, it has been difficult to ensure space for performing replacement work on the main ropes, etc., inside narrow hoistways. Since the first and second rope connecting portions are disposed on a lower frame of the car, compressive load also acts on the car frame, requiring reinforcing materials such as diagonal members, etc., between the lower frame and a vertical frame of the car frame.

**[0005]** The present invention aims to solve the above problems and an object of the present invention is to provide an elevator apparatus that can ensure space for replacement work on main ropes simply, and that also enables construction of a car frame to be simplified.

### MEANS FOR SOLVING THE PROBLEM

**[0006]** In order to achieve the above object, according to one aspect of the present invention, there is provided an elevator apparatus including: a driving machine that has a drive sheave, and that is disposed in an upper portion of a hoistway such that a rotating shaft of the drive sheave is vertical; a car that has a car suspension portion, and that is raised and lowered by a driving force from the driving machine; a counterweight that has a counterweight suspension portion, and that is raised and lowered by a driving force from the driving machine; a main rope that has a car end portion connected to the car suspension portion, and a counterweight end portion connected to the counterweight suspension portion, and that is wound around the drive sheave; a car return sheave that is disposed in an upper portion of the hoistway, and that directs the main rope toward the car suspension portion; and a counterweight return sheave that is disposed in an upper portion of the hoistway, and that directs the main rope toward the counterweight suspension portion, wherein the car suspension portion is disposed on an upper portion of the car, and the drive sheave and the car return sheave are disposed inside a region of the car when viewed from above.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0007]**

Figure 1 is a plan that shows an elevator apparatus according to Embodiment 1 of the present invention;
Figure 2 is a front elevation that shows a state in which a car from Figure 1 has stopped at an uppermost floor;
Figure 3 is an explanatory diagram that shows positional relationships between a driving machine and return sheaves from Figure 2;
Figure 4 is a front elevation that shows an elevator apparatus according to Embodiment 2 of the present invention;
Figure 5 is an explanatory diagram that shows a positional relationship between a driving machine and a second car return sheave from Figure 4;
Figure 6 is an explanatory diagram that shows positional relationships among the driving machine, a first car return sheave, and an inverting sheave from Figure 4;
Figure 7 is a plan that shows an elevator apparatus according to Embodiment 3 of the present invention;
Figure 8 is a plan that shows an elevator apparatus according to Embodiment 4 of the present invention; and
Figure 9 is a plan that shows an elevator apparatus according to Embodiment 5 of the present invention.

### BEST MODE FOR CARRYING OUT THE INVENTION

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

#### Embodiment 1

**[0009]** Figure 1 is a plan that shows an elevator apparatus (a machine-rcomless elevator) according to Embodiment 1 of the present invention, and Figure 2 is a front elevation that shows a state in which a car from Figure 1 has stopped at an uppermost floor. In the figures, first and second car guide rails 2 and 3 and first and second counterweight guide rails 4 and 5 are installed inside a hoistway 1. A car 6 is guided by the car guide rails 2 and 3 so as to be raised and lowered inside the hoistway 1. A counterweight 7 is guided by the counter-

weight guide rails 4 and 5 so as to be raised and lowered inside the hoistway 1.

**[0010]** The car 6 has: a front surface 6a in which a car entrance is disposed; a back surface 6b that is opposite the front surface 6a; and first and second side surfaces 6c and 6d that are opposite each other. The counterweight 7 is disposed beside the car 6 so as to face the second side surface 6d when positioned at equal height with the car 6.

**[0011]** The first car guide rail 2 is opposite the first side surface 6c. The second car guide rail 3 is opposite the second side surface 6d. The first and second car guide rails 2 and 3 are offset from each other in a depth direction of the car 6. Specifically, the first car guide rail 2 is disposed further rearward than center in the depth direction of the car 6, and the second car guide rail 3 is disposed further forward than center in the depth direction of the car 6. The first and second car guide rails 2 and 3 are disposed symmetrically relative to a center of gravity C of the car 6 when viewed from above.

**[0012]** In addition, the first and second car guide rails 2 and 3 are disposed such that center lines in horizontal cross sections thereof are parallel to a width direction of the car 6. The first and second counterweight guide rails 4 and 5 are disposed such that center lines in horizontal cross sections thereof are parallel to the depth direction of the car 6.

**[0013]** A supporting frame (not shown) is supported by upper portions of the car guide rails 2 and 3 and the counterweight guide rails 4 and 5. A driving machine 13 that raises and lowers the car 6 and the counterweight 7 is supported by the supporting frame. The driving machine 13 has: a driving machine main body 14 that includes a motor and a brake; and a drive sheave 15 that is rotated by the driving machine main body 14. A thin hoisting machine in which an axial dimension is less than a dimension that is perpendicular to an axial direction is used for the driving machine 13.

**[0014]** The driving machine 13 is disposed in an upper portion inside the hoistway 1 such that a rotating shaft of the drive sheave 15 is vertical (including approximately vertical). In addition, the driving machine 13 is disposed such that the drive sheave 15 is positioned above the driving machine main body 14. The drive sheave 15 is disposed inside a region of the car 6 when viewed from above. In this example, the whole driving machine 13 is disposed inside the region of the car 6 when viewed from above.

**[0015]** A plurality of main ropes are wound around the drive sheave 15. The main ropes include a plurality of first main ropes 16 and a plurality of second main ropes 17. The car 6 and the counterweight 7 are suspended inside the hoistway 1 by the first and second main ropes 16 and 17 using a one-to-one (1:1) roping method.

**[0016]** A first car suspension portion 6e that is connected to the first main ropes 16 and a second car suspension portion 6f that is connected to the second main ropes 17 are disposed on the upper portion of the car 6. The first and second car suspension portions 6e and 6f are disposed so as to be spaced apart from each other in the width direction and the depth direction of the car 6.

**[0017]** A counterweight suspension portion 7a that is connected to the first and second main ropes 16 and 17 is disposed on an upper portion of the counterweight 7. The counterweight suspension portion 7a is disposed on a central portion in a width direction of the counterweight 7.

**[0018]** The first main ropes 16 have: first car end portions that are connected to the first car suspension portion 6e; and first counterweight end portions that are connected to the counterweight suspension portion 7a. The second main ropes 17 have: second car end portions that are connected to the second car suspension portion 6f; and second counterweight end portions that are connected to the counterweight suspension portion 7a.

**[0019]** A first car return sheave 18 that directs the first main ropes 16 toward the first car suspension portion 6e; a second car return sheave 19 that directs the second main ropes 17 toward the second car suspension portion 6f; first and second counterweight return sheaves 20 and 21 that direct the first and second main ropes 16 and 17 toward the counterweight suspension portion 7a; and an inverting sheave 22 that directs the first main ropes 16 from the drive sheave 15 toward the first car return sheave 18 are disposed in an upper portion inside the hoistway 1.

**[0020]** The first and second car return sheaves 18 and 19 are supported by the supporting frame such that rotating shafts thereof are horizontal. The first and second counterweight return sheaves 20 and 21 are supported by the supporting frame such that rotating shafts thereof are horizontal. The inverting sheave 22 is supported by the supporting frame such that a rotating shaft thereof is vertical or approximately vertical. The first and second car return sheaves 18 and 19 and the inverting sheave 22 are disposed inside the region of the car 6 when viewed from above.

**[0021]** The first and second car suspension portions 6e and 6f are disposed at positions that are equidistant from the center of gravity of the car 6 when viewed from above. The first and second car suspension portions 6e and 6f and the center of gravity of the car 6 are disposed in a straight line when viewed from above. In other words, the first and second car suspension portions 6e and 6f are disposed symmetrically relative to the center of gravity of the car 6 when viewed from above.

**[0022]** In an elevator apparatus of this kind, since the first and second car suspension portions 6e and 6f are disposed on an upper portion of the car 6, space for replacement work on the main ropes 16 and 17 can be ensured easily and construction of the car frame can be simplified.

**[0023]** Since the drive sheave 15, the first and second car return sheaves 18 and 19, and the inverting sheave 22 are disposed inside the region of the car 6 when viewed from above, horizontal area of the hoistway 1 can

be reduced.

**[0024]** In addition, because the car 6 is suspended using one-to-one (1:1) roping, the configuration can be simplified and the rotational speed of the driving machine 13 can also be kept low. Thus, a quiet elevator apparatus can be provided that has low vibration and low noise even if the driving machine 13 is disposed inside the hoistway 1.

The car 4 can also be suspended at its center of gravity stably, preventing reaction forces that result from unbalanced loads from acting on the car guide rails 2 and 3, and enabling riding comfort to be improved.

**[0025]** Now, Figure 3 is an explanatory diagram that shows positional relationships between the driving machine 13 and the return sheaves 18 through 21 from Figure 2. In a configuration according to Embodiment 1, in order to minimize an overhead dimension H0 which is a dimension from an uppermost floor surface to a top portion of the hoistway 1 (see Figure 2), it is naturally important to reduce a thickness dimension of the driving machine 13 and diameters of the return sheaves 18 through 21, but positional relationships between the driving machine 13 and the return sheaves 18 through 21 are also important.

**[0026]** Specifically, the overhead dimension H0 can be minimized by disposing the drive sheave 15 above the driving machine main body 14 and arranging an upper end surface of the drive sheave 15 and upper ends of the return sheaves 18 through 21 so as to be at equal height, as shown in Figure 3.

Embodiment 2

**[0027]** Next, Figure 4 is a front elevation that shows an elevator apparatus according to Embodiment 2 of the present invention, Figure 5 is an explanatory diagram that shows a positional relationship between a driving machine 13 and a second car return sheave 19 from Figure 4, and Figure 6 is an explanatory diagram that shows positional relationships among the driving machine 13, a first car return sheave 18, and an inverting sheave 22 from Figure 4.

**[0028]** In this example, the driving machine 13 and the second car return sheave 19 are disposed such that an apex T0 of a pitch diameter of the second car return sheave 19 (the diameter of main ropes 17 when wound onto the return sheave 19) and a center C1 of all grooves of a drive sheave 15 into which the second main ropes 17 are wound are positioned at equal height.

**[0029]** Thus, the fleet angles of the second main ropes 17 relative to the drive sheave 15 (the approach angles of the main ropes 17 relative to a surface of the drive sheave 15 that includes the grooves) can be minimized. The fleet angles can also be made equal to each other if two second main ropes 17 are used.

**[0030]** The first car return sheave 18 is also disposed so as to be at equal height with the second car return sheave 19. The rotating shaft of the inverting sheave 22 is inclined relative to a vertical line so as to minimize the fleet angles of the first main ropes 16 that enter the drive sheave 15 from the inverting sheave 22.

**[0031]** By minimizing the fleet angles in this manner, abrasion of the main ropes 16 and 17 and the drive sheave 15 are suppressed, enabling extension of service life.

Embodiment 3

**[0032]** Next, Figure 7 is a plan that shows an elevator apparatus according to Embodiment 3 of the present invention. In this example, a counterweight 7 is disposed behind a car 6 so as to face a back surface 6b when positioned at equal height with the car 6.

Similar effects to those in Embodiment 1 can also be achieved in a layout in which the counterweight 7 is disposed behind the car 6 in this manner.

Embodiment 4

**[0033]** Next, Figure 8 is a plan that shows an elevator apparatus according to Embodiment 4 of the present invention. In the figure, a plurality of main ropes 31 are wound around a drive sheave 15. A car suspension portion 6g that is connected to the main ropes 31 is disposed on an upper portion of a car 6. The car suspension portion 6g overlaps approximately with a center of gravity of the car 6 when viewed from above.

**[0034]** A car return sheave 32 that directs the main ropes 31 toward the car suspension portion 6g and a counterweight return sheave 33 that directs the main ropes 31 toward a counterweight suspension portion 7a are disposed in an upper portion of a hoistway 1. A counterweight 7 is disposed beside the car 6. A driving machine 13 is disposed above a corner portion of the car 6 that is formed by a back surface 6b and a first side surface 6c.

**[0035]** In a layout in which the main ropes 31 are not distributed between two pathways in this manner, space for replacement work on the main ropes 16 and 17 can also be ensured easily and construction of a car frame can also be simplified since the car suspension portion 6g is disposed on the upper portion of the car 6.

Horizontal area of the hoistway 1 can also be reduced since the drive sheave 15 and the car return sheave 32 are disposed inside a region of the car 6 when viewed from above.

**[0036]** In addition, because the car 6 is suspended using one-to-one (1: 1) roping, the configuration can be simplified and the rotational speed of the driving machine 13 can also be kept low. Thus, a quiet elevator apparatus can be provided that has low vibration and low noise even if the driving machine 13 is disposed inside the hoistway 1.

Embodiment 5

**[0037]** Next, Figure 9 is a plan that shows an elevator apparatus according to Embodiment 5 of the present invention. In this example, a counterweight 7 is disposed behind a car 6 so as to face a back surface 6b when positioned at equal height with the car 6. A driving machine 13 is disposed above a corner portion of the car 6 that is formed by a front surface 6a and a first side surface 6c.

Similar effects to those in Embodiment 4 can also be achieved in a layout in which the counterweight 7 is disposed behind the car 6 in this manner.

**[0038]** Moreover, there may also be three or more car suspension portions. In other words, a third car suspension portion, fourth car suspension portion, etc., may also be disposed.

The main ropes may be normal ropes that have a circular cross section, or may also be belt-shaped ropes.

In addition, the counterweight may also be disposed so as to be divided into a plurality of parts.

A shared car may also be raised and lowered by a plurality of driving machines. In that case, similar effects to those in the above embodiments above can also be achieved by disposing all drive sheaves and car return sheaves inside the region of a car when viewed from above and disposing a car suspension portion on an upper portion of the car.

## Claims

**1.** An elevator apparatus comprising:

a driving machine that has a drive sheave, and that is disposed in an upper portion of a hoistway such that a rotating shaft of the drive sheave is vertical;
a car that has a car suspension portion, and that is raised and lowered by a driving force from the driving machine;
a counterweight that has a counterweight suspension portion, and that is raised and lowered by a driving force from the driving machine;
a main rope that has a car end portion connected to the car suspension portion, and a counterweight end portion connected to the counterweight suspension portion, and that is wound around the drive sheave;
a car return sheave that is disposed in an upper portion of the hoistway, and that directs the main rope toward the car suspension portion; and
a counterweight return sheave that is disposed in an upper portion of the hoistway, and that directs the main rope toward the counterweight suspension portion, wherein
the car suspension portion is disposed on an upper portion of the car, and
the drive sheave and the car return sheave are disposed inside a region of the car when viewed from above.

**2.** The elevator apparatus according to Claim 1, wherein
the car suspension portion includes first and second car suspension portions that are disposed on opposite sides of a center of gravity of the car from each other when viewed from above,
the main rope includes: a first main rope that is connected to the first car suspension portion; and a second main rope that is connected to the second car suspension portion,
the car return sheave includes: a first car return sheave that directs the first main rope toward the first car suspension portion; and a second car return sheave that directs the second main rope toward the second car suspension portion, and
an inverting sheave that directs the first main rope from the drive sheave toward the first car return sheave is disposed in an upper portion of the hoistway.

**3.** The elevator apparatus according to Claim 2, wherein the driving machine and the second car return sheave are disposed such that an apex of a pitch diameter of the second car return sheave and a center of all grooves of the drive sheave into which the second main rope is wound are positioned at equal height.

**4.** The elevator apparatus according to Claim 2, wherein a rotating shaft of the inverting sheave is inclined relative to a vertical line so as to minimize a fleet angle of the first main rope that enters the drive sheave from the inverting sheave.

**5.** The elevator apparatus according to Claim 1, wherein an upper end surface of the drive sheave and an upper end of the car return sheave and the counterweight return sheave are disposed at equal height.

FIG. 1

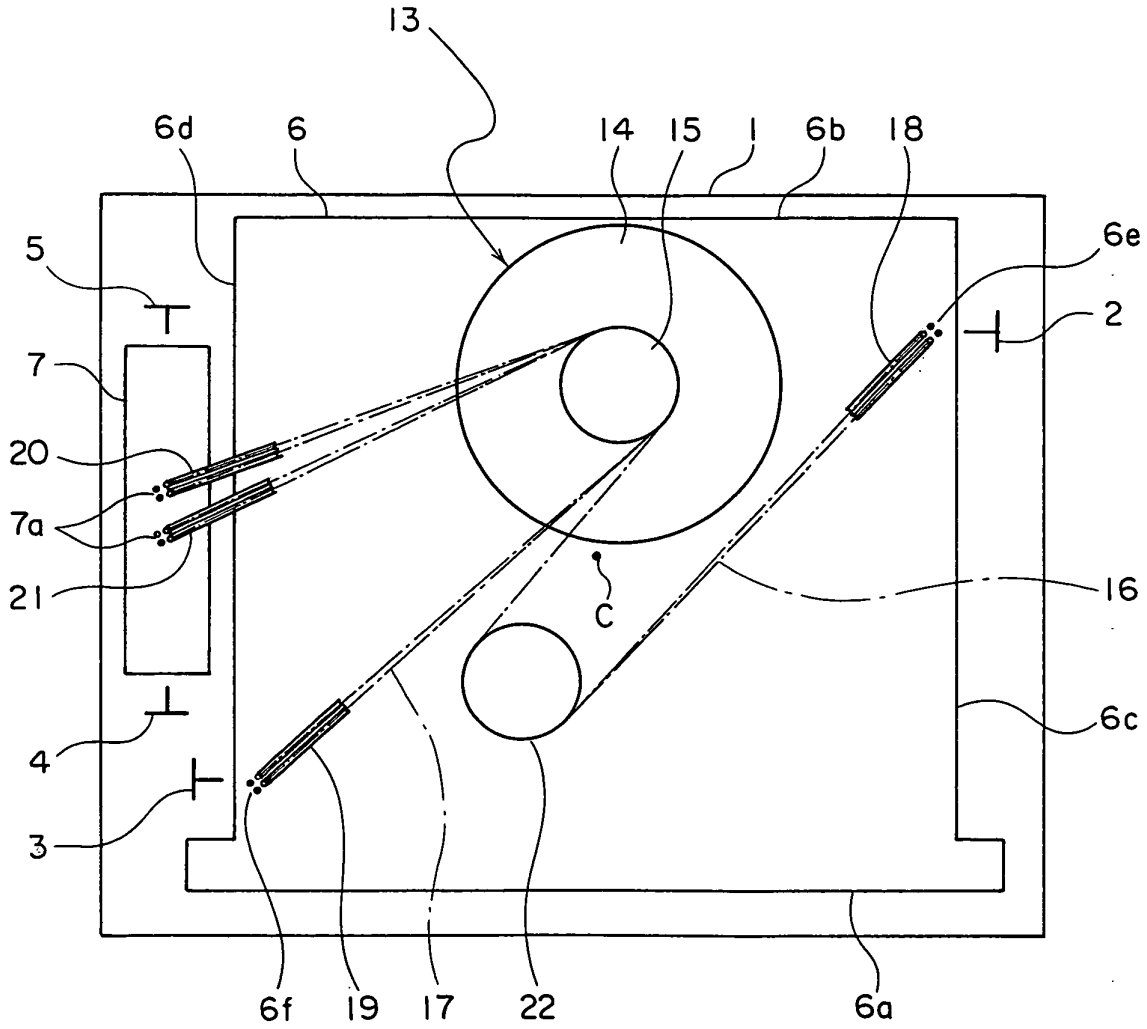


FIG. 2

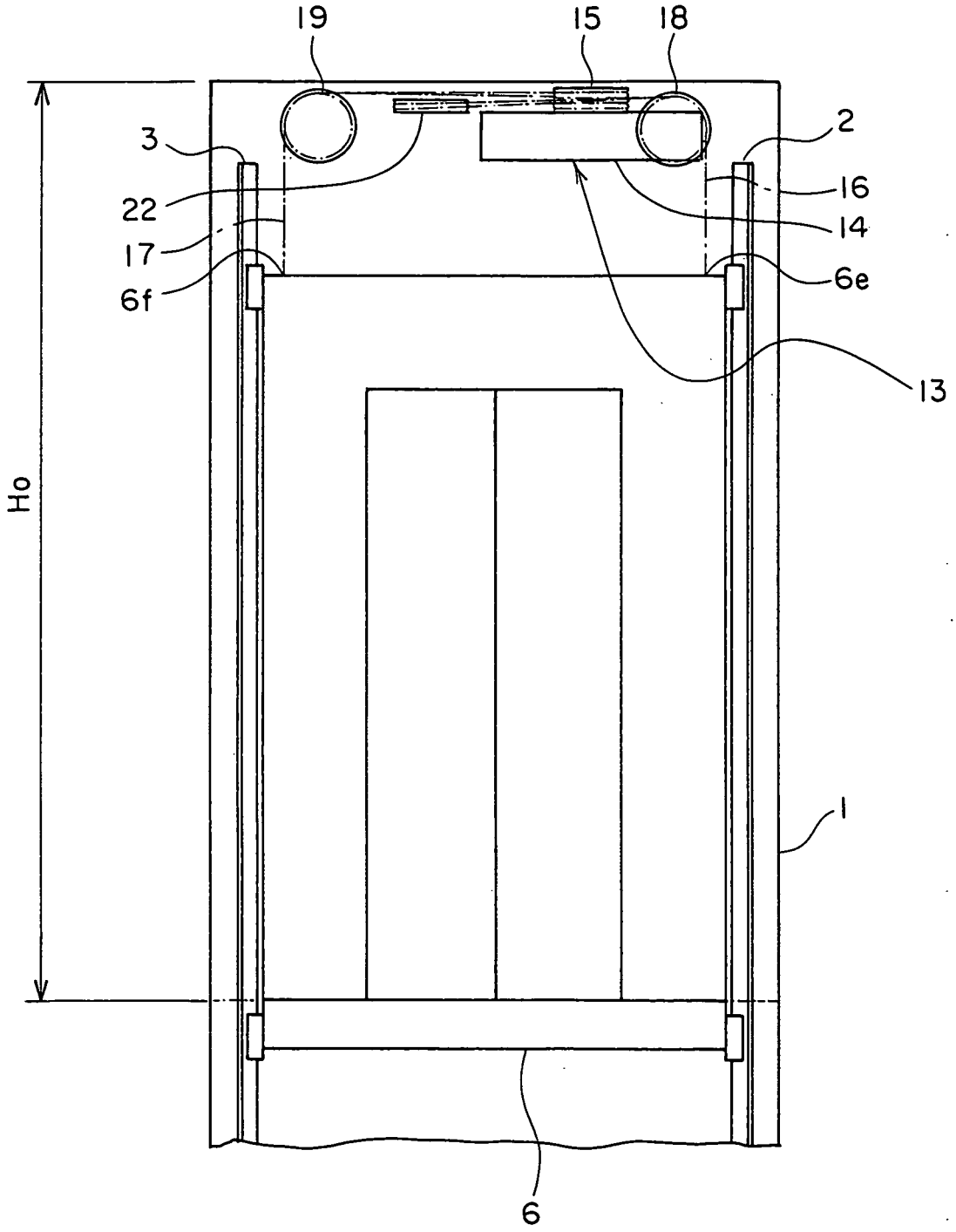


FIG. 3

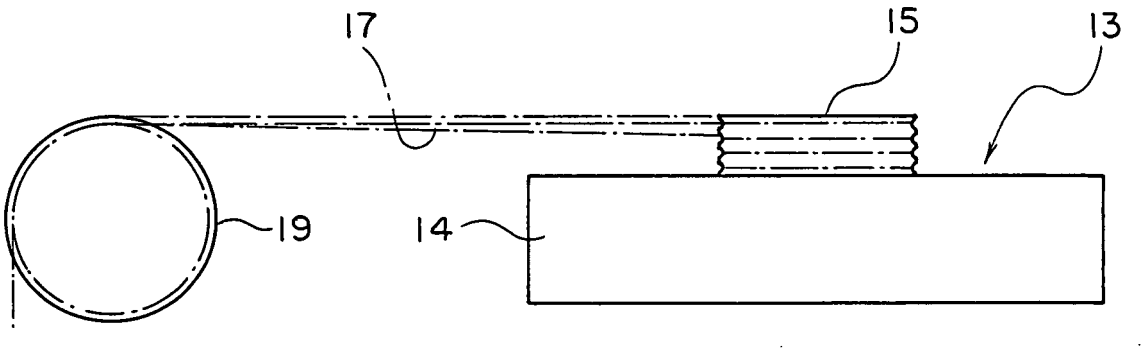


FIG. 4

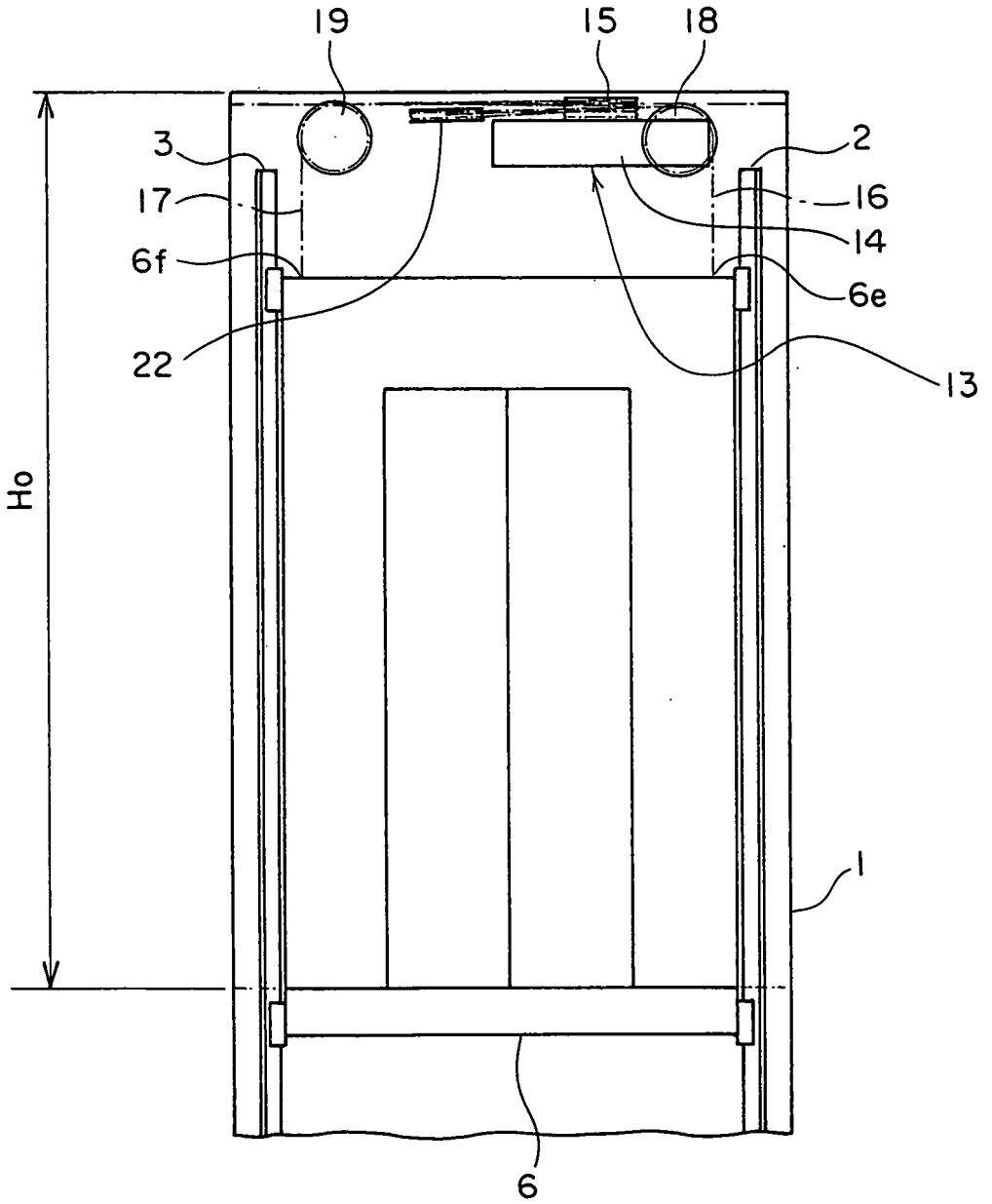


FIG. 5

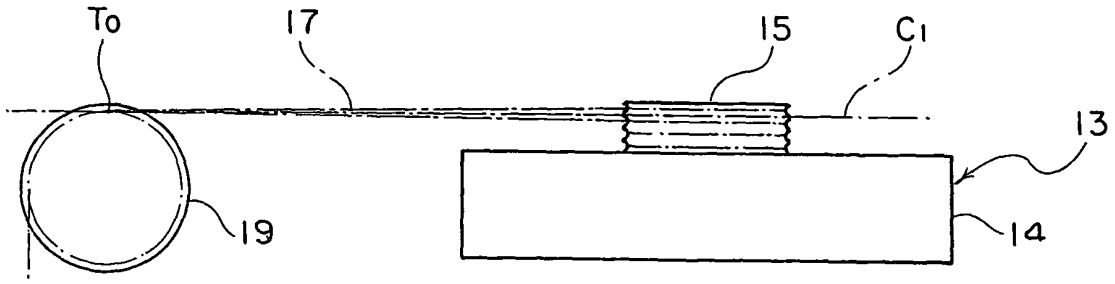

To
17
15
C1
13
19
14

FIG. 6

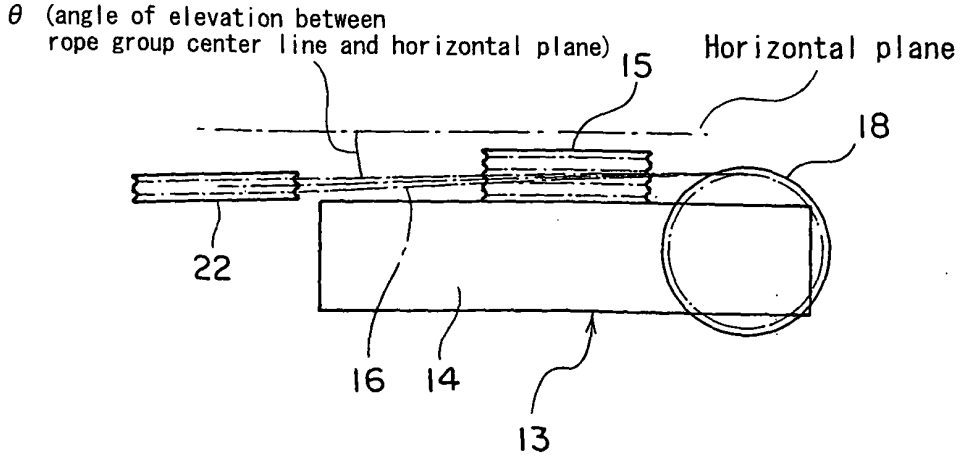

θ (angle of elevation between rope group center line and horizontal plane)
Horizontal plane
15
18
22
16
14
13

FIG. 7

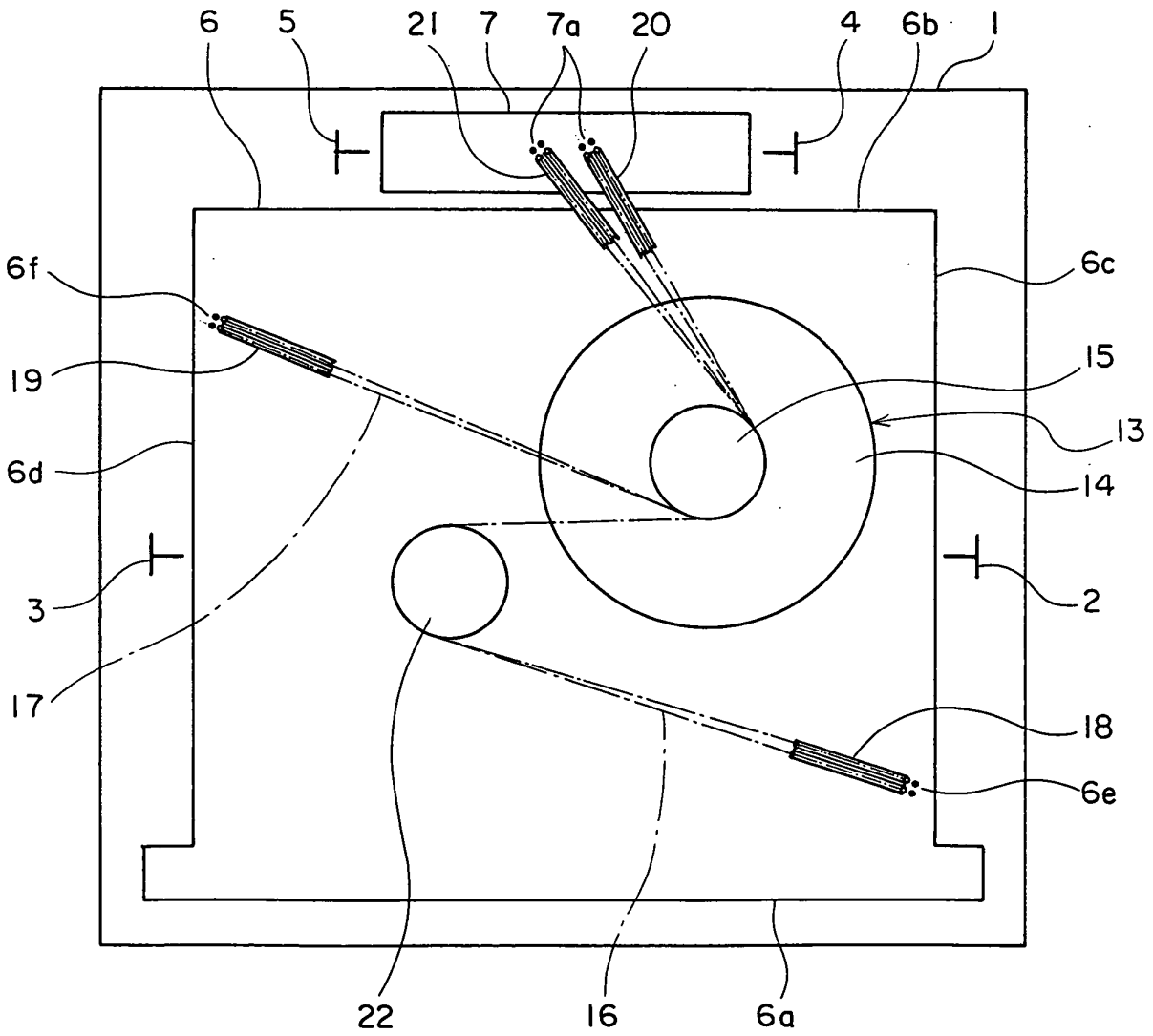


FIG. 8

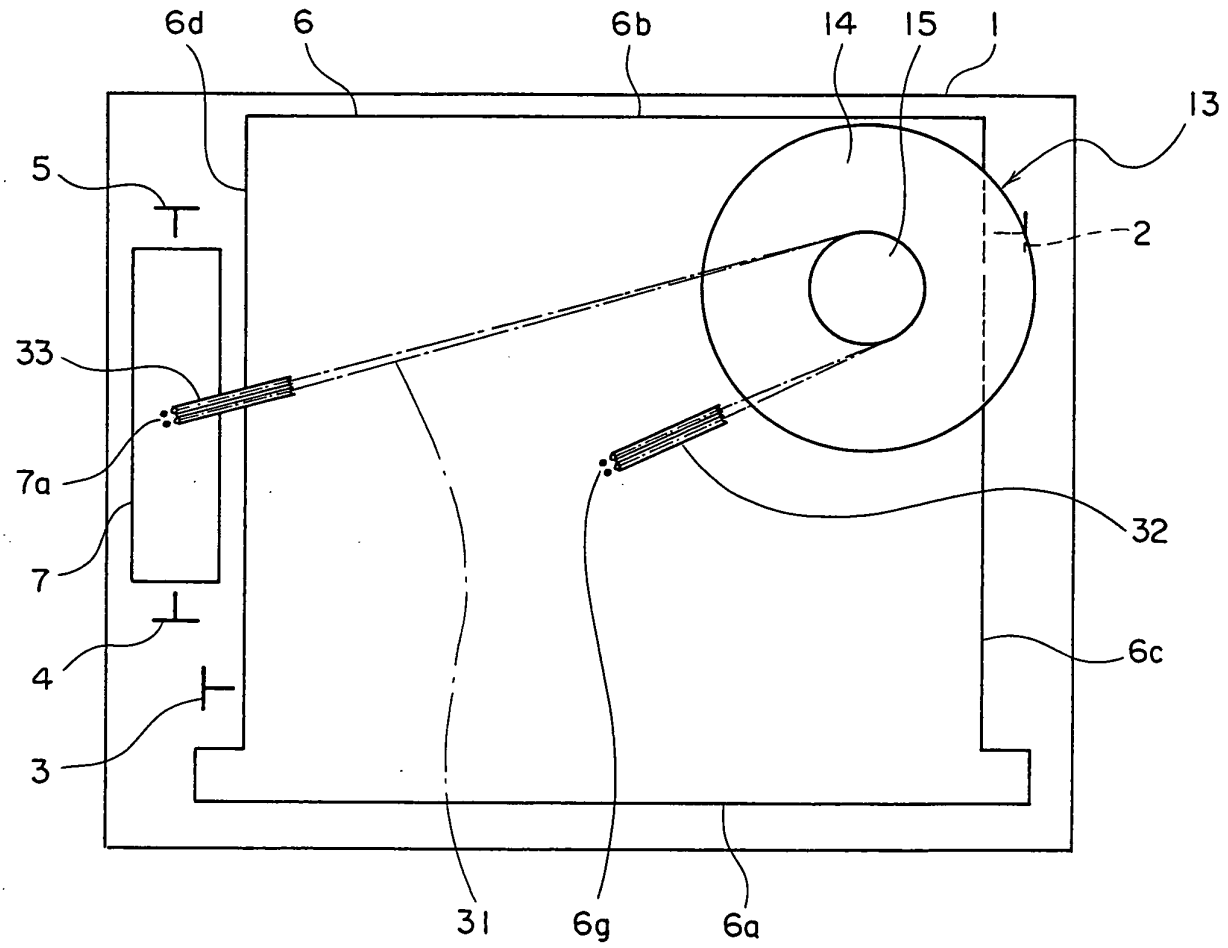
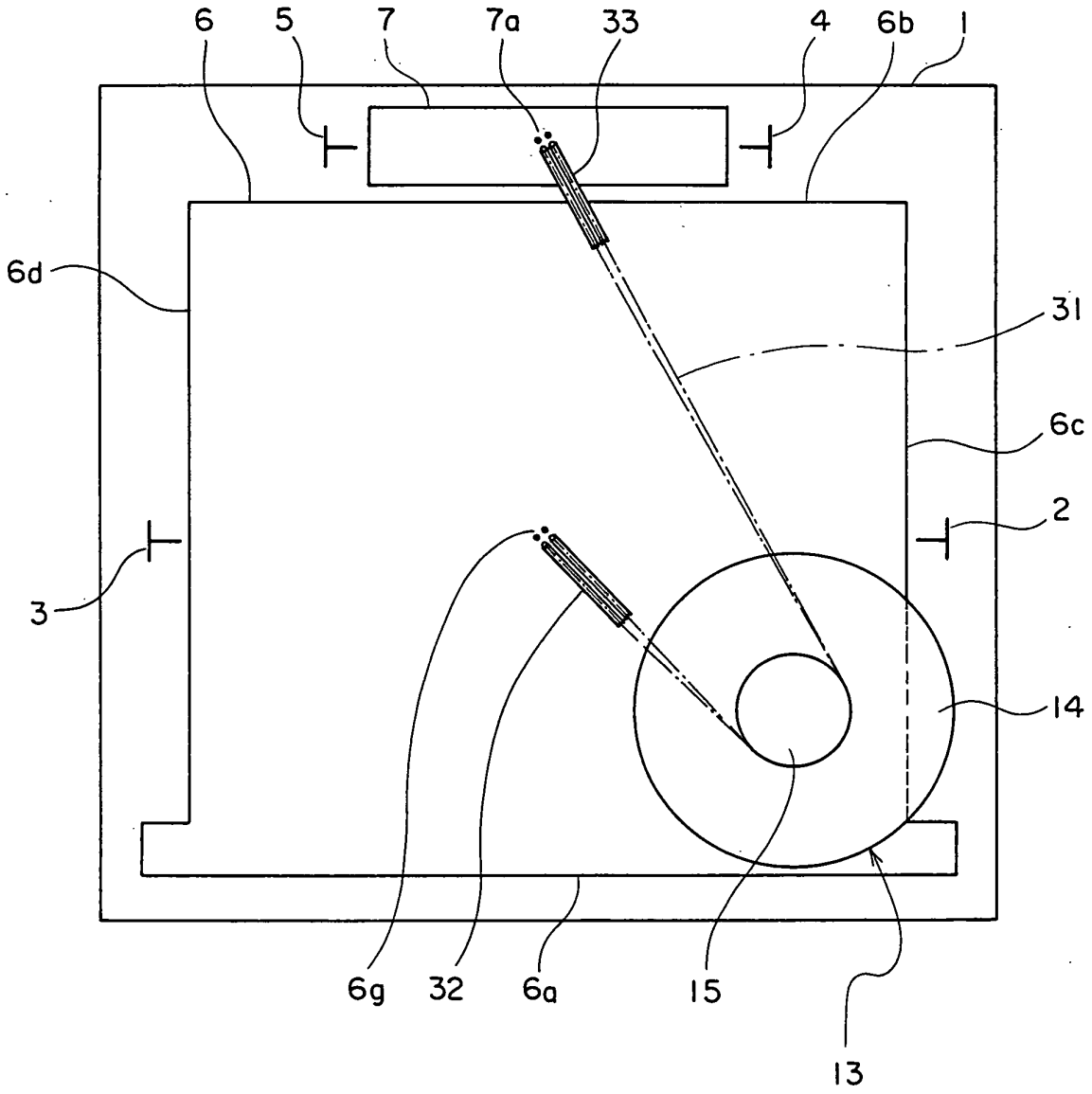


FIG. 9



**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2005/018158

A. CLASSIFICATION OF SUBJECT MATTER
***B66B7/06***(2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
***B66B7/00***(2006.01)-***B66B11/08***(2006.01)

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 1996-2006
Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006

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<br>Y | WO 2002/016247 A1 (Mitsubishi Electric Corp.),<br>28 February, 2002 (28.02.02),<br>& EP 1312573 A1 & CN 1382098 A | 1<br>2-5 |
| Y | WO 2003/074409 A1 (Mitsubishi Electric Corp.),<br>12 September, 2003 (12.09.03),<br>& EP 1481935 A1 | 2-5 |

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 29 June, 2006 (29.06.06) | 11 July, 2006 (11.07.06) |
| Name and mailing address of the ISA/<br>Japanese Patent Office<br><br>Facsimile No. | Authorized officer<br><br>Telephone No. |

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## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- WO 03074409 A **[0003]**