

"ELEVATOR APPARATUS"

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The present invention relates to an improvement of an elevator apparatus and, more particularly, to an improved elevator apparatus having an enhanced level
5 of safety at the time when the brake device is out of normal operation.

In general, an elevator driving system is of a type wherein sheaves are rotated by an electric motor and an elevator cage and a balance weight suspended
10 from the sheaves in the form of a well bucket are raised or lowered. In many cases, therefore, the sheaves are affected by an unbalance torque due to the difference in weight between the elevator cage and the balance weight. Therefore, a brake device, which functions to stop and
15 retain or support the elevator cage at their stopped position, is required to have a high level of safety.

For the above-mentioned reasons, a rigid drum type electromagnetic brake, which is disclosed in, for example, Japanese Patent Unexamined Publication No.
20 57-1180, has hitherto been employed.

Meanwhile, in an elevator equipped with a gear reducer called "geared elevator", a worm gear reducer has hitherto been employed. With this worm gear, the efficiency of torque transmission from an electric motor
25 to sheaves is very high whereas the retrograde

1 efficiency of torque transmission from the sheaves to an
electric motor is considerably low. Accordingly, this
worm gear reducer is advantageous in respect of
lessening the possibility that the normal rotation of
5 the electric motor is hindered by the unbalance torque.

On the other hand, the use of a parallel axis
gear reducer has recently been proposed in place of such
worm gear reducer.

In this case, however, the retrograde efficiency
10 also is increased with the result that much more care
must be taken about the safety of the brake device.

Further, for miniaturization of the brake device,
change-over from the drum type electromagnetic brake
device to a disk type brake device has also been proposed.

15 In the field of a disk type brake device,
detection of the operating condition of a brake device is
known as disclosed in Japanese Patent Unexamined
Publication No. 58-109741.

Further, in the field of an elevator, it is
20 known that an unbalance torque is detected on the basis
of an amount of displacement of a retainer or support
section for the electromagnetic brake device to thereby
be used for control of the brake as in said Japanese
Patent Unexamined Publication No. 57-1180, or that an
25 unbalance torque as in Japanese Patent Unexamined Publica-
tion No. 62-56277 is detected on the basis of distortion
of a retainer section for the electromagnetic brake
device to thereby be used for control of, for example,

1 starting compensation for an elevator.

The safety and reliability of brake devices including the disk type brake device, etc. have already been established. In case of elevators, however, it is
5 desirable to take perfect measures for safety.

What is the most important matter for the brake device of an elevator is as follows. Namely, during the running of an elevator, electricity is supplied to braking coils. When, however, the attractive force of
10 the braking coils has decreased for some malfunction to amount to half of a normal attractive force, an armature of the brake is caused to contact with a lining thereof while the latter is being rotated. The wear of the lining thus is further vigorous due to the
15 friction between the two until a braking force could not be obtained even if the supply of electricity to the coils is paused. This is a very important point which may lead to accidents resulting in injury or death, for the brake device for causing the elevator to be
20 stopped and supported or retained at its stopped position.

In an elevator including many operating conditions, or in an elevator in which an unbalance torque always acts, it is desirable to prevent the occurrence of any accident when some malfunction occurs in the
25 brake device including a disk brake device and the like. To this end, it is also desirable to realize such a system as would be able to prevent the occurrence of any such accident.

Accordingly, an object of the present invention is to reduce the possibilities of accidents by way of precaution against abnormality or malfunction of the brake device included in the elevator apparatus.

The present invention is directed to an elevator apparatus including an electric motor for driving an elevator, an elevator cage raised or lowered by the electric motor, and a brake device for stopping and retaining in its stopped position an elevator driving system, the elevator apparatus being characterized by a malfunction detecting means operative in response to the application of a torque to a retainer section of the brake device during the raising or lowering of the elevator cage.

The present brake device generates a braking force by stopping and retaining its torque by means of its retainer section. On the other hand, the brake device causes its retainer section to release its rotating body, for free rotation. The most dangerous malfunction happens when the retainer section loses its ability to stop and retain the rotating body. That is, when the rotating body must have been being released, the rotating body and the retainer section are in a half-contact condition (i.e., the half-attraction of the rotating body by the retainer section takes place), so that the rotating body continues to move while rubbing

the braking surface, or lining, of the brake device. Consequently, the stopping and retaining (braking) ability of the retainer section comes to be decreased or lost due to wear or burning.

For the above-mentioned reasons, a half-contact condition (half-attraction) with respect to the rotating body and the retainer section of the brake device during the raising or lowering of the elevator cage is detected on the basis of the acting of torque upon the retainer section so that some measures for precaution are taken.

By so doing, it is possible to greatly lessen the possibility that the brake device loses its ability of stopping and retaining the elevator driving system at its stopped position to cause the occurrence of serious accidents.

In another aspect the present invention provides an elevator apparatus including an electric motor for driving the elevator apparatus, an elevator cage lifted or lowered by said electric motor, and a brake device for causing an elevator driving system to be stopped and retained, characterized by a resiliently supported retainer section for a rotating body, means for detecting the rotating displacement of said retainer section, and a malfunction detecting means operative in response to the operation of said displacement detecting means during the lifting or lowering of said elevator

cage.

In a further aspect the present invention provides an elevator apparatus including an electric motor for driving the elevator apparatus, a hoist having sheaves adapted to be driven by said electric motor, an elevator cage and a balance weight suspended from said sheaves in a manner like a well bucket via a rope, and a brake device for holding an unbalance torque produced between said elevator cage and said balance weight, characterized by said brake device comprising a brake disk, a disk-retainer section resiliently supported for retaining or releasing said brake disk, a switch means operative in response to the rotation and displacement of said disk-retainer section in a normal or reverse direction, a malfunction detecting means operative in response to the operation of said switch means during the lifting or lowering of said elevator cage, and means responsive to an output from said malfunction detecting means to effect emergency suspension of said elevator cage.

The present invention will now be described in greater detail by way of example with reference to the accompanying drawings, wherein:-

Fig. 1 is a schematic constructional view of an elevator apparatus as a whole according to an embodiment of the present invention;

Fig. 2 is a front view of a disk brake device for use in an elevator thereof;

Fig. 3 is a sectional view taken along the line III-III of Fig. 2;

Figs. 4 and 5 are flow charts for processing operations performed by a brake-malfunction detecting section according to an embodiment of the present invention; and

Fig. 6 is an illustration of the operation

1 of the detecting section.

A preferred embodiment of the present invention will now be described with reference to Figs. 1 to 6.

5 Fig. 1 is a schematic constructional view of the entire elevator apparatus according to an embodiment of the present invention. The elevator apparatus includes an elevator cage 1 and a balance weight 2, which are connected to each other by means of a length of
10 rope 3 and which are suspended from sheaves 4 in the form of a well bucket. The sheaves 4 are connected to an elevator-driving three-phase induction motor 6 via a parallel axis gear reducer 5.

A control device 7 includes a velocity command
15 generating section 71, a torque command generating section 72, and a torque control section 73 having a PWM inverter. A velocity command which has been issued from the velocity command generating section 71 is supplied to the section 72 which supplies a torque
20 command to the torque control section 73. The torque control section receives as a feedback input an output from a velocity detector (pulse encoder) 8 to make vector control of the frequency ω , phase θ and current i of a three-phase alternating electric power supplied to the
25 induction motor 6.

The control device 7 further includes an elevator operation control section 74 for effecting

1 other control required for an elevator than the velocity
control, and a brake malfunction detecting section 75
which constitutes an essential part of the present
invention. This brake malfunction detecting section 75
5 executes its processing operations by means of a
microcomputer within the control device 7, which process-
ing operations will be later described with reference
to a flow chart.

A disk brake 9 includes a rotating body 91
10 connected to an elevator driving system including
sheaves 4, a reducer 5 and the electric motor 6, and a
retainer section 92 for causing the rotating body 91
to be braked or stopped and retained at its stopped
position. The retainer section 92 is elastically
15 supported on a structure of a machine room by means of
an elastic body 925. When a switch 94 is closed, the
retainer section 92 releases the rotating body 91 so as
to make it freely rotatable. When the switch 94 is
opened, the retainer section 92 brakes the rotating
20 body 91 to stop and retain the same at its stopped
position. The retainer section 92 is equipped with a
pair of cams 928 and 929. Rotation of the cams in a
normal or reverse direction causes the closing of the
microswitch 10.

25 Meanwhile, a contact 11, which is turned on
when the elevator cage 1 is located at other positions
than a zone of door opening of each floor, and a contact
12, which is turned on when the travel or running speed

1 of the elevator is higher than a specified speed, are
connected in series (AND circuited) to energize a relay
13. Accordingly, while the elevator cage is running
at areas other than the door opening zone of each floor
5 at high speed, the relay 13 is energized to close its
contact 131 to thereby make the operation of the
microswitch 10 effective, which energizes a relay 15.
Upon energization of the relay 15, a signal therefrom is
supplied to the brake malfunction detecting section 75
10 within the control device 7.

When the elevator cage 1 is being stopped at
any given floor and when, during this stoppage, three
minutes lapse without a sign for starting the running of
the elevator, the contact 14 is turned on to energize the
15 relay 13 to make the contact 131 "on" to thereby make the
microswitch operation effective. This starts the
checking of the function of the brake malfunction
detecting section per se as later described.

Fig. 2 is a front schematic view of the disk
20 brake device, and Fig. 3 is a sectional view taken along
the line III-III of Fig. 2.

The brake device basically comprises the
rotating body 91 connected to a rotating shaft of the
elevator driving system and adapted to rotate, and the
25 retainer section 92 for effecting the braking of the
rotating body 91 to stop and retain the same at its
stopped position. The rotating body 91 comprises a
brake disk 914 provided with a lining 913 and mounted

1 on a hoist shaft 911 by way of a spline 912. On the
other hand, the retainer section 92 of the brake device
comprises coils 921, 922, a spring 923, a movable member
924, etc. as known disk brake members. It is to be noted
5 in this connection that the retainer section 92 as a
whole is coupled, via elastic members or rubber members
925 to 927, to a member 51 secured to the reducer (hoist)
5, and that the retainer section 92 can be displaced by
rotation through an angle of small degrees. In order to
10 detect this rotary displacement by means of the microswitch
10, the pair of cams 928 and 929 are provided.

In the disk type electromagnetic brake device
9 having the described construction, during the halt of
the elevator, the movable member 924 is biased by
15 means of the spring 923 to clamp the disk 914 and the
lining portions. Thus, the device 9 overcomes the
unbalance torque by its frictional force developed
between the member 924 and the lining, thereby applying
a braking force onto the elevator driving system to
20 maintain the same at its stopped position.

When it is desired to start the running of the
elevator, the switch 94 shown in Fig. 1 is closed to
energize the coils 921 and 922, thereby attracting the
movable member 924 to release the disk to make the same
25 freely rotatable.

Since the brake device is of a structure wherein
its retainer section is elastically and rotatably
supported by the hoist, the retainer section 92 is

1 displaced in the rotational direction of a brake shaft
when the braking is to be effected. This displacement
actuates the microswitch 10 provided on the stationary
side, thereby providing detection of application of the
5 brake torque. Normally, during the travel of the
elevator, the brake disk is released and made freely
rotatable. That is, the brake torque is zero.
However, when the elevator runs in a state wherein the
brake device is in a condition of half-attraction due
10 to some malfunction, some torque is applied onto the
brake disk, so that the microswitch acts. Namely,
malfunction of the brake device can be detected on the
basis of a running signal of the elevator and an operation
signal of the microswitch.

15 Figs. 4 and 5 are flow charts illustrating an
example of the processing operation performed by the brake
malfunction detecting section 75 according to the present
invention.

Firstly, it is judged in step 101 whether or
20 not the elevator is running or traveling. If the
elevator is traveling (YES), the operation proceeds to
step 102 in which it is confirmed that the traveling
speed is higher than a predetermined value. If the
traveling speed of the elevator is higher than a
25 predetermined traveling speed, the operation proceeds to
step 103. In this step 103, it is judged whether or not
the elevator cage is located at other position than
the door opening zone. Accordingly, insofar as the

1 elevator cage 1 is traveling at an area other than the door
opening zone at high speed, the operation proceeds to
step 104, in which it is confirmed whether or not the
brake operation switch (microswitch) 10 is in normal
5 operation.

In Fig. 1, illustration is made in the form
wherein the processing operation is executed by the relay
sequence up to a midway of step 104 following steps
101 to 103. Depending upon whether or not the relay 15
10 is energized, it is judged whether or not the brake
device 9 involves malfunction.

By way of the foregoing operations, the follow-
ing operations are carried out. Namely, when the brake
device has been brought to a state of half-attraction
15 during the running of the elevator such that the disk
rotates while rubbing the lining, the relay 15 is
energized. Continuation of this energization for three
seconds causes the brake malfunction detecting section
75 to judge that the brake device is in malfunction
20 (step 105) and to execute the following processing of
precaution. After judgement of malfunction has been
made, the elevator can be high-speed travelled to the
nearest floor, while according to this embodiment the
elevator is stopped in an emergency as a temporary
25 measure in step 106. Then, in step 107, the elevator
cage 1 thus once halted is low-speed traveled to the
nearest floor for rescue.

However, in case the low-speed operation for

1 rescue is not ended within a specified period of time,
there exists a possibility that the brake device has been
further worn or damaged and the operation for rescue is
then regarded as being in danger, so that the elevator
5 is stopped (steps 108 and 109). If the elevator cage
reaches the nearest floor within such specified period
of time, an elevator door would be opened in step 110
and, after escape of passengers, be again closed and the
elevator would be stopped in step 111. Simultaneously,
10 display is made, in a supervisor room, of the informa-
tion that "The Elevator Is Stopped Due To Malfunction
of The Brake Device".

On the other hand, in case the answer to the
question in steps 102 and 103 is "NO", malfunction
15 diagnosis is not made. The reason for this is as follows.

In order for the elevator to be halted, the
relay 13 is not energized and its contact 131 is kept
open when the elevator is running at low speeds or the
elevator cage is located within the zone of door opening
20 such that the brake device 9 is frequently actuated.
Each time the frequent halting of the elevator is
effected, the brake device 9 operates and the micro-
switch 10 also operates. Therefore, if energization and
deenergization of the microswitch 10 are repeated for
25 each such normal operation, the microswitch 10 would be
reduced in service life and its electric service life
would be ended within a term of even one year.

A contact of the microswitch has a sufficient

1 length of mechanical service life but is short in its
electric service life which amounts to an extent of five
hundred thousand times. The elevator is a machine
which has high frequency in starting and which can be
5 started about two thousand times a day. Each time
the starting and halting of the elevator are effected,
the brake device repeats its attraction and release.
Therefore, since the contact of the microswitch also is
turned on and off accordingly, the microswitch will fail
10 to stand a term of even one year. In contrast, according
to this embodiment, at the time of normal stoppage of
the elevator, the microswitch effects neither energiza-
tion nor deenergization, so that it is possible to extend
or prolong the electric service life of the microswitch
15 semi-permanently.

Further, the reason why, in steps 104 and 105,
it is judged that the brake device is in malfunction only
when operation of the microswitch 10 continues for three
seconds or more is for the purpose of overlooking
20 chattering of the contact, some erroneous operation
due to non-reproducible and transitory noises, etc.

Now, in case it is judged in step 101 that the
elevator is kept halted, the operation proceeds to steps
in a flow chart of Fig. 5. In case it is judged that
25 three minutes have lapsed after the ending of a sign
to start the running of the elevator, the relay 13 is
turned on in step 113. Namely, in Fig. 1, the relay 13
is compulsively turned on by closure of the contact 14

1 adapted to be turned on when three minutes have lapsed
after ending of the sign. Then, the contact 131 of the
relay 13 is closed. Accordingly, by utilizing the
operation checking function of the microswitch 10 in
5 Fig. 1, the operation thereof is confirmed or checked
in step 114. Thus, the result of this confirmation is
sent to the brake malfunction detecting section 75 in
the form of an "on" or "off" information of the relay 15.
If the microswitch 10 is in operation, it is judged in
10 step 115 that the brake device is in a normal state of
operation and the checking of the brake device by the
microswitch then is finished. If three minutes have lapsed
after ending of the sign, insofar as the brake device is
normal, the retainer section 92 would be rotated and
15 displaced with the result that the microswitch 10 must
also be in operation. This is because the elevator
cage 1 is empty and therefore the balance weight 2 is
heavier than the elevator cage and therefore this
unbalance torque is rendered ineffective by action of
20 the brake device 9, so that the two are retained at
their stopped positions. When it is now assumed that the
microswitch 10 at this time is kept out of operation,
then it is judged in step 116 that the brake abnormality
detecting function is out of normal operation. Thus,
25 in step 117, the running of the elevator is stopped and
an information to this effect is given to the supervisor
room.

Fig. 6 is an illustration of the contacts in

1 steps 102 and 103 and the malfunction diagnosis action
in Fig. 5. When the elevator cage is located in the
zone of door opening or runs at low speeds, the relay 13
in principle is turned off to make the brake abnormality
5 detecting function inoperative. When, at this time,
any sign for elevator-starting is not given for three
minutes or more, the checking of whether or not said brake
abnormality detecting function per se can normally
operate is executed. Since this brake abnormality
10 detecting function works rarely, it is of significance to
check whether or not it can normally operate.

According to the present invention, it is
possible to lessen the possibility of accidents due to the
malfunction of the brake device of the elevator apparatus.



CLAIMS:-

1. An elevator apparatus including an electric motor for driving an elevator, an elevator cage raised or lowered by said electric motor, and a brake device for stopping and retaining in its stopped position an elevator driving system, the apparatus being characterized by a malfunction detecting means operative in response to the application of a torque to a retainer section of said brake device during the raising or lowering of said elevator cage.
2. An elevator apparatus according to Claim 1, wherein said malfunction detecting means operates in response to application of torque to said retainer section of said brake device being continued for a predetermined period of time or more.
3. An elevator apparatus according to Claim 1, further comprising means for stopping said elevator cage in response to an output from said malfunction detecting means.
4. An elevator apparatus according to Claim 1, further comprising means for causing said elevator cage to halt at the nearest floor in response to an output from said malfunction detecting means.
5. An elevator apparatus according to Claim 1, further comprising means for causing said elevator cage to once halt in response to an output from said malfunction detecting means and then be moved and halted at the nearest floor.
6. An elevator apparatus according to Claim 4 or



5, further comprising means for stopping said elevator cage in response to a predetermined period of time being exceeded by a period of time during which said elevator cage is run by said means for causing said elevator cage to stop at said nearest floor.

7. An elevator apparatus according to Claim 1, wherein said malfunction detecting means comprises an electric switch means, and means for rendering ineffective the detecting function of said malfunction detecting means when said elevator cage is located in a door opening zone of each floor.

8. An elevator apparatus according to Claim 1, wherein said malfunction detecting means comprises an electric switch means, and means for rendering ineffective the detecting function of said malfunction detecting means when the running speed of said elevator cage is less than a predetermined value.

9. An elevator apparatus according to Claim 7 or 8, further comprising means for confirming the operation of said electric switch means when suspension of said elevator cage continues for a predetermined period of time or more.

10. An elevator apparatus including an electric motor for driving the elevator apparatus, an elevator cage lifted or lowered by said electric motor, and a brake device for causing an elevator driving system to be stopped and retained, characterized by a resiliently supported retainer section for a rotating



body, means for detecting the rotating displacement of said retainer section, and a malfunction detecting means operative in response to the operation of said displacement detecting means during the lifting or lowering of said elevator cage.

11. An elevator apparatus including an electric motor for driving the elevator apparatus, a hoist having sheaves adapted to be driven by said electric motor, an elevator cage and a balance weight suspended from said sheaves in a manner like a well bucket via a rope, and a brake device for holding an unbalance torque produced between said elevator cage and said balance weight, characterized by said brake device comprising a brake disk, a disk-retainer section resiliently supported for retaining or releasing said brake disk, a switch means operative in response to the rotation and displacement of said disk-retainer section in a normal or reverse direction, a malfunction detecting means operative in response to the operation of said switch means during the lifting or lowering of said elevator cage, and means responsive to an output from said malfunction detecting means to effect emergency suspension of said elevator cage.

12. An elevator apparatus constructed substantially as herein described with reference to and as illustrated in the accompanying drawings.
