

ELEVATOR APPARATUS

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This invention relates to an elevator apparatus, and more particularly to an elevator apparatus provided with a guide device which can guide a
5 car without shaking or vibrating it.

Generally, a car of an elevator is guided along a pair of guide rails by guide devices comprising guide slide members and guide rollers, and is driven to run in such a manner to be held horizontally. At this
10 time, the position of the gravity center of the car during the operation varies in accordance with the distribution of a live load in the car and the distribution of weights of cables for supplying electric power to the car, a compensation rope, etc., which weights
15 vary with time, so that this gravity center position does not coincide with the axis of suspension of the car. Therefore, the car guide devices, while receiving deflected loads of the car resulting from the deviation of the car suspension axis from its gravity center
20 position, guide the car.

If the guide rail is bent at a portion thereof, the car is subjected to a forcible excitation or vibration due to this bending through the guide devices. In order to reduce a lateral vibration of the
25 car due to this forcible excitation, the guide device

1 guides the car, usually, through guide members in the
form of a resilient support member such as a spring, a
rubber member or the like.

5 In order to prevent the lateral vibration of
the car due to the above-mentioned bending of the guide
rail, it is desired to reduce the elastic constant of
the resilient support member; however, in order to keep
the flexure, due to the deflected load of the car, to
within a predetermined range, so as to guide the car
10 safely, the guide member is required to have a
predetermined rigidity.

Prior art addressing these two problems includes,
for example, Japanese Patent Publication No. 58-39753 and
Japanese Unexamined Patent Publication No. 63-87482.

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These prior art techniques are directed to a
system in which guide portions of a magnetic guide-type
are used to guide a car in a non-contact manner.

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Another example of the prior art is known from
Japanese Unexamined Patent Publication No. 58-104885.

In this prior art, the axis of suspension of a car is
deviated from the position of its gravity center toward
an entrance-exit of the car, and guide devices guide the
25 car in a manner to urge the car against guide rails,
thereby preventing a lateral vibration of the car.

In the above prior art technique using the
magnetic guide system (Japanese Patent Publication No.

1 58-39753 and Japanese Unexamined Patent Publication No.
63-87482), magnetic controllers are required respective-
ly for the guide devices provided in the rail gauge
direction of a pair of guide rails and on opposite sides
5 of a plane in which the guide rails are disposed. A
displacement of the car due to a bending of the guide
rail is detected based on a reference line extending
from an uppermost stair to a lowermost stair, thereby
controlling the position of the car relative to the
10 guide rails. Therefore, this system is quite expensive,
and therefore has a problem that it is not easily
applied to ordinary elevators.

In the above prior art (Japanese Unexamined
Patent Publication No. 58-104885) in which the suspen-
15 sion axis of the car is deviated from the position of
its gravity center toward the entrance/exit of the car,
there is encountered a problem that vibration of the car
due to a bending of the guide rail can not be prevented.

20 With the above problems of the prior art in
view, it would be desirable to
provide an elevator apparatus in which a deflected load
acting on a guide device for a car is effectively
reduced, and a lateral vibration of the car due to a
25 bending of the guide rail due to an error in instal-
lation of a guide rail or aging can be prevented,

1 thereby preventing passengers of the elevator from
feeling uneasy.

It would also be desirable to provide
an elevator apparatus in which a good ride of the
5 elevator can be provided even if a deflected load is
produced in the elevator apparatus.

A further preferred aim is to
provide an elevator apparatus in which a slight bending
of a guide rail produced during the installation thereof
10 can be allowed, thereby enabling an efficient and
rational installation of the elevator.

In this invention we provide anti-deflection
load generating devices on a car which devices reduce
15 deflected loads developing in guide devices and by
making small the elastic constant of resilient support
members for guide members of the guide devices.

The anti-deflected load generating device can
be constituted by magnet means or pneumatic bearing
20 means.

The number of the anti-deflected load gener-
ating means can be reduced by deviating the suspension
axis of the car from the position of its gravity center,
so that the anti-deflected load generating means reduces
25 only the load acting on the guide member disposed on one
side of the guide rail.

In the prior art, the resilient member for
supporting the guide member of the guide device is

1 required to have a sufficient spring constant to
withstand the deflected load acting on the car. In the
present invention, however, since there are used the
anti-deflected load generating devices for reducing the
5 deflected loads, the resilient member of a small spring
constant can be used. As a result,

a forcible excitation of the car due to a
bending of the guide rail can be reduced, thereby
providing the elevator apparatus capable of offering a
10 good ride.

The anti-deflected load generating device may
be constituted by a magnet or a pneumatic bearing. By
deviating the suspension axis of the car from the
position of its gravity center, the deflected load acts
15 only on the guide member disposed on one side of the
guide rail. Therefore, it is only necessary to reduce
the deflected load acting on this guide member disposed
on the one side of the guide rail, so that the number of
the anti-deflected load generating devices can be
20 reduced.

With the suspension
axis of the car deviated from the position of its
gravity center, it is possible to use a hoisting device
having no deflector wheel, and the concept can be
25 applied to an elevator of the hydraulic jack-suspending
type in which the car is suspended at a position
rearwardly of a rear portion of the car remote from its
entrance/exit.

1 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side-elevational schematic view of an elevator embodying the invention;

Fig. 2 is a plan view of this embodiment;

5 Fig. 3 is a side-elevational view showing an anti-deflected load generating device;

Fig. 4 is a graph showing the relation between the amount of flexure of a roller support spring and a spring force;

10 Fig. 5 is a side-elevational view showing a different form of anti-deflected load generating device;

Figs. 6 and 7 are views showing another form of anti-deflected load generating device,
15 used in a guide device of the slide type; and

Fig. 8 is a side-elevational view of another elevator embodying the invention.

DESCRIPTION OF EMBODIMENTS

Embodiments of the present
20 invention will now be described with reference to the drawings.

In Figs. 1 to 3, reference numeral 2 denotes a car (cage), reference numeral 4 a guide rail, reference numeral 6 a guide device, reference numeral 8 a rope,
25 reference numeral 10 a counterweight, reference numeral 12 a drive pulley (sheave), and reference numeral 14 an electromagnet.

1 In the embodiment of the present invention
shown in Figs. 1 and 2, the car 2 is guided by a pair of
guide rails 4 and the guide devices 6 engaged with the
guide rails 4. The car 2 and the counterweight 10 are
5 fixedly secured to the opposite ends of the rope 8,
respectively. The rope 8, extended around the sheave 12
of a hoisting device, is driven by the rotating sheave
12 to move the car 2 upward and downward.

 The axis O of suspension of the car 2 is
10 deviated from the position W of the gravity center of
the car 2 toward the side of the counterweight 10. As a
result, the car 2 tends to tilt or angularly move in a
direction A toward an entrance/exit 2a of the car 2.
The guide devices 6 support deflected (unbalanced) loads
15 due to the tilting of the car 2, and guide the car 2.

 At this time, the guide devices 6 guide the
car 2 in such a manner that the guide load, applied to
one side surface of each of the pair of guide rails 4
via a guide member (roller) 24b (Fig. 3) in a direction
20 perpendicular to the plane of the guide rail 4, is
unbalanced (deflected) with the guide load acting on the
other side surface of the guide rail 4. Each of the
guide devices 6, mounted respectively on the upper and
lower portions of the car 2, has an anti-deflected load
25 generating device which comprises an electromagnet 14
for attracting the guide rail 4 in such a direction as
to reduce the deflected component of the guide load.

1 As best shown in Fig. 3 (which shows the guide
device 6 mounted on the upper portion of the car 2), the
guide device 6 comprises arms 22a and 22b pivotally
mounted at their one ends on bases 18a and 18b by pins
5 20a and 20b, respectively, rollers 24a and 24b supported
respectively on the distal ends of the arms 22a and 22b,
and roller support springs 26a and 26b urging the
rollers 24a and 24b against the opposite side surfaces
of the guide rail 4, respectively. The car 2 is guided
10 by the rollers 24a and 24b to be moved along the guide
rail 4.

The guide device 6 also includes the anti-
deflected load generating device which comprises the
magnet 14 and serves to cancel the deflected load
15 developing in the construction,
as later described. This device cancels the deflected
load, so that the car 2 can be guided without receiving
vibrations. More specifically, the anti-deflected load
generating device attracts the guide rail 4 by the
20 magnet 14, and this attraction force serves to angularly
move the car 2 (on which the guide devices 6 each
provided with the anti-deflected load generating device
(the magnet 14) are mounted) in a direction opposite to
the direction A (Fig. 1) so as to cancel the above-
25 mentioned deflected load. The magnet 14 may be an
electromagnet or a permanent magnet, as later described,
and also may be constituted by a combination of them.

1 Here, assuming that the axis O of suspension
of the car 2 is deviated from the position W of the
gravity center of the car 2 as shown in Fig. 2, the
roller support spring 26a is compressed (Fig. 3), and
5 the roller support spring 26b becomes longer than the
roller support spring 26a. As a result, the base 18a
comes closer to the guide rail 4. Prima facie, each of
the roller support springs 26a and 26b is required to
have a predetermined rigidity acting against expected
10 deflected loads so that the bases 18a and 18b, a brake
member (not shown) mounted on the car 2 for stopping the
car 2 in the event of an emergency, and etc., may not be
contacted with the side surfaces of the guide rail 4.

In that event, were the guide rail 4 to be bent at a
15 portion thereof, the rollers 24a and 24b would be
displaced in an amount corresponding to the amount of this
bending, and a force corresponding to a force $P = krSr$,
(obtained by multiplying the amount Sr of displacement of
the rollers 24a and 24b relative to the bases 18a and 18b
20 by a spring constant kr , which is the resultant of the
spring constants of the roller support springs 26a and
26b), would be as an exciting force acting on the car 2 in
its lateral direction, so that the car 2 would be vibrated
or shaken in its lateral direction.

25 With respect to the flexure-load character-
istics of the roller support springs 26a and 26b, if the
spring constant kr is small when the flexure amount is
in the range of $-\delta_1$ to $+\delta_1$ around the central set value

1 of the guide device 6, as shown in Fig. 4, the exciting
force P causing the lateral vibration can be made
sufficiently small, and a slight bending of the guide
rail 4 can be allowed.

5 To achieve this, it is necessary that the
deflected components of the guide loads acting on the
rollers (guide members) 24a and 24b should be reduced.

But, these deflected load
components vary with a change in the gravity center of
10 the car 2 which change is caused by the distribution of
a live load on the car 2 and a fluctuating load of trail
cords (not shown) for supplying electric power to the
car 2. Therefore, even if the axis of suspension of the
car 2 is set in agreement with the static gravity center
15 of the car 2 determined by the structure of the car 2,
the guide loads acting on the rollers 24a and 24b would
be varied.

In order to control the variation of the guide
loads by the electromagnets, it is necessary that the
20 electromagnets should be provided respectively on both
side surfaces of the guide rail so as to achieve this
control even when the deflected load acts in either of
the direction A (Fig. 1) and the direction opposite
thereto.

25 In the arrangement shown here,
however, since the axis O of suspension of the car 2 is
deviated from the gravity center position W of the car
2, one of the guide loads acting respectively on the

1 rollers 24a and 24b is always greater. Therefore, by
reducing the deflected load component of the greater
guide load by means of the electromagnet, the deflection
(unbalance) of the guide loads acting on the rollers 24a
5 and 24b can be prevented.

As a result, the number of the
electromagnets for control-
ling the deflected loads can be reduced to half
that otherwise required, and the deflected load
10 control can be achieved at lower costs. And besides,
since the deflected load is reduced by the anti-
deflected load generating device, the displacement of
the guide device is reduced, so that the spring constant
 k_r of the roller support springs can be reduced. There-
15 fore, the forcible exciting force acting on the car 2 in
its lateral direction due to the bending of the guide
rail can be reduced, so that the lateral vibration of
the car 2 can be prevented.

Incidentally, preferably, the spring constant
20 k_r of the roller support springs should be large when
the amount of flexure of the spring is above an appro-
priate value of δ_2 , as shown in Fig. 4, so as to prevent
part of the car 2 from being contacted with the guide
rail.

25 In the embodiment of the present
invention shown in Figs. 1 and 2, other advantageous
effects, obtained by deviating the axis of suspension of

1 the car from the gravity center position, will now be described.

In conventional elevator devices of the type in which the axis O of suspension of the car generally
5 coincides with the position W of the gravity center of the car, so that the interval B between the axis S of suspension of the counterweight 10 and the position W of the gravity center of the car 2 is greater than the diameter C of the sheave 12 (the relation between the
10 gravity center position of the car and the axis of suspension of the counterweight is usually established in this manner), the interval between the axis O of suspension of the car 2 and the axis S of suspension of the counterweight 10 is greater than the diameter C of
15 the sheave 12, so that the car 2 will impinge upon the counterweight 10. To avoid this, the hoisting device comprises a deflector wheel for increasing the interval between the opposed straight portions of the rope.

On the other hand, in the arrangement
20 shown here, the axis O of suspension of the car 2 is disposed closer to the axis S of suspension of the counterweight 10, and the deflected load produced by this arrangement is canceled by the anti-deflected load generating device, and the interval between the suspen-
25 sion axes O and S can be made generally equal to the diameter C of the sheave 12. Therefore, a deflector wheel is not needed, and the space for installing the hoisting device can be made small.

1 In the arrangement shown here, by
obviating the need for a deflector wheel as described
above, the angle (lap angle) of contact of the rope 8
around the sheave 12 is increased, and therefore a slip
5 of the rope 8 relative to the sheave 12 is reduced,
 increasing a lifetime of the rope 8. Also, even
in the case where the car 2 is made more lightweight,
the car of the elevator can be started and stopped
without causing a slip of the rope.

10 While the anti-deflected load generating device
is constituted by an electromagnet 14, a permanent
magnet 28 may be incorporated in the magnetic path of
the electromagnet 14 (anti-deflected load generating
15 device) so that the attraction force of this permanent
magnet can undertake part of the canceling of the
deflected load component. By doing so, the magneto-
motive force of a coil 30 of the electromagnet 14 is
reduced, and the attraction force of the electromagnet
20 14 can be controlled.

 The deflected load
component can be reduced even if the anti-deflected load
generating device is constituted entirely of a permanent
magnet. However, in this case, the attraction force can
25 not be controlled, and therefore a stopper for prevent-
ing the permanent magnet from being contacted with the
guide rail needs to be mounted on the arm 22b.

1 The attraction force of the electromagnet 14
can be controlled by a signal from a load gauge for
detecting the spring force of the roller support spring
or a signal from a displacement gauge for detecting the
5 flexure of this spring. By doing so, a uniform control
of the guide loads acting on the rollers 24a and 24b can
be effected.

 The deflected load component, produced by the
deviation of the suspension axis of the car 2 from its
10 gravity center position, hardly varies during the
running of the elevator. On the other hand, lateral
vibration components during the running of the elevator
are contained in the signal from the above-mentioned
detector for controlling the electromagnet 14. There-
15 fore, these components are removed from the signal by a
low-pass filter or the like, and thereafter the signal
is used for controlling the attraction force of the
electromagnet 14.

 Fig. 5 shows a different form of anti-deflected
20 load generating device embodying the invention.

 In Fig. 5, as described above for Fig. 3, a
guide device 6 guides a car 2 in such a manner that a
guide load on a roller 24a is greater than a guide load
on a roller 24b.

25 In the anti-deflected load generating device
shown in Fig. 5, a pneumatic bearing 32 mounted on a
base 18a acts on one side surface of a guide rail 4
disposed in contact with the roller 24a, and an air

1 pressure is supplied to the pneumatic bearing 32 via an
air source controller 34 and a pipe 36, and this pres-
sure is controlled in accordance with spring forces or
flexures of roller support springs 26a and 26b. With
5 this arrangement again, the deflected load component
acting on the roller 24a can be reduced, and similar
effects as described above for the preceding embodiment
can be achieved.

In the above embodiments, although the guide
10 devices of the roller guide type are used, the present
concepts can also be embodied in devices of the
slide type.

Figs. 6 and 7 shows an anti-deflected load
generating device incorporated in a guide device of the
15 slide type. In this
case, as in the guide device of the roller guide type, a
deflected load component acting on a side surface of a
guide rail can be controlled.

In Fig. 6, a slide type guide member 40
20 engaged with the guide rail 4 is fixed to a frame 44
through rubber members (resilient guide members) 42a and
42b, and the frame 44 constitutes the guide device of
the slide type mounted on a car 2.

In this guide device of the slide type, an
25 electromagnet 46 mounted on the frame 44 constitutes the
anti-deflected load generating device, and therefore
similar effects as described for the above embodiments
can be achieved.

1 Fig. 8 shows a different general arrangement of
elevator apparatus.

 In ~~this~~ arrangement, the axis of suspen-
sion of a car is deviated to such an extent that a guide
5 load of a guide device is disposed on one side of a
guide rail.

 The axis O of suspension
of the car 2 is disposed exteriorly of a floor 50 of the
car 2. A rope 54, connected between the suspension axis
10 O and a building foundation 60, supports the car 2
through a deflector wheel 58 mounted on a distal end of
a hydraulic plunger 56, and the car 2 is driven by the
hydraulic plunger 56.

 In such a typical hydraulic elevator of the
15 back plunger type, since the suspension axis O of the
car 2 is disposed exteriorly of the floor 50, the guide
load acting on the guide device 6 acts only on one side
surface of the guide rail 4 regardless of the distribu-
tion of a live load in the car 2.

20 Therefore, generally, in this type of elevator
apparatus, a large guide load acts on a roller 52 of the
guide device 6, and therefore a support spring 62 for
this roller is required to have a high rigidity, and the
car 2 is liable to vibration under the influence of a
25 bending of the guide rail and an irregularity in the
shape of the roller 52.

 The present concepts may also be applied to
such a roping-type elevator apparatus in which the car

1 is suspended by a rope. More specifically, electro-
magnets 64 constituting anti-deflected load generating
devices are mounted respectively on the upper and lower
portions of the car 2. Each of the electromagnets 64
5 serves to reduce the guide load acting in one direction,
and reduces a strain due to a creep of the roller 52.
The anti-deflected load generating device can be similar
in construction to any of the above-mentioned types, and
by doing so, the comfort of a ride can be improved.

10 While in the above embodiments of the invention
the suspension axis of the car is deviated from
the position of the gravity center of the car in the
direction perpendicular to the plane of the entrance/
exit of the car, the axis may alternatively deviate
15 from the gravity center position in a direction parallel
to the plane of the entrance-exit of the car.

As described above, the suspension axis of the
car is deviated from the position of the gravity center
of the car, and the deflected load component of the
20 guide load acting on the guide device for the car can be
reduced by the anti-deflected load generating device.
Therefore, the guide device does not need to directly
bear the deflected load, and the spring constant of the
support spring for the guide member of the guide device
25 can be reduced. As a result, vibration due to a bending
of the guide rail can be reduced.

The guide load acting in the direction
perpendicular to the plane of the guide rail is designed

1 to produce the deflected load acting on the guide rail
in one direction, and therefore the number of the anti-
deflected load generating devices can be reduced to a
half of the number heretofore required, and therefore
5 the manufacturing cost of the elevator apparatus can be
reduced.

Since the provision of the anti-deflected load
generating devices allows the deviation of the suspen-
sion axis of the car, the interval between the suspen-
10 sion axis of the car and the suspension axis of the
counterweight can be made generally equal to the
diameter of the sheave of the hoisting device, and with
this arrangement, the hoisting device can be of a
compact size. Also, since the lap angle of the sheave
15 is about 180° , a sufficient hoisting force can be
ensured even if the tension of the rope is small, and
therefore the car can be lightweight.

In the roping of the hydraulic elevator
apparatus of the back plunger type in which the
20 deflected load of the guide device acts only in one
direction, the guide load of the guide device is large;
however, by the use of the anti-deflected load gener-
ating device as described herein this guide load
can be reduced, and therefore a comfortable ride can be
25 provided for the hydraulic elevator apparatus.

Furthermore, bending
of the guide rail can be allowed to a certain extent,

- 1 and therefore the installation of the guide rail can be facilitated.

CLAIMS:

1. Elevator apparatus comprising

a car, a pair of guide rails, upper and lower guide
5 devices mounted respectively on upper and lower portions
of the car and co-operating with the guide rails to align
the car, and

means for providing a car deflection bias load,
acting perpendicularly sideways against a guide rail side
10 surface permanently in one direction through each guide
device;

wherein each guide device comprises

(a) an anti-deflection load generating device acting
between the car and respective guide rail to counter
15 the car deflection bias load and thereby steady the
car, and separately

(b) a guide member mounted by a resilient support of
small spring constant so as to be movable in the
guide device in a direction perpendicular to the
20 guide rail, and engaging the respective guide rail to
guide the guide device along the guide rail.

2. Elevator apparatus according to claim 1 in which the
car deflection bias load is provided by means for
25 producing a tilting moment in the car, the anti-deflection
load generating device acting to produce an anti-tilting
moment.



3. Elevator apparatus according to claim 2 in which the car deflection bias load is provided by suspending the car at a suspension axis offset from the centre of gravity of the car.

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4. Elevator apparatus according to claim 3 in which the car is suspended on a rope which passes through a hoisting drive sheave, a counterbalance being suspended on the rope on the other side of the sheave, the horizontal distance
10 between the car's axis of suspension and the axis of suspension of the counterbalance being substantially equal to a diameter of the sheave.

5. Elevator apparatus according to claim 3 in which the
15 car is suspended on a rope at a suspension location behind the car, and the rope is connected to a hydraulic jack for driving the car.

6. Elevator apparatus according to any one of the
20 preceding claims in which each anti-deflection load generating device acts on the guide rail from only one side.

7. Elevator apparatus according to any one of the
25 preceding claims in which the anti-deflection load generating device comprises means for attracting the guide rail magnetically.



* C L M S *

8. Elevator apparatus according to claim 7 in which the anti-deflection load generating device comprises a permanent magnet permanently attracting the guide rail.
- 5 9. Elevator apparatus according to claim 7 in which the anti-deflection load generating device comprises an electromagnet.
- 10 10. Elevator apparatus according to claim 9 in which the anti-deflection load generating device comprises also a permanent magnet provided in the magnetic path of the electromagnet.
- 15 11. Elevator apparatus according to any one of claims 1 to 6 in which the anti-deflection load generating device comprises a pneumatic bearing for repelling the guide rail surface.
- 20 12. Elevator apparatus according to any one of claims 9 to 11 in which means are provided for controlling the force applied by the anti-deflection load generating device in dependence on either of
- 25 (a) a detected spring force arising in the resilient support member of the guide member, or
- (b) a detected degree of flexural displacement of the resilient support member of the guide member.
13. Elevator apparatus according to any one of the



preceding claims in which the guide members are rollers rolling against the guide rails.

14. Elevator apparatus according to any one of claims 1
5 to 12 in which the guide members are sliders sliding against the guide rails.

15. Elevator apparatus according to claim 1,
substantially as described and shown herein with reference
10 to the accompanying drawings.

