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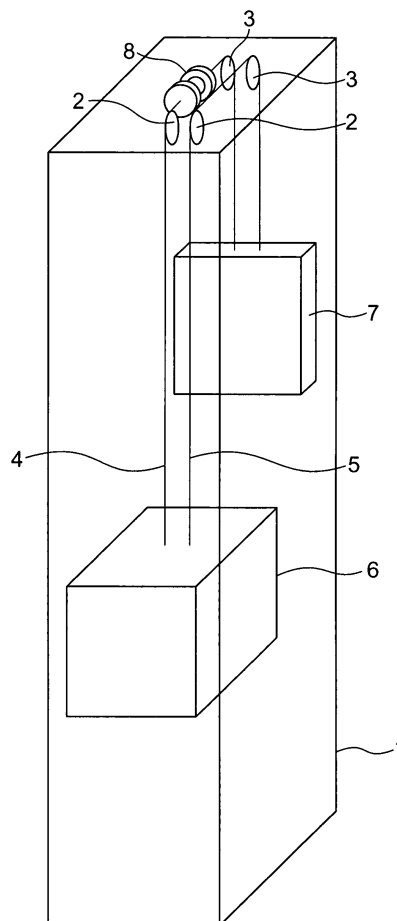
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(54) **ELEVATOR DEVICE**

(57) A car and a counterweight are suspended within a hoistway by a main rope. A driving machine for moving the main rope to raise/lower the car and the counterweight is provided within the hoistway. The driving machine has a driving machine main body and a contact roller. The driving machine main body includes a rotor penetrated by the main rope serving as a penetration body. The contact roller is provided on the rotor, is in contact with the penetration body, and can rotate around a rotational shaft that is inclined with respect to a center line of the penetration body when the contact roller is vertically projected onto the penetration body. When the rotor is rotated, the contact roller is thereby so rolled as to leave a spiral trace on an outer peripheral surface of the penetration body while being in contact with the penetration body. When the contact roller is rolled while being in contact with the penetration body, the main rope is thereby moved with respect to the driving machine in a longitudinal direction of the main rope.

FIG. 1



Description

Technical Field

5 **[0001]** The present invention relates to an elevator apparatus having a car and a counterweight that are raised/lowered within a hoistway.

Background Art

10 **[0002]** In a conventional elevator apparatus, main ropes for suspending a car and a counterweight are wound around a driving sheave of a hoisting machine. When the driving sheave is rotated, the car and the counterweight are thereby raised/lowered within the hoistway (see Patent Document 1).
[0003] Patent Document 1: JP 2002-80178 A

15 Disclosure of the Invention

Problem to be solved by the Invention

20 **[0004]** In the conventional elevator apparatus constructed as described above, however, a driving force is applied to bent portions of the main ropes. Therefore, the main ropes are under strain, so the life thereof is shortened. Thus, the number of the main ropes needs to be increased.

The hoisting machine cannot be disposed at a location other than the bent portions of the main ropes, so the degree of freedom in designing the layout of the hoisting machine is limited. Thus, the entire elevator apparatus cannot be reduced in size.

25 **[0005]** The present invention has been made to solve the above-mentioned problem, and it is therefore an object of the present invention to obtain an elevator apparatus which makes it possible to reduce the number of restrictions imposed on the degree of freedom in designing the layout of a driving machine while achieving a reduction in size.

[0006] According to the present invention, there is provided an elevator apparatus including:

30 a car which is raised/lowered within a hoistway;
a counterweight which is raised/lowered within the hoistway;
a main rope for suspending the car and the counterweight within the hoistway; and
a driving machine provided in the hoistway, for moving the main rope to raise/lower the car and the counterweight,
the elevator apparatus being characterized in that:

35 the driving machine has a driving machine main body, which includes a motor and a rotor rotated by the motor and is penetrated by the main rope serving as a penetration body, and a contact roller provided in the rotor, which is in contact with the penetration body, and can rotate around a rotational shaft that is inclined with respect to a center line of the penetration body when the contact roller is vertically projected onto the penetration body;
40 the contact roller is so rolled as to leave a spiral trace on an outer peripheral surface of the penetration body while being in contact with the penetration body, as a result of rotation of the rotor; and
the main rope is moved with respect to the driving machine in a longitudinal direction of the main rope, as a result of a rolling movement of the contact roller in a state of being in contact with the penetration body.

45 Brief Description of the Drawings

[0007]

50 Fig. 1 is a schematic diagram showing an elevator apparatus according to Embodiment 1 of the present invention.
Fig. 2 is a front view showing a driving machine of Fig. 1.
Fig. 3 is a cross-sectional view taken along a line III-III of Fig. 2.
Fig. 4 is a schematic diagram showing an elevator apparatus according to Embodiment 2 of the present invention.
Fig. 5 is a schematic diagram showing an elevator apparatus according to Embodiment 3 of the present invention.
Fig. 6 is a schematic diagram showing an elevator apparatus according to Embodiment 4 of the present invention.
55 Fig. 7 is an enlarged view showing a driving rod-shaped member of Fig. 6.
Fig. 8 is a cross-sectional view showing driving machines of an elevator apparatus according to Embodiment 5 of the present invention.
Fig. 9 is a cross-sectional view showing driving machines of an elevator apparatus according to Embodiment 6 of

the present invention.

Best Modes for carrying out the Invention

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

Embodiment 1

[0009] Fig. 1 is a schematic diagram showing an elevator apparatus according to Embodiment 1 of the present invention. Referring to Fig. 1, a plurality of car side deflector sheaves 2 and a plurality of counterweight side deflector sheaves 3 are provided at an upper end of a hoistway 1. The car side deflector sheaves 2 and the counterweight side deflector sheaves 3 are disposed apart from each other in a horizontal direction.

[0010] A plurality of main ropes 4 and 5 are wound around the car side deflector sheaves 2 and the counterweight side deflector sheaves 3. Each of the main ropes 4 and 5 is connected at one end thereof to a car 6, and at another end thereof to a counterweight 7. That is, each of the main ropes 4 and 5, which extends from the aforementioned one end connected to the car 6, is sequentially wound around each of the car side deflector sheaves 2 and each of the counterweight side deflector sheaves 3 and is extended to the aforementioned other end connected to the counterweight 7. Thus, the car 6 and the counterweight 7 are suspended within the hoistway 1 by the respective main ropes 4 and 5.

[0011] A driving machine 8 for raising/lowering the car 6 and the counterweight 7 within the hoistway 1 is provided between the car side deflector sheave 2 and the counterweight side deflector sheave 3. The driving machine 8 is supported by a support member (not shown), which is fixed within the hoistway 1. Out of the plurality of the main ropes 4 and 5, only the main rope 4 serving as a penetration body penetrates the driving machine 8. That is, only the portion of the main rope 4 which is suspended between the car side deflector sheave 2 and the counterweight side deflector sheave 3 serves as the penetration body to penetrate the driving machine 8. Accordingly, when the driving machine 8 applies a driving force only to the main rope 4 which penetrates the driving machine 8, the car 6 and the counterweight 7 are thereby raised/lowered.

[0012] Fig. 2 is a front view showing the driving machine 8 of Fig. 1. Fig. 3 is a cross-sectional view taken along a line III-III of Fig. 2. Referring to Figs. 2 and 3, a pedestal 11 having a cylindrical portion 10, which is formed in a shape of a circular cylinder, is fixed to the support member by bolts 12. The pedestal 11 is disposed such that a center line of the main rope (i.e., the penetration body) 4 extends coaxially with an axis of the cylindrical portion 10.

[0013] The driving machine 8 is supported by the pedestal 11. The driving machine 8 has a driving machine main body 13 and a plurality of contact rollers 14. The contact rollers 14, which are provided in the driving machine main body 13, are in contact with the main rope 4.

[0014] The driving machine main body 13 has a motor 15 provided within the cylindrical portion 10, and a rotor 16 rotated by the motor 15. The rotor 16 is fitted through the cylindrical portion 10. An axis of the rotor 16 is disposed coaxially with the axis of the cylindrical portion 10. A pair of bearings 17 are disposed between the rotor 16 and the cylindrical portion 10. The rotor 16 is rotatably supported by the cylindrical portion 10 via the respective bearings 17. The main rope 4 serving as the penetration body is passed through the rotor 16.

[0015] The rotor 16 has a pair of annular wheels 18 and 19 so disposed as to sandwich the cylindrical portion 10 in an axial direction thereof, and a coupling portion 20 for coupling the respective wheels 18 and 19 to each other. The coupling portion 20 is provided with a through-hole 21 through which the main rope 4 is extended. The coupling portion 20 is passed through the cylindrical portion 10. Note that, the respective wheels 18 and 19 are larger in outer diameter than the coupling portion 20.

[0016] The motor 15 is disposed between the coupling portion 20 and the cylindrical portion 10. The motor 15 has a plurality of permanent magnets 22 provided on an outer peripheral surface of the coupling portion 20, and a stator 23 provided on an inner peripheral surface of the cylindrical portion 10 and opposed to the permanent magnets 22 via a gap. The respective permanent magnets 22 are disposed side by side in a circumferential direction of the rotor 16, thereby constituting an annular body. A rotational force is applied to the permanent magnets 22 through energization of the stator 23. Thus, the rotor 16 is rotated integrally with the permanent magnets 22 around the axis of the cylindrical portion 10. Note that, in this example, the motor 15 is designed as a permanent-magnetic motor. Instead, however, the motor 15 may be designed as an induction motor.

[0017] The respective contact rollers 14 are provided in the wheels 18 and 19 respectively. In this example, four of the contact rollers 14 are provided in each of the wheels 18 and 19. Outer peripheral portions of the respective contact rollers 14 are made of a material with a high coefficient of friction. The outer peripheral portions of the respective contact rollers 14 are in contact with the main rope 4. The respective contact rollers 14 are disposed inside the wheels 18 and 19 and around the main rope 4. The respective contact rollers 14 restrain the main rope 4 from being displaced with respect to the rotor 16 in a direction perpendicular to the axis thereof. The contact rollers 14 can rotate around rotational shafts 24 respectively, which are inclined with respect to the center line of the main rope 4 when the respective contact

rollers 14 are vertically projected onto the main rope 4. The angle of inclination formed by each of the rotational shafts 24 and the center line of the main rope 4 at the time when the respective contact rollers 14 are vertically projected onto the main rope 4 is λ [rad].

[0018] When the rotor 16 is rotated, the respective contact rollers 14 are thereby so rolled as to leave spiral traces on the outer peripheral surface of the main rope 4, while being in contact therewith. When the respective contact rollers 14 are rolled while being in contact with the main rope 4, the main rope 4 is thereby moved in a longitudinal direction thereof with respect to the driving machine 8.

[0019] A relationship between a rotational angular speed ω [rad/s] of the rotor 16 and a rotational frequency f [1/s] of the rotor 16 is expressed by the following equation (1).

$$\omega = 2 \cdot \pi \cdot f \quad \dots \quad (1)$$

[0020] Accordingly, given that the main rope 4 has a diameter of d [m], a moving speed V [m/s] of the main rope 4 is expressed by the following equation (2).

$$V = \pi \cdot d \cdot f \cdot \tan \lambda \quad \dots \quad (2)$$

[0021] Given that twice the distance from the center line of the main rope 4 to the outer peripheral surface of each of the permanent magnets 22, namely, the outer diameter of an annular body constituted by the permanent magnets 22 is D_r [m], a circumferential speed V_g [m/s] of the annular body of the permanent magnets 22 when the rotor 16 is rotated is expressed by the following equation (3).

$$V_g = 2 \cdot \pi \cdot f \cdot D_g / 2 \quad \dots \quad (3)$$

[0022] Accordingly, a ratio of the moving speed V of the main rope 4 to the circumferential speed V_g of the annular body of the permanent magnets 22, namely, a speed reducing ratio z is expressed by the following equation (4).

$$\begin{aligned} z &= V / V_g \\ &= (\pi \cdot d \cdot f \cdot \tan \lambda) / (2 \cdot \pi \cdot f \cdot D_g / 2) \\ &= (d \cdot \tan \lambda) / D_g \quad \dots \quad (4) \end{aligned}$$

[0023] Thus, a tangential force F_g [N] received by an outer peripheral region of the annular body of the permanent magnets 22 is expressed by the following equation (5), for a force F [N] applied to the main rope 4.

$$\begin{aligned} F_g &= F \cdot V / V_g \\ &= (F \cdot d \cdot \tan \lambda) / D_g \quad \dots \quad (5) \end{aligned}$$

[0024] Accordingly, a torque T_q [N·m] generated by the motor 15 is expressed by the following equation (6).

$$\begin{aligned} T_q &= F_g \cdot D_g / 2 \\ &= (F \cdot d \cdot \tan \lambda) / 2 \quad \dots \quad (6) \end{aligned}$$

[0025] Next, an operation will be described. When an AC power is supplied to the stator 23, a revolving magnetic field is generated, so the rotor 16 is rotated. Thus, the respective contact rollers 14 are moved around the main rope 4 while being in contact therewith. At this moment, the respective contact rollers 14 are so rolled as to leave spiral traces on the outer peripheral surface of the main rope 4. Thus, the main rope 4 is moved in the longitudinal direction thereof with respect to the driving machine 8. Thus, the car 6 and the counterweight 7 are raised/lowered within the hoistway 1.

[0026] In the elevator apparatus constructed as described above, the rotor 16 is provided with the plurality of the contact rollers 14 that are rotatable around the rotational shafts 24, which are inclined with respect to the center line of the main rope 4 respectively when the respective contact rollers 14 are vertically projected onto the main rope 4. When the rotor 16 is rotated, the respective contact rollers 14 are thereby so rolled as to leave spiral traces on the outer peripheral surface of the main rope 4 while being in contact therewith. Therefore, a driving force of the driving machine 8 can be applied to the main rope 4 without bending the main rope 4. Thus, the driving machine 8 can be installed on a linearly suspended region of the main rope 4, so the number of restrictions imposed on the degree of freedom in designing the layout of the driving machine 8 can be reduced. Accordingly, the entire elevator apparatus can be reduced in size.

[0027] While the torque T_q [N·m] generated by the driving machine 8 thus structured is expressed by the foregoing equation (6), a torque T_{qm} [N·m] generated by a conventional hoisting machine having no reducer is expressed by the following equation (7), given that a driving sheave has an outer diameter of D_s [m].

$$T_{qm} = F \cdot D_s / 2 \quad \dots \quad (7)$$

[0028] As a rule, in consideration of the bending life of the main rope 4, the outer diameter D_s of the conventional driving sheave needs to be several dozen times as large as a diameter d of the main rope 4. When the equations (6) and (7) are compared with each other from this viewpoint, the required torque T_q of the driving machine 8 according to Embodiment 1 of the present invention has only to be a value obtained by dividing the required torque T_{qm} of the conventional hoisting machine by several dozen. That is, in the conventional hoisting machine, the reducer, which is composed of gears, needs to be provided separately from a motor with a view to reducing the required torque of the motor. Accordingly, since the reducer composed of the gears is not necessitated in the elevator apparatus according to Embodiment 1 of the present invention, the driving machine 8 can also be reduced in size.

Embodiment 2

[0029] Fig. 4 is a schematic diagram showing an elevator apparatus according to Embodiment 2 of the present invention. Referring to Fig. 4, an upper connecting portion 31 is provided at the upper end of the hoistway 1, which is located above the counterweight 7. A lower connecting portion 32 is provided at a lower end of the hoistway 1, which is located below the counterweight 7. A driving rope 33, which is a track body extending in a direction in which the counterweight 7 is raised/lowered, is suspended within the hoistway 1. The driving rope 33 is connected at one end thereof to the upper connecting portion 31, and at the other end thereof to the lower connecting portion 32.

[0030] A space portion 34 is provided inside the counterweight 7. The counterweight 7 is provided with an upper through-hole 35 extending upward from the space portion 34, and a lower through-hole 36 extending downward from the space portion 34. The driving machine 8 constructed in the same manner as in Embodiment 1 of the present invention is provided in the space portion 34. The driving machine 8 is supported by a pedestal 37, which is fixed to the counterweight 7. That is, the driving machine 8 is mounted on the counterweight 7.

[0031] The driving rope 33, which extends from one end connected to the upper connecting portion 31 to the other end connected to the lower connecting portion 32, is sequentially passed through the upper through-hole 35, the driving machine 8, and the lower through-hole 36.

[0032] The driving rope 33 serving as a penetration body penetrates the driving machine 8. The driving machine 8 is mounted on the counterweight 7 such that the axis of the rotor 16 extends coaxially with the center line of the driving rope (i.e., the penetration body) 33. The respective contact rollers 14 (shown in Fig. 3) of the driving machine 8 are in contact with the driving rope 33. The respective contact rollers 14 are rotatable around rotational shafts respectively, which are inclined with respect to a center line of the driving rope 33 when the respective contact rollers 14 are vertically projected onto the driving rope 33.

[0033] When the rotor 16 (shown in Fig. 3) is rotated, the respective contact rollers 14 are thereby so rolled as to leave spiral traces on an outer peripheral surface of the driving rope 33 while being in contact therewith. When the respective contact rollers 14 are rolled while being in contact with the driving rope 33, the driving machine 8 is thereby moved together with the counterweight 7 with respect to the driving rope 33 in a longitudinal direction thereof. By being moved with respect to the driving rope 33 in the longitudinal direction thereof, the driving machine 8 raises/lowers the car 6 and

the counterweight 7. Embodiment 2 of the present invention is identical to Embodiment 1 of the present invention in other constructional details.

[0034] Next, an operation will be described. When the rotor 16 rotates, the respective contact rollers 14 are rolled while being in contact with the driving rope 33. Thus, the driving machine 8 is moved with respect to the driving rope 33 in the longitudinal direction thereof. At this moment, the counterweight 7 is also moved together with the driving machine 8. Thus, the car 6, which is linked to the counterweight 7 by the common main rope 5, is also moved. That is, when the driving machine 8 is moved with respect to the driving rope 33, the car 6 and the counterweight 7 are thereby raised/lowered within the hoistway 1.

[0035] In the elevator apparatus constructed as described above, the driving machine 8 is mounted on the counterweight 7, and the driving rope 33 serving as the penetration body penetrating the driving machine 8 is suspended within the hoistway 1. When the driving machine 8 is moved with respect to the driving rope 33, the car 6 and the counterweight 7 are thereby raised/lowered within the hoistway 1. Therefore, the driving machine 8 can be mounted on the counterweight 7, and the number of restrictions in designing the layout of the driving machine 8 can further be reduced.

[0036] The driving machine 8 is moved with respect to the driving rope 33, which is different from the main rope 5 for suspending the car 6 and the counterweight 7. Therefore, when the driving rope 33, which is larger in diameter than the main rope 5, is suspended within the hoistway 1, the car 6 and the counterweight 7 can thereby be raised/lowered more stably. As is apparent from the foregoing equation (6), the larger torque T_q can be generated by the driving machine 8.

Embodiment 3

[0037] In Embodiment 2 of the present invention, which has been described above, the driving rope 33 serving as the track body is suspended within the hoistway 1. However, a circular cylinder (i.e., a driving rod-shaped member) may also be used as a track body to be installed within the hoistway 1. That is, Fig. 5 is a schematic diagram showing an elevator apparatus according to Embodiment 3 of the present invention. Referring to Fig. 5, a circular cylinder (i.e., a driving rod-shaped member) 41 serving as a track body extending in the direction in which the counterweight 7 is raised/lowered is installed within the hoistway 1.

[0038] An upper fixing portion 42 is provided at the upper end of the hoistway 1, which is located above the counterweight 7. A lower fixing portion 43 is provided at the lower end of the hoistway 1, which is located below the counterweight 7. The circular cylinder 41 is fixed at one end thereof to the upper fixing portion 42, and at the other end thereof to the lower fixing portion 43.

[0039] The circular cylinder 41, which extends from the aforementioned one end fixed to the upper fixing portion 42 to the other end fixed to the lower fixing portion 43, is sequentially passed through the upper through-hole 35, the driving machine 8, and the lower through-hole 36.

[0040] The circular cylinder 41 serving as the penetration body penetrates the driving machine 8. The driving machine 8 is mounted on the counterweight 7 such that the axis of the rotor 16 extends coaxially with a center line of the circular cylinder 41. When the rotor 16 is rotated, the driving machine 8 is thereby moved together with the counterweight 7 with respect to the circular cylinder 41 in the longitudinal direction thereof. Embodiment 3 of the present invention is identical to Embodiment 2 of the present invention in other constructional details.

[0041] In this manner as well, the driving machine 8 can be mounted on the counterweight 7, and the number of restrictions in designing the layout of the driving machine 8 can further be reduced. The circular cylinder 41 is installed as the track body within the hoistway 1. Therefore, the diameter of the track body can be increased in comparison with a case in which the driving rope 33 is used as the track body, so the car 6 and the counterweight 7 can be raised/lowered more stably. The larger torque T_q can also be generated by the driving machine 8.

Embodiment 4

[0042] Fig. 6 is a schematic diagram showing an elevator apparatus according to Embodiment 4 of the present invention. Referring to Fig. 6, a pair of driving rod-shaped members 51 serving as track bodies extending in the direction in which the car 6 is raised/lowered are installed within the hoistway 1. Each of the driving rod-shaped members 51 is fixed at one end thereof to an upper fixing portion 52, which is provided at the upper end of the hoistway 1, and at the other end thereof to a lower fixing portion 53, which is provided at the lower end of the hoistway 1.

[0043] The car 6 is disposed between the respective driving rod-shaped members 51. A pair of driving machines 8, which are penetrated by the driving rod-shaped members 51 respectively as penetration bodies, are provided on lateral surfaces of the car 6 respectively. The respective driving machines 8 are provided on the car 6 such that the axis of the rotor 16 (shown in Fig. 3) extends coaxially with a center line of each of the driving rod-shaped members 51.

[0044] In each of the driving machines 8, when the rotor 16 is rotated, the respective contact rollers 14 (shown in Fig. 3) are thereby so rolled as to leave spiral traces on an outer peripheral surface of each of the driving rod-shaped members 51 while being in contact therewith. When the respective contact rollers 14 are rolled while being in contact with each

of the driving rod-shaped members 51, each of the driving machines 8 is thereby moved with respect to each of the driving rod-shaped members 51 in the longitudinal direction thereof. Thus, the car 6 and the counterweight 7 are raised/lowered within the hoistway 1.

[0045] Fig. 7 is an enlarged view showing each of the driving rod-shaped members 51 of Fig. 6. Referring to Fig. 7, a plurality of guide grooves 54 for guiding the respective contact rollers 14 are provided in the outer peripheral surface of each of the driving rod-shaped members 51. The respective guide grooves 54 extend along the spiral traces that are left when the contact rollers 14 are rolled. That is, the respective contact rollers 14 are rolled while being guided by the guide grooves 54 in such a manner as to leave the spiral traces on the outer peripheral surface of each of the driving rod-shaped members 51. Embodiment 4 of the present invention is identical to Embodiment 1 of the present invention in other constructional details.

[0046] In the elevator apparatus constructed as described above, the driving machines 8 are provided on the car 6, and the driving rod-shaped members 51 penetrating the driving machines 8 respectively are provided within the hoistway 1. When the driving machines 8 are moved with respect to the driving rod-shaped members 51 respectively, the car 6 and the counterweight 7 are thereby raised/lowered. Therefore, the driving machines 8 can be mounted on the car 6, and the number of restrictions in designing the layout of the driving machines 8 can further be reduced. The diameter of the track bodies can be increased in comparison with the case in which the driving rope 33 is used as the penetration body, so the car 6 and the counterweight 7 can be raised/lowered more stably. The larger torque T_q can also be generated by the driving machines 8.

[0047] The guide grooves 54 for guiding the contact rollers 14 are provided in the outer peripheral surface of each of the driving rod-shaped members 51 along the spiral traces. Therefore, the contact rollers 14 can be restrained from slipping with respect to each of the driving rod-shaped members 51, so the car 6 and the counterweight 7 can be raised/lowered more stably.

[0048] In the foregoing example, the driving rod-shaped body 51 having the outer peripheral surface in which the guide grooves 54 are provided is installed within the hoistway 1. However, a circular cylinder having an outer peripheral surface in which the guide grooves 54 are not provided, or the driving rope suspended within the hoistway 1 may be used as a track body. In this manner as well, the driving machine 8 can be mounted on the car 6, and the number of restrictions in designing the layout of the driving machine 8 can be reduced.

Embodiment 5

[0049] Fig. 8 is a cross-sectional view showing driving machines of an elevator apparatus according to Embodiment 5 of the present invention. Referring to Fig. 8, a pair of pedestals 37, which are disposed apart from each other in the longitudinal direction of the driving rope (i.e., the track body) 33 (in a vertical direction in this example), are fixed in the space portion 34 provided in the counterweight 7. The respective pedestals 37 are identical in construction to the pedestal 37 according to Embodiment 2 of the present invention. A first driving machine 61 is supported by one of the pedestals 37, and a second driving machine 62 is supported by the other pedestal 37. That is, the first driving machine 61 and the second driving machine 62 serving as a pair of driving machines are disposed apart from each other in the longitudinal direction of the driving rope 33 in the space portion 34. The common driving rope 33 serving as a penetration body is passed through the first driving machine 61 and the second driving machine 62.

[0050] The first driving machine (i.e., one of the driving machines) 61 is identical in construction to the driving machine 8 according to Embodiment 1 of the present invention. The second driving machine (i.e., the other driving machine) 62 is identical in construction to the first driving machine 61 except for the rotational direction of the rotor 16 and the directions of inclination of the rotational shafts 24 of the respective contact rollers 14.

[0051] That is, the rotor 16 in the first driving machine 61 and the rotor 16 in the second driving machine 62 are rotated in opposite directions around the center line of the driving rope 33. The rotational shafts 24 of the respective contact rollers 14 in the first driving machine 61 and the rotational shafts 24 of the respective contact rollers 14 in the second driving machine 62 are inclined in opposite directions with respect to the center line of the driving rope 33 when being vertically projected onto the driving rope (i.e., the penetration body) 33.

[0052] The rotational speed of the rotor 16 in the first driving machine 61 and the rotational speed of the rotor 16 in the second driving machine 62 are equal to each other. When the contact rollers 14 in the first driving machine 61 and the contact rollers 14 in the second driving machine 62 are vertically projected onto the driving rope 33 respectively, the absolute value of an angle of inclination formed by each of the rotational shafts 24 of the contact rollers 14 in the first driving machine 61 and the center line of the driving rope 33 and the absolute value of an angle of inclination formed by each of the rotational shafts 24 of the contact rollers 14 in the second driving machine 62 and the center line of the driving rope 33 are equal to each other. Embodiment 5 of the present invention is identical to Embodiment 2 of the present invention in other constructional details.

[0053] In the elevator apparatus constructed as described above, each of the rotational shafts 24 of the contact rollers 14 in the first driving machine 61 and each of the rotational shafts 24 of the contact rollers 14 in the second driving

machine 62 are inclined in opposite directions with respect to the center line of the driving rope 33 when vertically projected onto the driving rope 33, and the rotor 16 in the first driving machine 61 and the rotor 16 in the second driving machine 62 are rotated in opposite directions. Therefore, a torque in a torsional direction which is applied to the driving rope 33 by the first driving machine 61 and a torque in a torsional direction which is applied to the driving rope 33 by the second driving machine 62 are counterbalanced with each other. As a result, the first driving machine 61 and the second driving machine 62 can be moved with respect to the driving rope 33 more stably.

[0054] That is, when the contact rollers 14 are rolled through rotation of the rotor 16, a counteractive torque of a torque generated by the motor 15 is applied to the driving rope 33 as the torque in the torsional direction. When a counteractive torque is applied to the driving rope 33 only in one direction, the driving rope 33 is elastically deformed in the torsional direction, so a driving force is not efficiently transmitted to the driving rope 33. In the elevator apparatus according to Embodiment 5 of the present invention, torques in opposite directions are applied to the driving rope 33 by the first driving machine 61 and the second driving machine 62, so the counteractive torques applied to the driving rope 33 can be counterbalanced with each other. Accordingly, the amount of elastic deformation of the driving rope 33 in the torsional direction can be reduced, and driving forces from the first driving machine 61 and the second driving machine 62 can be efficiently transmitted to the driving rope 33.

Embodiment 6

[0055] Fig. 9 is a cross-sectional view showing driving machines of an elevator apparatus according to Embodiment 6 of the present invention. Referring to Fig. 9, a pedestal 71 is fixed in the space portion 34 provided in the counterweight 7 by bolts. The pedestal 71 has a cylindrical portion 72 formed in the shape of a circular cylinder. The driving rope (i.e., the track body) 33, which is suspended within the hoistway 1, is passed inside the cylindrical portion 72. An axis of the cylindrical portion 72 is coaxial with the center line of the driving rope 33.

[0056] A first driving machine 73 and a second driving machine 74 as a pair of driving machines, which are disposed coaxially with the axis of the cylindrical portion 72 respectively, are supported by the pedestal 71. The first driving machine (i.e., one of the driving machines) 73 is provided inside the cylindrical portion 72, and the second driving machine (i.e., the other driving machine) 74 is so provided outside the cylindrical portion 72 as to surround the cylindrical portion 72. Thus, the first driving machine 73 and the second driving machine 74 are integrated with each other.

[0057] The first driving machine 73 has a first driving machine main body 75 disposed inside the cylindrical portion 72, and a plurality of first contact rollers 76 provided in the first driving machine main body 75 while being in contact with the driving rope 33.

[0058] The first driving machine main body 75 has a first motor 77 provided in the cylindrical portion 72, and a first rotor 78 rotated by the first motor 77. The first rotor 78 is fitted through the cylindrical portion 72. An axis of the first rotor 78 is disposed coaxially with an axis of the cylindrical portion 72. In addition, a pair of bearings 79 are disposed between the first rotor 78 and the cylindrical portion 72. The first rotor 78 is rotatably supported by the cylindrical portion 72 via respective bearings 79. The driving rope 33 serving as the penetration body penetrates the first rotor 78.

[0059] The first rotor 78 has a rotor body 80 passed through the cylindrical portion 72, and an annular wheel 81 provided only at one end of the rotor body 80. The rotor body 80 is provided with a through-hole 82 through which the driving rope 33 is passed. The wheel 81 is larger in outer diameter than the rotor body 80.

[0060] The first motor 77 is disposed between the rotor body 80 and the cylindrical portion 72. The first motor 77 has a plurality of permanent magnets 83 provided on an outer peripheral surface of the rotor body 80, and a stator 84 so provided on an inner peripheral surface of the cylindrical portion 72 as to be opposed to the permanent magnets 83 via a gap. The respective permanent magnets 83 are disposed side by side in a circumferential direction of the first rotor 78, thereby constituting an annular body. A rotational force is applied to the permanent magnets 83 through energization of the stator 84. Thus, the first rotor 78 is rotated integrally with the permanent magnets 83 around the axis of the cylindrical portion 72.

[0061] The respective first contact rollers 76 are provided in the wheel 81. In this example, the four first contact rollers 76 are provided in the wheel 81. Outer peripheral portions of the respective first contact rollers 76 are made of a material with a high coefficient of friction. The outer peripheral portions of the respective first contact rollers 76 are in contact with the driving rope 33. The respective first contact rollers 76 are disposed inside the wheel 81 and around the driving rope 33. The respective first contact rollers 76 restrain the driving rope 33 from being displaced with respect to the first rotor 78 in a direction perpendicular to the axis of the first rotor 78.

[0062] The respective first contact rollers 76 are rotatable around first rotational shafts 85 respectively, which are inclined with respect to the center line of the driving rope 33 when the first contact rollers 76 are vertically projected onto the driving rope 33. The angle of inclination formed by each of the first rotational shafts 85 and the center line of the driving rope 33 at the time when the respective first contact rollers 76 are vertically projected onto the driving rope 33 is λ [rad].

[0063] When the first rotor 78 is rotated, the respective first contact rollers 76 are thereby so rolled as to leave spiral

traces on the outer peripheral surface of the driving rope 33 while being in contact therewith.

[0064] The second driving machine 74 has a second driving machine main body 86, which assumes a cylindrical shape and is disposed outside the cylindrical portion 72, and a plurality of second contact rollers 87, which are provided in the second driving machine main body 86 while being in contact with the driving rope 33.

[0065] The second driving machine main body 86 has a second motor 88, which assumes an annular shape and is provided on an outer periphery of the cylindrical portion 72, and a second rotor 89, which is so disposed as to surround a third motor 88 to be rotated by the second motor 88. An axis of the second rotor 89 is disposed coaxially with the axis of the cylindrical portion 72. Furthermore, a pair of bearings 90 are disposed between the second rotor 89 and the cylindrical portion 72. The second rotor 89 is rotatably supported by the cylindrical portion 72 via the respective bearings 90. The driving rope 33 serving as the penetration body penetrates the second rotor 89.

[0066] The second rotor 89 has an annular rotor body 91 disposed around the cylindrical portion 72, and an annular wheel 92 provided only at the other end of the rotor body 91, namely, at the end opposite to the wheel 81 side. The wheel 92 is smaller in outer diameter than the rotor body 91.

[0067] The second motor 88 is disposed between the rotor body 91 and the cylindrical portion 72. The second motor 88 has a plurality of permanent magnets 93 provided on an inner peripheral surface of the rotor body 91, and a stator 94 provided on the outer peripheral surface of the cylindrical portion 72 and opposed to the permanent magnets 93 via a gap. The respective permanent magnets 93 are disposed side by side in a circumferential direction of the second rotor 89, thereby constituting an annular body. A rotational force is applied to the permanent magnets 93 through energization of the stator 94. Thus, the second rotor 89 is rotated integrally with the permanent magnets 93.

[0068] The respective second contact rollers 87 are provided in the wheel 92. In this example, the four second contact rollers 87 are provided in the wheel 92. Outer peripheral portions of the respective second contact rollers 87 are made of a material with a high coefficient of friction. The outer peripheral portions of the respective second contact rollers 87 are in contact with the driving rope 33. The respective second contact rollers 87 are disposed inside the wheel 92 and around the driving rope 33. The respective second contact rollers 87 restrain the driving rope 33 from being displaced with respect to the second rotor 89 in a direction perpendicular to an axis of the second rotor 89.

[0069] The respective second contact rollers 87 are rotatable around second rotational shafts 95 respectively, which are inclined with respect to the center line of the driving rope 33 when the second contact rollers 87 are vertically projected onto the driving rope 33. The angle of inclination formed by each of the second rotational shafts 95 and the center line of the driving rope 33 at the time when the respective second contact rollers 87 are vertically projected onto the driving rope 33 is λ [rad].

[0070] When the second rotor 89 is rotated, the respective second contact rollers 87 are thereby so rolled as to leave spiral traces on the outer peripheral surface of the driving rope 33 while being in contact therewith.

[0071] The first rotor 78 and the second rotor 89 are rotated in opposite directions around the axis of the cylindrical portion 72. The rotational speed of the first rotor 78 and the rotational speed of the second rotor 89 are equal to each other.

[0072] When each of the rotational shafts 85 of the respective first contact rollers 76 and each of the rotational shafts 95 of the respective second contact rollers 87 are vertically projected onto the driving rope 33, they are inclined in opposite directions with respect to the center line of the driving rope 33. Furthermore, when the respective first contact rollers 76 and the respective second contact rollers 87 are vertically projected onto the driving rope 33, the absolute value of an angle of inclination formed by each of the first rotational shafts 85 and the center line of the driving rope 33 and the absolute value of an angle of inclination formed by each of the second rotational shafts 95 and the center line of the driving rope 33 are equal to each other.

[0073] When the respective first contact rollers 76 and the respective second contact rollers 87 are rolled while being in contact with the driving rope 33, the first driving machine 73 and the second driving machine 74 are thereby moved integrally with the counterweight 7 with respect to the driving rope 33 in the longitudinal direction thereof. Embodiment 6 of the present invention is identical to Embodiment 2 of the present invention in other constructional details.

[0074] In the elevator apparatus constructed as described above, the pedestal 71 having the cylindrical portion 72 is provided on the counterweight 7. The first driving machine 73 is provided inside the cylindrical portion 72, and the second driving machine 74 is so provided outside the cylindrical portion 72 as to surround the cylindrical portion 72. The first driving machine 73 and the second driving machine 74 are thereby integrated with each other. Therefore, as is the case with Embodiment 5 of the present invention, the first driving machine 73 and the second driving machine 74 can be moved more stably with respect to the driving rope 33. Also, the space for installing the driving machines can be reduced.

[0075] In Embodiments 5 and 6 of the present invention, which have been described above, the driving rope 33 serving as the penetration body penetrates the first driving machine and the second driving machine. However, the main rope 4 for suspending the car 6 and the counterweight 7 may be used as penetration bodies to penetrate the first driving machine and the second driving machine. In this case, the first driving machine and the second driving machine are provided on the support member within the hoistway 1.

[0076] In Embodiments 5 and 6 of the present invention, which have been described above, the driving rope 33 suspended within the hoistway 1 is used as the track body. However, the circular cylinder 41 in Embodiment 3 of the

present invention or the driving rod-shaped member 51 in Embodiment 4 of the present invention may be used as the track body.

[0077] In the foregoing respective embodiments of the present invention, the respective contact rollers are simply in contact with the penetration body. However, the respective contact rollers may be pressed against the penetration body. That is, each of the contact rollers may be urged by a spring (i.e., an elastic body) in such a direction as to come into contact with the penetration body. In this manner, the contact rollers can further be restrained from slipping with respect to the penetration body, so the car 6 and the counterweight 7 can be raised/lowered more stably.

Claims

1. An elevator apparatus, comprising:

a car which is raised/lowered within a hoistway;
a counterweight which is raised/lowered within the hoistway;
a main rope for suspending the car and the counterweight within the hoistway; and
a driving machine provided in the hoistway, for moving the main rope to raise/lower the car and the counterweight, the elevator apparatus being **characterized in that**:

the driving machine has a driving machine main body, which includes a motor and a rotor rotated by the motor and is penetrated by the main rope serving as a penetration body, and a contact roller provided in the rotor, which is in contact with the penetration body, and can rotate around a rotational shaft that is inclined with respect to a center line of the penetration body when the contact roller is vertically projected onto the penetration body;

the contact roller is so rolled as to leave a spiral trace on an outer peripheral surface of the penetration body while being in contact with the penetration body, as a result of rotation of the rotor; and
the main rope is moved with respect to the driving machine in a longitudinal direction of the main rope, as a result of a rolling movement of the contact roller in a state of being in contact with the penetration body.

2. An elevator apparatus, comprising:

a car which is raised/lowered within a hoistway;
a counterweight which is raised/lowered within the hoistway;
a main rope for suspending the car and the counterweight within the hoistway;
a track body provided within the hoistway, which extends in a direction in which the car and the counterweight are raised/lowered; and
a driving machine provided on at least one of the car and the counterweight, by being moved with respect to the track body in a longitudinal direction of the track body, for raising/lowering the car and the counterweight, the elevator apparatus being

characterized in that:

the driving machine has a driving machine main body, which includes a motor and a rotor rotated by the motor and is penetrated by the track body serving as a penetration body, and a contact roller provided in the rotor, which is in contact with the penetration body, and can rotate around a rotational shaft that is inclined with respect to a center line of the penetration body when the contact roller is vertically projected onto the penetration body; the contact roller is so rolled as to leave a spiral trace on an outer peripheral surface of the penetration body while being in contact with the penetration body, as a result of rotation of the rotor; and
the driving machine is moved with respect to the track body in a longitudinal direction of the track body, as a result of a rolling movement of the contact roller in a state of being in contact with the penetration body.

3. The elevator apparatus according to Claim 2, **characterized in that** the track body is a driving rope suspended within the hoistway.

4. The elevator apparatus according to Claim 2, **characterized in that** the track body is a driving rod-shaped member fixed within the hoistway.

5. The elevator apparatus according to Claim 4, **characterized in that** the driving rod-shaped member has an outer

peripheral surface on which a guide groove for guiding the contact roller along the spiral trace is provided.

6. The elevator apparatus according to any one of Claims 1 to 5, **characterized in that** the contact roller is urged by an elastic body in such a direction as to come into contact with the penetration body.

7. The elevator apparatus according to any one of Claims 1 to 6, comprising a pair of above-mentioned driving machines through which the common penetration body is passed, the elevator apparatus being **characterized in that**:

the rotational shaft of the contact roller in one of the driving machines and the rotational shaft of the contact roller in another driving machine are inclined in opposite directions with respect to the center line of the penetration body when the contact rollers are vertically projected onto the penetration body; and the rotor in one of the driving machines and the rotor in the other driving machine are rotated in opposite directions.

8. The elevator apparatus according to Claim 7, **characterized in that** the pair of the driving machines are supported by a pedestal having a cylindrical portion, and are integrated with each other, by disposing one of the driving machines inside the cylindrical portion and disposing the another driving machine outside the cylindrical portion so as to surround the cylindrical portion.

FIG. 1

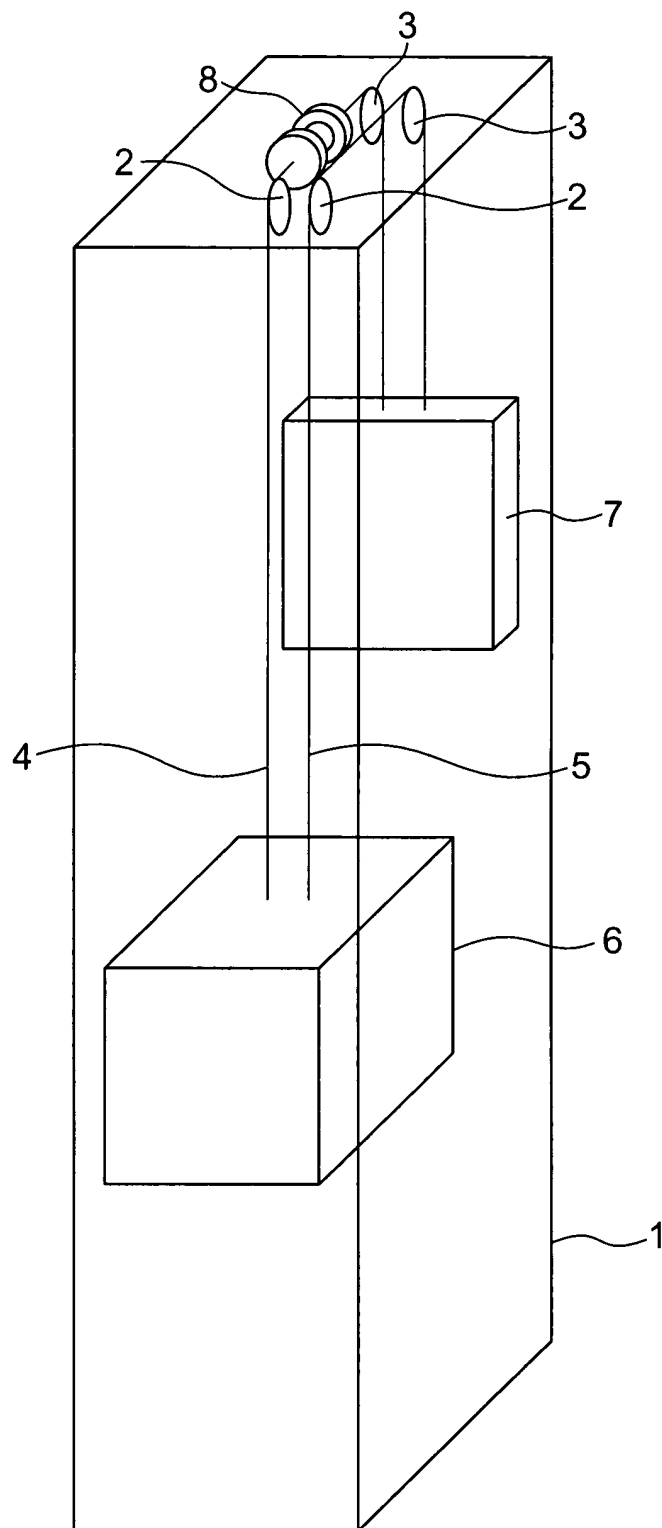


FIG. 2

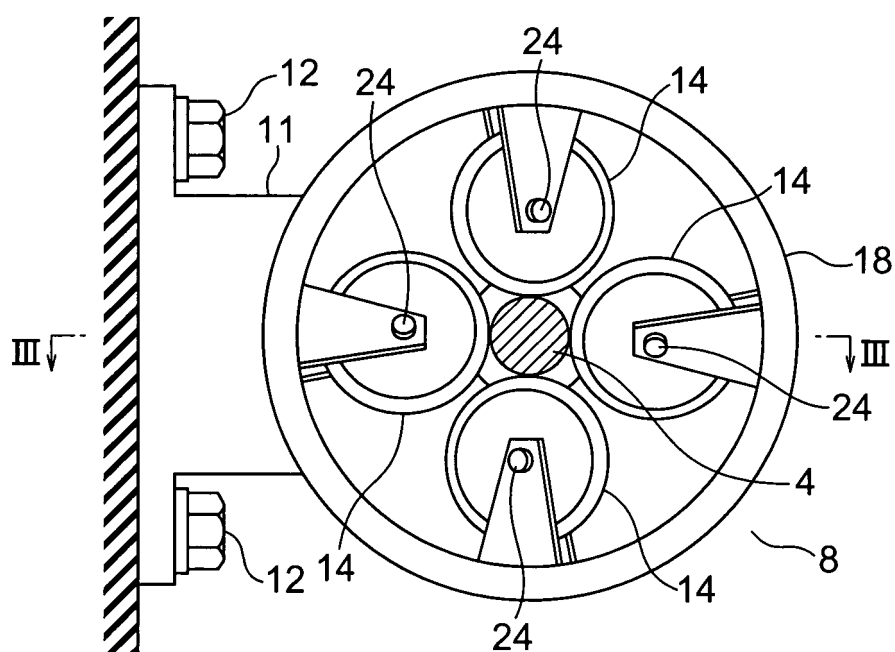


FIG. 3

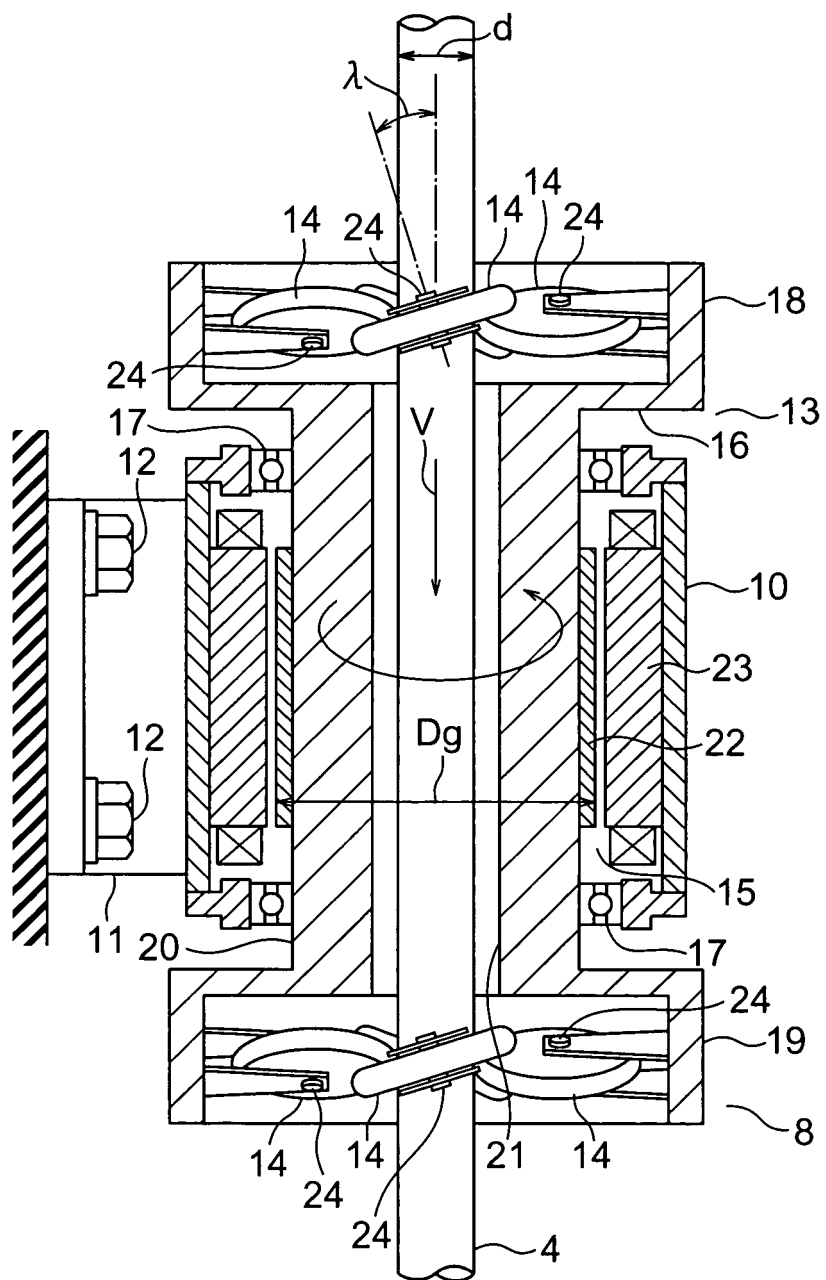


FIG. 4

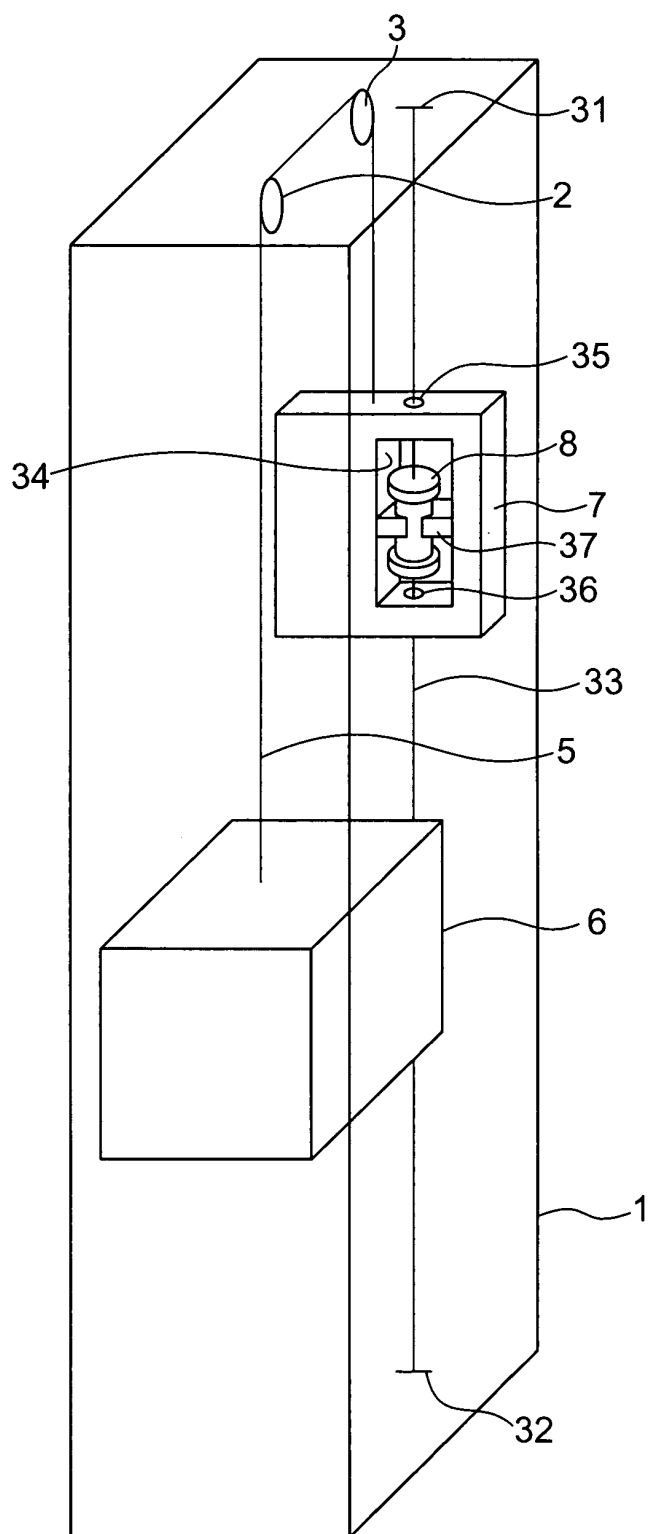


FIG. 5

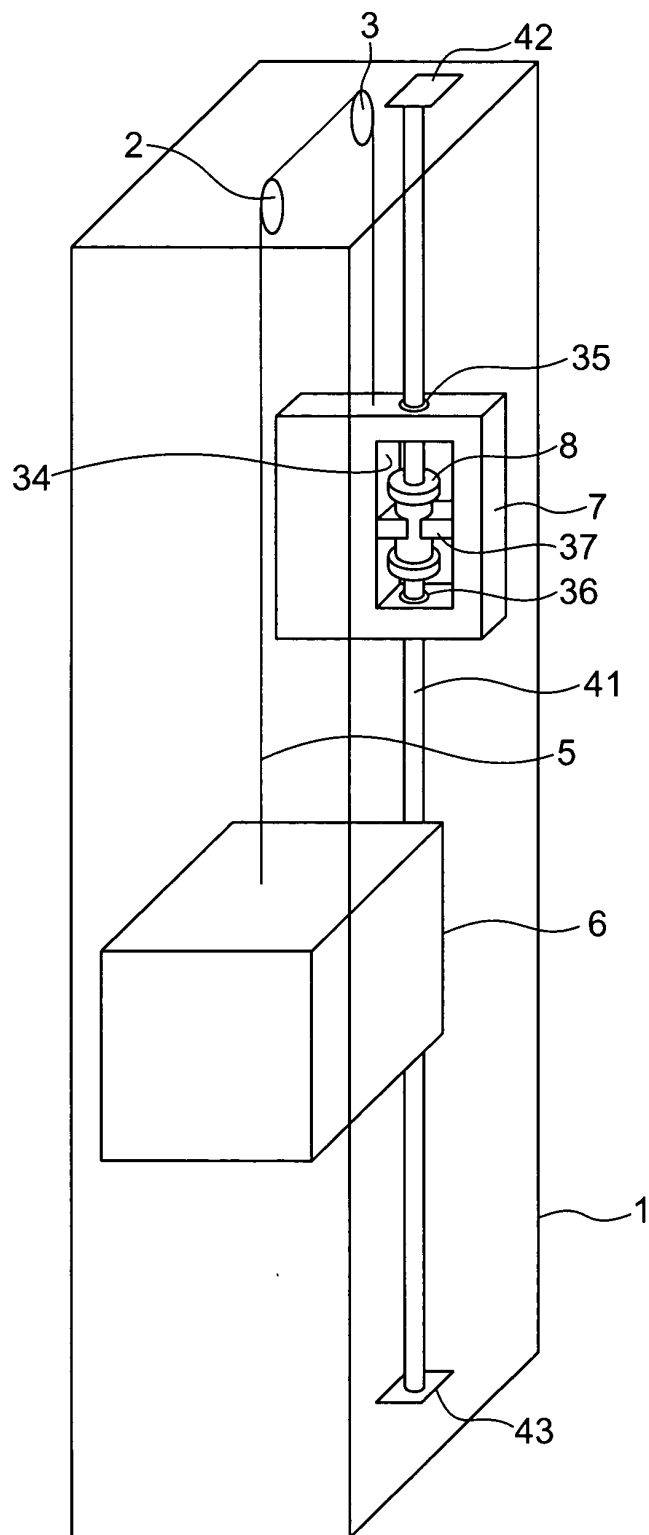


FIG. 6

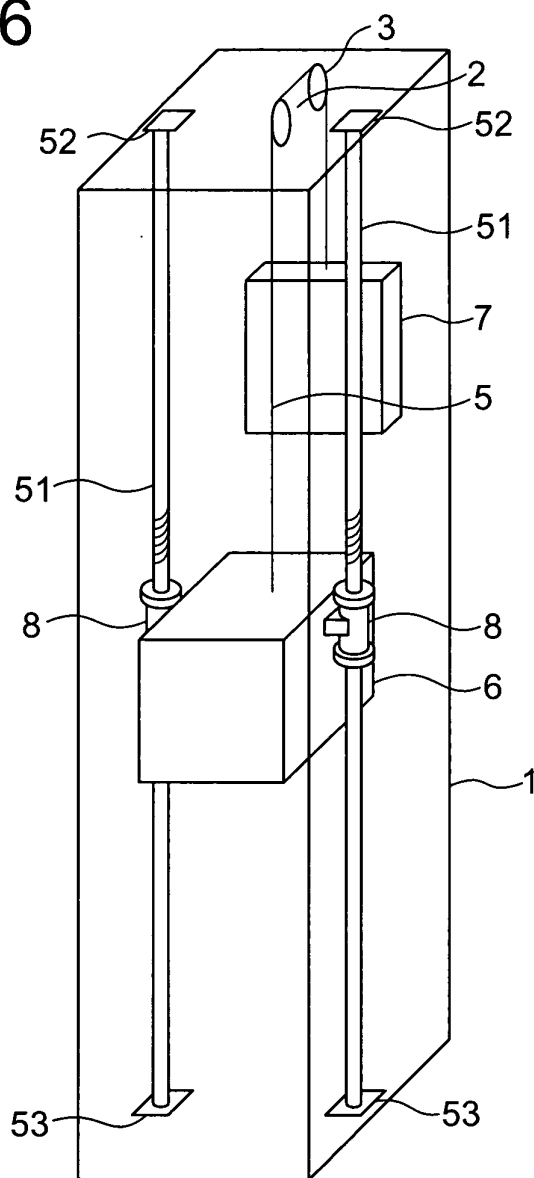


FIG. 7

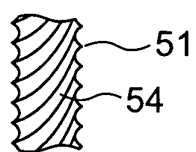


FIG. 8

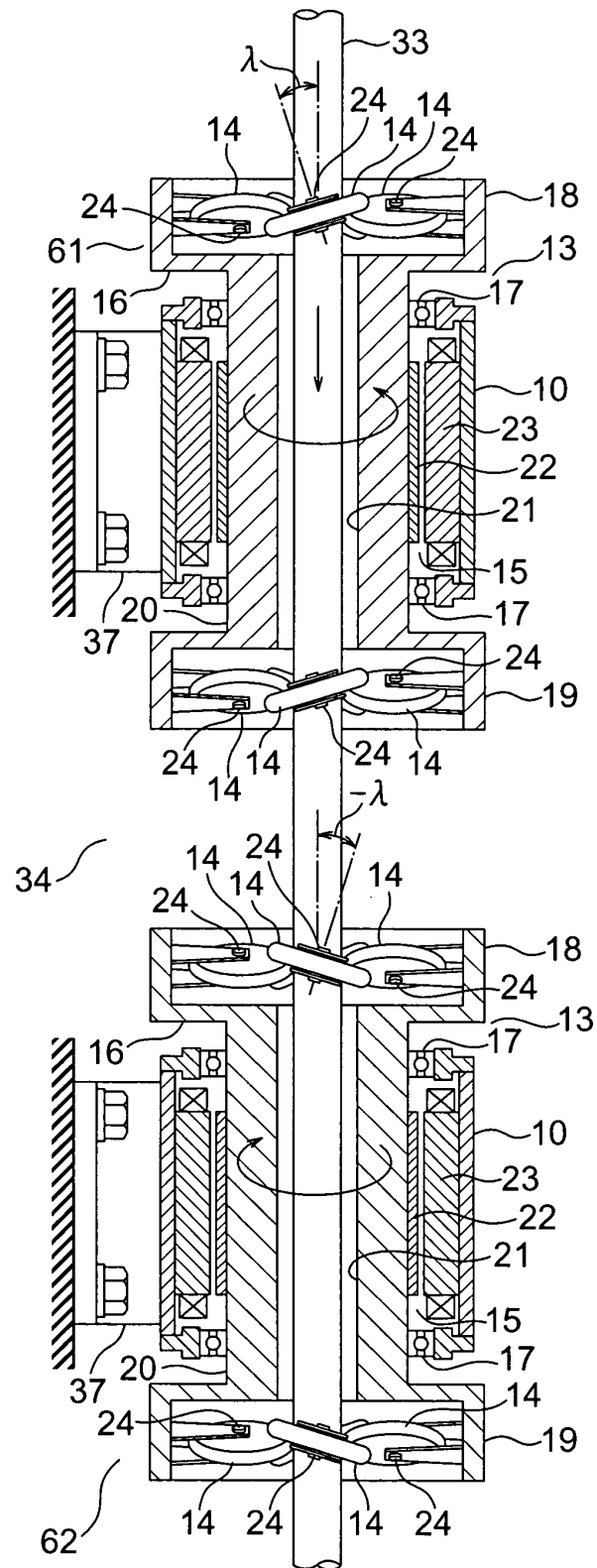
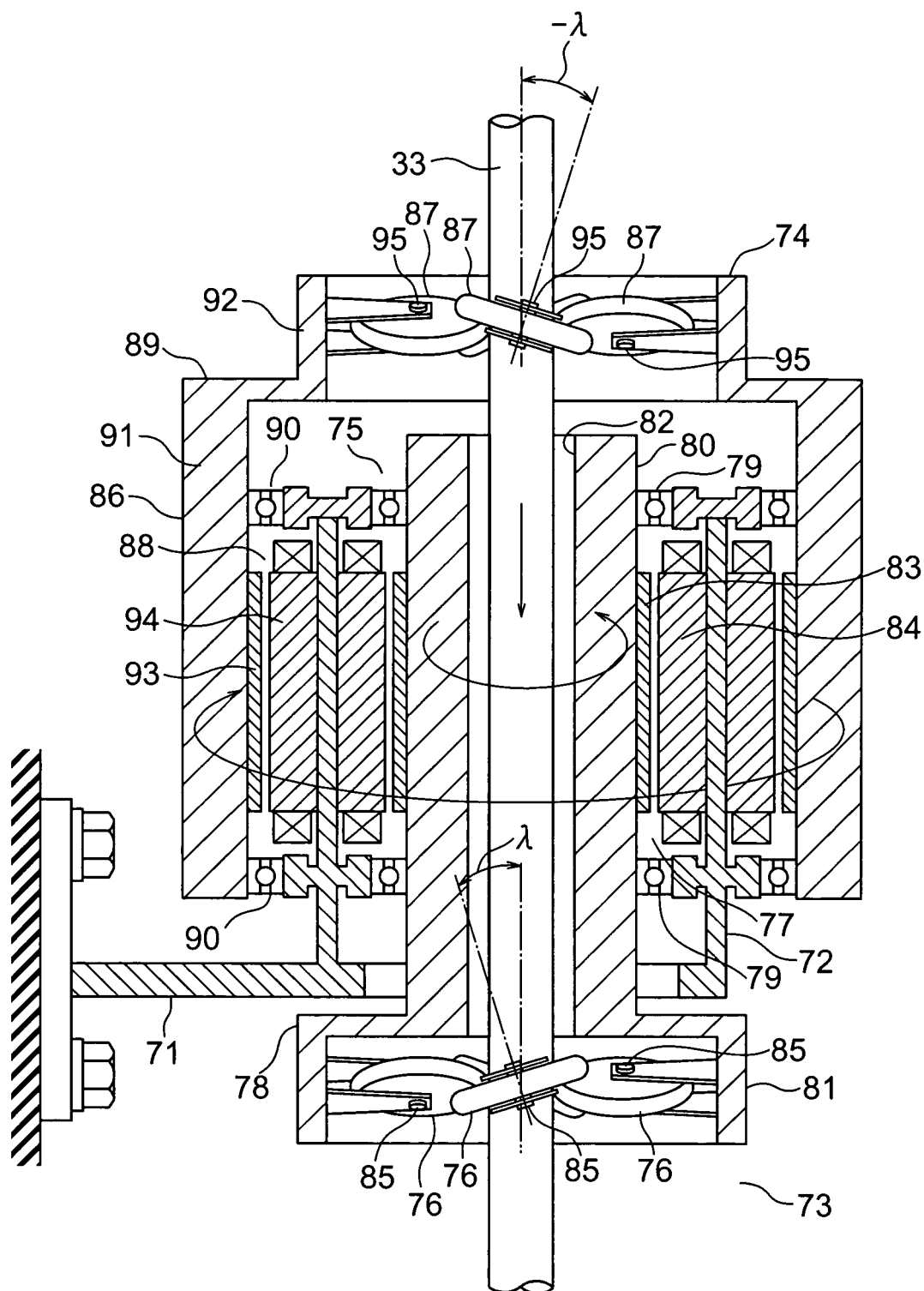


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/007224

A. CLASSIFICATION OF SUBJECT MATTER B66B11/04 (2006.01), B66B9/02 (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), F16H19/02 (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.
Y A	JP 2000-63057 A (Meidensha Corp.), 29 February, 2000 (29.02.00), Abstract; Fig. 1 (Family: none)	1, 6 7-8
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 161801/1980 (Laid-open No. 86077/1982) (Matsushita Electric Industrial Co., Ltd.), 27 May, 1982 (27.05.82), Description, page 1, line 19 to page 3, line 2; Fig. 1 (Family: none)	1-3, 6 7-8
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 13 January, 2006 (13.01.06)		Date of mailing of the international search report 24 January, 2006 (24.01.06)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/007224

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 10-109851 A (Hitachi, Ltd.), 28 April, 1998 (28.04.98), Par. No. [0009]; Fig. 4 Par. No. [0015]; Fig. 5 (Family: none)	2, 4-6 7-8
Y A	JP 6-227776 A (Hidenobu TOYOOMI), 16 August, 1994 (16.08.94), Abstract; Fig. 2 (Family: none)	2, 4-6 7-8
Y	JP 8-285027 A (Nippon Bearing Co., Ltd.), 01 November, 1996 (01.11.96), Abstract; Fig. 2 (Family: none)	5
Y A	JP 45-13762 B1 (Polyprodukte AG.), 18 May, 1970 (18.05.70), Column 3, line 45 to column 4, line 44; Figs. 3 to 5 Column 4, line 45 to column 6, line 4; Fig. 6 & NL 6615420 A & BE 694491 A & FR 1499796 A & AT 259964 B & GB 1110084 A & CH 457070 A & US 3424012 A & SE 336722 B & DE 1550759 A1	6 7-8
Y A	JP 2004-1918 A (Otis Elevator Co.), 08 January, 2004 (08.01.04), Abstract; Fig. 1 (Family: none)	2-3, 6 7-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2002080178 A [0003]