

ELEVATOR APPARATUS

Background of the invention

(1) Field of the invention

The present invention relates to an elevator apparatus in which controlled operation is carried out for vibration damping when a building is shaken due to an earthquake or
5 the like.

(2) Description of the related art

As a conventional elevator apparatus, there is known the one which calculates a maximum relative displacement amount of a lengthy article such as a main rope with respect to a
10 building in a calculation part based on a detection signal of a vibration meter when detecting shaking of the building at the time of occurrence of an earthquake, and carries out multiple-stage controlled operation in accordance with the calculated maximum relative displacement amount (see JP-A-2008-114944, JP-A-2008-114945 and JP-A-2008-230771, for example). Further, there are proposed various vibration damping devices in order to damp vibration of a main rope
15 and the like (see JP-U-50-062870, JP-U-52-015008, JP-U-54-023473, JP-A-57-116519, JP-A-3-003884, JP-A-5-004787 and JP-A-2007-022673, for example).

Brief summary of the invention

However, when a vibration damping device as disclosed in JP-U-50-062870, JP-
20 U-52-015008, JP-U-54-023473, JP-A-57-116519, JP-A-3-003884, JP-A-5-004787 and JP-A-2007-022673 is provided in the conventional elevator apparatus, since the vibration damping device is configured to suppress vibration by always acting on not only a small maximum relative displacement amount but also on a large maximum relative displacement amount of a main rope, there has been the problem that the vibration damping device becomes a large-scale
25 heavy product if the vibration damping device has sufficient mechanical strength for withstanding the maximum relative displacement amounts. Further, while there is the one in which a vibration damping device is provided in a cage, this merely prevents vibration from being transmitted to the cage through the main rope, and is not a positive one that suppresses vibration of the main rope. Further, in the case of the one provided on a hoistway wall side,
30 since the position at which a vibration damping action is given is fixed, an effective vibration damping effect cannot be expected. Further, in the ones as disclosed in above JP-A-2008-

114944, JP-A-2008-114945 and JP-A-2008-230771 that calculate maximum relative displacement amounts of the main ropes, and carry out stepwise controlled operation in accordance with the maximum relative displacement amounts, the vibration damping effect of the main ropes cannot be expected.

5 An object of the present invention is to provide an elevator apparatus which can carry out controlled operation corresponding to a maximum relative displacement amount of a main rope calculated by a calculation part, and can obtain an effective vibration damping effect for the main rope.

10 In order to attain the above-described object, an elevator apparatus including a cage and a counter weight which are connected by a main rope to be movable upward and downward, a vibration meter for detecting a shake of a building, a calculation part for calculating a maximum relative displacement amount of the main rope based on a detection signal of the vibration meter, and a controlled-operation control part which performs controlled operation
15 device having a vibration damping member for suppressing vibration of the main rope is provided in an upper portion of the cage, and the controlled operation control part is configured to perform vibration damping controlled operation which includes moving the cage to a position where the vibration of the main rope is restrained when detecting that the maximum relative displacement amount calculated in the calculation part is not more than a predetermined relative
20 displacement amount threshold value.

 According to the configuration as above, in the situation in which a shake of a building is relatively small, and vibration of the main rope continues for a relatively long time even after the shake of the building is attenuated, the vibration of the main rope can be damped in a short time by using the cage by moving the cage to the position where the vibration of the
25 main rope is damped without complicating the configuration, and the time until return to a normal operation can be reduced. Further, the vibration damping device which is a stabilizer of the main rope is disposed in the upper portion of the cage. Therefore, even when the maximum relative displacement amount of the main rope calculated in the calculation part exceeds the predetermined relative displacement amount threshold value, the vibration damping device can
30 damp the vibration of the main rope close to the cage side without receiving influence of a vibration center portion of the main rope that vibrates significantly, and the vibration damping device with a relatively simple configuration can be provided.

 Further, the present invention is characterized in that the vibration damping apparatus has an expanding mechanism which further moves the vibration damping member to

an upper portion side of the cage when performing the vibration damping controlled operation by the controlled operation control part.

According to such a configuration, when the vibration damping controlled operation is performed to damp the vibration of the main rope, the vibration damping member is moved to the further upper portion of the cage, and the vibration damping member can be worked at the upper position which is not in the vicinity of a fixed end portion of the main rope at the cage side, but a little away from the fixed end portion, whereby the vibration of the main rope can be suppressed more effectively.

Further, the present invention is characterized in that the position of the cage where the vibration of the main rope is restrained is any one of a vicinity of a position at half of the length of the main rope, a middle floor position substantially corresponding to a position at half of the length of the main rope, and a position in a vicinity of an antinode portion with a maximum amplitude of the vibration of the main rope when the maximum relative displacement amount is calculated in the calculation part.

According to such a configuration, at the time of the vibration damping controlled operation, the cage is always moved to a desirable position where the vibration damping effect can be expected, and the vibration damping device can be worked on the main rope. Therefore, the vibration of the main rope can be suppressed more effectively.

Further, the present invention is characterized in that the controlled-operation control part is configured to perform pausing controlled operation to move and evacuate the cage to a nearest floor when detecting that the maximum relative displacement amount calculated in the calculation part exceeds a predetermined relative displacement amount threshold value.

According to such a configuration, in the situation in which the vibration of the main rope cannot be damped even if the vibration damping member at the upper portion of the cage is used, the aforementioned vibration damping is not performed, and therefore, in the situation, unnatural vibration and load are not applied to the vibration damping device and the cage, and the existing structures is protected. Further, since the vibration damping device does not have to be made stout, the weight of the cage is not needlessly increased, and the components of the other driving system does not have to be changed.

Further, the present invention is characterized in that the nearest floor is a vicinity of a position at one third of the length of the main rope, or a non-resonant floor in a vicinity of a position at one third of a building height.

According to such a configuration, the vibration of the main rope can be also damped by bringing the main rope into a non-resonant state. When the cage is located in the

vicinity of the middle floor of the building, or located in the vicinity of the position at half of the length of the main rope, natural frequencies easily approach a primary natural frequency of the building or a value close to it in the governor rope and the compensation rope having the tension smaller than the main rope, and therefore, the governor rope and the compensation rope easily
5 vibrate. However, by performing the pausing controlled operation to move and evacuate the cage to the nearest floor according to the present invention, the cage is away from the primary natural frequency of the building or the value close to it, and since the nearest floor is nearer to the ground than the position in the vicinity of the middle floor, the time required before rescue can be made short at the time of entrapment.

10 According to the elevator apparatus of the present invention, in the situation in which a shake of a building is relatively small, and vibration of the main rope continues for a relatively long time even after the shake of the building is attenuated, the vibration of the main rope can be damped in a short time by using the cage by moving the cage to the position where the vibration of the main rope is damped without complicating the configuration, and the time
15 until return to a normal operation can be reduced. Further, the vibration damping device which is a stabilizer of the main rope is disposed at the upper portion of the cage. Therefore, even when the maximum relative displacement amount of the main rope that is calculated in the calculation part exceeds the predetermined relative displacement amount threshold value, the vibration damping device can damp the vibration of the main rope close to the cage side without
20 receiving influence of the center portion the vibration of the main rope that vibrates significantly, and the vibration damping device with a relatively simple configuration can be provided.

Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

25 Brief description of the several views of the drawing

Fig. 1 is a schematic configuration view showing an entire configuration of an elevator apparatus according to one embodiment of the present invention;

Fig. 2 is an enlarged view of an essential part of the elevator apparatus shown in
30 Fig. 1; and

Fig. 3 is a flowchart showing an operation at the time of controlled operation by the elevator apparatus shown in Fig. 1.

Detailed description of the invention

Hereinafter, an embodiment of the present invention will be described based on the drawings.

An elevator apparatus according to one embodiment of the present invention is configured to be able to hoist and lower along a guide rail not illustrated by connecting a cage 2 and a counter weight 3 by a main rope 4 in a hoistway 1 as shown in Fig. 1. In a machine room 5 formed in an upper part of the hoistway 1, a traction machine 6 on which the main rope 4 is wound, a control panel 7 which controls the traction machine 6 and the like, a vibration meter 8 which detects shaking of a building, a governor 10 on which a governor rope 9 is wound and the like are disposed. Further, in the hoistway 1, a compensation rope 11 which is connected 10 between the cage 2 and the counter weight 3 to compensate the difference in weight of the main rope 4 seen from the traction machine 6 side, a tail code 12 for supplying power to the cage 2, buffer devices 13 which are placed at a lower part from the cage 2 and the counter weight 3, a bracket 14 which supports a guide rail, other devices in the hoistway and the like which are not illustrated, and the like are placed. Further, a vibration damping device 17 which extends to an 15 upper part when a predetermined condition is satisfied the details of which will be described later, and restrains vibration of the main rope 4 is provided on an upper part of the cage 2.

Fig. 2 shows a main part in the elevator apparatus shown in Fig. 1, a crosshead 16 is provided on an upper portion of a cage frame 15 of the cage 2, and the aforementioned vibration damping device 17 is mounted on the crosshead 16. The vibration damping device 17 20 is configured to have a pantograph type expanding/contracting mechanism part 18 having a lower base portion side fixed to the crosshead 16, a driving device 19 which expansively/contractively drives the expanding/contracting mechanism part 18 by air pressure or hydraulic pressure, or other means, a drive device control part 20 which expansively/contractively operates the driving device 19 when receiving an 25 expanding/contracting operation signal from the control panel 7, and a vibration damping member 21 made from rubber or the like, which is provided on an upper expanding/contracting side of the expanding/contracting mechanism part 18 and has a through-hole in a center portion thereof into which the main rope 4 inserted. The vibration damping member 21 is configured so as not to interfere with the main rope 4 at the time of steady hoisting and lowering, but to 30 apply a vibration damping action by repeating collision of the main rope 4 against an annular inner wall surface thereof in a state in which the main rope 4 vibrates significantly in the expanded state of the expanding/contracting mechanism part 18.

The vibration meter 8 which detects shaking of a building and is shown in Fig. 1 has an acceleration detecting function in horizontal directions (x and y directions) orthogonal to

each other, and a detection signal from the vibration meter 8 is transmitted to a calculation part 22 which is configured in the control panel 7. The calculation part 22 is configured so that a maximum relative displacement amount is arithmetically calculated in an assumption condition where the vibration of the main rope 4 with respect to an assumed displacement of the hoistway 1 in the elevator apparatus becomes maximum, based on the acceleration signal in the horizontal direction detected by the vibration meter 8. The calculation part 22 arithmetically calculates the maximum relative displacement amount of an antinode portion where the vibration of the main rope 4 has the maximum amplitude, thereafter, compares the relative maximum displacement amount with a predetermined relative displacement amount threshold value which is set in advance, and transmits the comparison result to a controlled operation control part 23. The controlled operation control part 23 which receives this is configured to carries out controlled operation of the cage 2 in accordance with the comparison result.

Here, for simplification of description, the description will be made on the assumption that the calculation part 22 arithmetically calculates the maximum relative displacement amount based on an acceleration signal from the vibration meter 8, determines whether the maximum relative displacement amount of the main rope 4 exceeds a predetermined relative displacement amount threshold value, for example, 20 cm or less, or exceeds 20 cm, transmits the determination signal to the controlled operation control part 23, the controlled operation control part 23 which receives this carries out two-stage controlled operation, that is, carries out vibration damping controlled operation including moving the cage 2 to a position where the maximum relative displacement amount of the main rope 4 is decreased when receiving the determination signal indicating that the maximum relative displacement amount of the main rope 4 in the calculation part 22 is the aforementioned predetermined relative displacement threshold value or less, whereas when the controlled operation control part 23 receives a determination signal indicating that the maximum relative displacement amount of the main rope 4 in the calculation part 22 exceeds the aforementioned predetermined relative displacement threshold value, the controlled operation control part 23 carries out pausing controlled operation to evacuate the cage 2 to the nearest floor and pause the operation.

Next, the controlled operation by the controlled operation control part 23 when the vibration meter 8 detects shaking of a building will be described with use of a flowchart shown in Fig. 3.

When the vibration meter 8 which always performs monitoring detects shaking of a building in step S1, presence/absence of a passenger is detected in step S2, and when a passenger is present, a cage stops at the nearest floor to let the passenger off, in step S3. When

a passenger is absent, the cage does not stop at the nearest floor. In parallel with this, the calculation part 22 arithmetically calculates a maximum relative displacement amount α under the assumption condition that the relative displacement amount in an antinode portion of the vibration of the main rope 4 becomes maximum based on an acceleration signal in a horizontal
5 direction from the vibration meter 8 in step S4, and determines whether the maximum relative displacement amount α which is arithmetically calculated in step S5 is not more than or exceeds a predetermined relative displacement amount threshold value a , for example, 20 cm, in step S5. When the maximum relative displacement amount α is not more than the predetermined relative displacement amount threshold value a as a result of the determination, that is, when the relative
10 maximum displacement amount α of the main rope 4 is relatively small, the controlled operation control part 23 which receives the determination signal carries out vibration damping controlled operation which includes moving of the cage 2 to a position where the relative displacement amount of the main rope 4 is decreased, in step S6.

The moving position of the cage 2, where the relative displacement amount of the
15 main rope 4 is decreased is, for example, under the assumption condition that the relative displacement amount in the antinode portion of the vibration of the main rope 4 becomes maximum, the position where the cage is moved in the direction to shorten the length of the main rope 4, more specifically, the position at half of the length of the main rope 4 which is set in advance, or a middle floor position substantially corresponding thereto, while the length of the
20 main rope 4 is the length when the cage 2 is located at the lowest floor. These positions are not limited to the positions which are set in advance, and may be an antinode portion or a positions in vicinity thereof by arithmetically calculating the antinode portion which has the maximum amplitude of the vibration of the main rope 4 at the same time when the maximum relative displacement amount α is calculated in the aforementioned calculation part 22.

25 In the aforementioned step S5, the maximum relative displacement amount α of the main rope 4 and the predetermined relative displacement amount threshold value a are compared, and $\alpha \leq a$ is detected, but when the maximum relative displacement amount α of the main rope 4 is sufficiently small, the aforementioned vibration damping controlled operation may be cancelled, and in this case, when a lower limit relative displacement threshold value at
30 the time when the vibration damping controlled operation is not performed is set as b , $b < \alpha \leq a$ may be detected in step S5.

Before and after the cage 2 moves to the predetermined position by the vibration damping controlled operation, the driving device control part 20 shown in Fig. 2 receives a

signal from the controlled operation control part 23 in step S7, and gives an expansion operation signal to the driving device 19. The driving device 19 which receives this expands, for example, a piston side to expand the pantograph type expanding/contracting mechanism part 18 upward, and further moves the vibration damping member 21 to an upward portion. Thereby, the vibration of the main rope 4 which vibrates in the horizontal direction can be damped in a short time as compared with the case in which the vibration attenuates naturally, while repeating collision to the annular inner peripheral wall of the vibration damping member 21.

After a lapse of a predetermined time after arithmetic calculation in the aforementioned calculation part 22 is carried out, the arithmetic calculation is carried out again in the calculation part 22 based on the signal from the vibration meter 8, and when it is detected that the maximum relative displacement amount α of the main rope 4 becomes sufficiently small, or when the shaking detection signal from the vibration meter 8 is not present, or when a return signal is given in the other timing, the return signal is detected in step S8, the vibration damping controlled operation by the controlled operation control part 23 is canceled in step S9, and the operation is returned to a normal operation. At this time, the controlled operation control part 23 which detects the return signal gives a return operation signal to the driving device control part 20, and the driving device control part 20 which receives this operates the driving device 19 in the reverse direction from the expanded state of Fig. 2 to contract the expanding/contracting mechanism part 18 and brings the elevator apparatus into a steady state of Fig. 1.

In this manner, even if a phenomenon in which the main rope 4 consisting of a long article continues to vibrate for a long time even after an earthquake or the like comes to an end occurs, a phenomenon peculiar to the elevator apparatus can be detected by the calculation part 22, and for relatively small vibration of which the maximum relative displacement amount α is the relative displacement amount threshold value a or less, the vibration of the main rope 4 can be forcefully dampened in a short time by the aforementioned vibration damping controlled operation, and the time required until return to a normal operation can be reduced.

Meanwhile, when it is determined that the maximum relative displacement amount α of the main rope 4 from the calculation part 22 exceeds the predetermined relative displacement amount threshold value a in the determination of step S5, the situation is considered to be difficult for carrying out dampening of the vibration of the main rope 4 by the aforementioned vibration damping controlled operation, the controlled operation control part 23 carries out pausing controlled operation in step S10, and evacuates the cage 2 to the nearest floor to pause the operation. Thereafter, when the controlled operation control part 23 detects the return signal which is given when inspection or the like is finished in step S8, the controlled

operation control part 23 returns the elevator apparatus to a normal operation.

In the pausing controlled operation, the vibration damping member 21 in the vibration damping device 17 is not moved upward by the expanding/contracting mechanism part 18 unlike the above vibration damping controlled operation. Accordingly, the vibration damping member 21 is located in the vicinity of an end portion at the cage 2 side in the main rope 4, and is not broken by receiving an influence of large vibration of the main rope 4.

In the situation in which the pausing controlled operation is carried out in step S10, the maximum relative displacement amount α of the main rope 4 which is arithmetically calculated in the calculation part 22 is large as compared with the situation in which the vibration damping controlled operation is carried out, and in particular, the antinode portion having the maximum amplitude of the vibration of the main rope 4 is likely to interfere with the devices in the hoistway 1. Accordingly, in such a case, the vibration of the main rope 4 can be also damped by bringing the main rope 4 into a nonresonance state by carrying out controlled operation to the nearest floor, for example, to a nonresonant floor in the vicinity of the position at one third of the length of the main rope 4, or in the vicinity of the position at one third of the height of the building. When the cage 2 is located in the vicinity of the middle floor of the building, or located in the vicinity of the position at half the length of the main rope 4, a natural frequency easily approaches a primary natural frequency of the building or a value close to it in the governor rope 9 and the compensation rope 11 having the tension smaller than the main rope 4, and therefore, the governor rope 9 and the compensation rope 11 easily vibrate. Therefore, the nearest floor is desirably set at the position at one third of the length of the main rope 4 nearer to the ground than the position in the vicinity of the middle floor of the building, or the floor at one third of the building height so that the main rope is away from the primary natural frequency of the building or the value close to it, and the time before rescue becomes short even in case of entrapment.

However, in the pausing controlled operation in step S10, vibration damping of the governor rope 9 and the compensation rope 11 can be carried out by the other vibration damping means, and therefore, the other nearest floor which is set in advance may be adopted.

According to such an elevator apparatus, when the maximum relative displacement amount α of the main rope 4 which is arithmetically calculated in the calculation part 22 is the predetermined relative displacement amount threshold value a or less, the cage 2 is moved to the position where the vibration of the main rope 4 is restrained, and the vibration damping controlled operation which damps the vibration of the main rope 4 is carried out by the vibration damping member 21 of the vibration damping device 17, whereby even in the situation

in which vibration of the main rope 4 continues for a relatively long time even after shaking of the building is attenuated, the vibration of the main rope 4 can be damped in a short time by using the position of the cage 2 and the vibration damping device 17 without complicating the configuration, and the time until return to a normal operation can be reduced. Further, the vibration damping device 17 which is a stabilizer of the main rope 4 is disposed at the upper portion of the cage 2. Therefore, even when the maximum relative displacement amount α of the main rope 4 which is arithmetically calculated in the calculation part 22 exceeds the predetermined relative displacement amount threshold value a , the vibration damping device 17 does not damp the vibration of the vibration center portion of the main rope 4 that vibrates significantly, but damps the vibration of the main rope 4 at the position near the cage 2 side, and the configuration can be relatively simplified.

In addition, when the vibration damping device 17 is configured, the vibration damping member 21 which suppresses vibration of the main rope 4 is made movable further upward by the expanding/contracting mechanism part 18. Therefore, when the vibration damping controlled operation is carried out to damp the vibration of the main rope 4, the vibration damping member 21 is moved to a further upper portion of the cage 2, and the vibration damping member 21 can be worked at the upper position a little away from the vicinity of the fixed end portion at the cage 2 side in the main rope 4, whereby the vibration of the main rope 4 can be suppressed more effectively.

Further, according to the aforementioned elevator apparatus, when the maximum relative displacement amount α of the main rope 4 which is arithmetically calculated in the calculation part 22 exceeds the predetermined relative displacement amount threshold value a , the pausing controlled operation of letting the cage 2 escape to the nearest floor which is set in advance is carried out. Therefore, in the situation in which the vibration of the main rope 4 cannot be damped even if the vibration damping member 21 at the upper portion of the cage 2 is used, the aforementioned vibration damping is not carried out, and therefore, in the situation, unnatural vibration and load are not applied to the vibration damping member 21 and the cage 2, and the existing structures can be protected. Further, since the vibration damping device 17 does not have to be made so stout as to withstand the situation, the weight of the cage 2 is not needlessly increased, and the components of the other driving system are not influenced.

In the aforementioned embodiment, the predetermined relative displacement amount threshold value is set as 20 cm, but the predetermined relative displacement amount threshold value is not limited to this, and can be set optionally in accordance with the elevator apparatus. Further, the controlled operation is described such that the two-stage controlled

operation is divided into the vibration damping controlled operation and the pausing controlled operation by using one relative displacement amount threshold value a , but three-stage controlled operation may be carried out. Further, the calculation part 22 is disposed in the control panel 7, but may be configured in a cover of the vibration meter 8.

5 It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

CLAIMS:

1. An elevator apparatus comprising:
 - a cage and a counter weight which are connected by a main rope to be movable upward and downward;
 - a vibration meter for detecting a shake of a building;
 - a calculation part for calculating a maximum relative displacement amount of the main rope based on a detection signal of the vibration meter; and
 - a controlled-operation control part for performing controlled operation based on a result calculated in the calculation part, characterized in that
 - a vibration damping device having a vibration damping member for suppressing vibration of the main rope is provided in an upper portion of the cage, and the controlled-operation control part is configured to perform vibration damping controlled operation which includes moving the cage to a position where the vibration of the main rope is restrained when detecting that the maximum relative displacement amount calculated in the calculation part is not more than a predetermined relative displacement amount threshold value.
2. The elevator apparatus according to claim 1, characterized in that the vibration damping apparatus comprises an expanding mechanism which further moves the vibration damping member to an upper portion side of the cage when performing the vibration damping controlled operation by the controlled-operation control part.
3. The elevator apparatus according to claim 1, characterized in that the position of the cage where the vibration of the main rope is restrained is any one of a vicinity of a position at half of the length of the main rope, a middle floor position substantially corresponding to the position at half of the length of the main rope, and a position in a vicinity of an antinode portion corresponding to a maximum amplitude of the vibration of the main rope when the maximum relative displacement amount is calculated in the calculation part.
4. The elevator apparatus according to claim 1, characterized in that the controlled-operation control part is configured to perform pausing controlled operation in which the cage is moved to be evacuated to a nearest floor, when detecting that the maximum relative displacement amount calculated in the calculation part exceeds the predetermined relative displacement amount threshold value.
5. The elevator apparatus according to claim 4, characterized in that the nearest floor is a vicinity of a position at one third of the length of the main rope, or a non-resonant floor in a vicinity of the position at one third of a building height.