

SYSTEM FOR INSPECTING ROPE OF ELEVATOR

FIELD

Embodiments described herein relate generally to a rope inspection system for inspecting the state of degradation of a wire rope used for the main rope of an elevator, etc.

BACKGROUND

Recently, wire rope manufactured by covering the surface of a tensile strength member with a resinous material which is resistant to abrasion and has a high coefficient of friction, such as polyurethane, has become widespread. In this type of wire rope, the inner tensile strength member cannot be visually observed. Thus, the state of abrasion of wire or the number of wire breaks cannot be visually inspected to manage the strength. For this reason, for example, electricity is supplied to wire to measure the change in electrical characteristics due to aging degradation. Alternatively, a conductive member which degrades faster than the tensile strength member is provided inside the rope to measure the state of conduction. In the former method, the tensile strength member is limited to a rope structure in which the number of wires is less, such as steel cord. The latter method can be applied to wire rope having aramid fibers or covered with resin. However, the rope structure is complicated, thereby increasing the manufacturing cost.

In an elevator comprising a belt for pulling up a car, marks are made on the surface of the belt at regular intervals. The state of degradation of the belt is inspected based on the change in the intervals between the marks. In the structure of the car pulled up by the belt, the contact pressure between the belt and each sheave is low. Thus, the marks made on the surface of the belt are difficult to damage. Further,

as the belt does not rotate with respect to its longitudinal axis, the marks can be easily detected.

In comparison with the above elevator, a common elevator has a structure in which a car is pulled up by rope. In this structure, the contact pressure between the rope and the groove of each sheave is high. Thus, the marks made on the surface of the rope are easily damaged. Moreover, the rope rotates with respect to its longitudinal axis during operation. Since the positions of the marks are changed in the circumferential direction, the marks may not be accurately detected.

SUMMARY

According to one embodiment, a system for inspecting a rope of an elevator includes: a mark detection unit which detects a plurality of marks provided at regular intervals in a longitudinal direction of the rope to be inspected; a pulse generation unit which generates a pulse signal in synchronization with movement of the rope; and a calculation unit which calculates intervals between the marks based on detection timing of the marks by the mark detection unit and count values of pulse signals output from the pulse generation unit, and determines a state of degradation of the rope from a result of calculation.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

FIG. 1 shows the general structure of a machine room-less elevator according to a first embodiment.

FIG. 2 is a cross-sectional view showing the structure of a main rope used for the elevator according to the first embodiment.

5 FIG. 3 is a perspective view showing the external appearance of the main rope used for the elevator according to the first embodiment.

FIG. 4 is a diagram in which a mark detection sensor is laterally viewed according to the first embodiment.

10 FIG. 5 is a diagram in which the mark detection sensor is obliquely viewed from behind according to the first embodiment.

FIG. 6 shows a state in which a pair of mark detection sensors is provided on the two sides of the main rope according to the first embodiment.

15 FIG. 7 shows the structure of guide devices according to the first embodiment.

FIG. 8 is a flowchart shown for explaining the operation of a rope inspection system according to the first embodiment.

20 FIG. 9A is shown for explaining the relationship between pulse signals and the intervals between marks according to the first embodiment, and shows pulse signals output in synchronization with the movement of the main rope.

FIG. 9B is shown for explaining the relationship between pulse signals and the intervals between marks according to the first embodiment, and shows the intervals between marks at the time of installation.

30 FIG. 9C is shown for explaining the relationship between pulse signals and the intervals between marks according to the first embodiment, and shows the intervals between marks when the rope is elongated with time.

35 FIG. 10 shows the general structure of a machine

room-less elevator according to a second embodiment.

DETAILED DESCRIPTION

Embodiments will be described hereinafter with reference to the accompanying drawings.

5 (First Embodiment)

FIG. 1 shows the general structure of a machine room-less elevator according to a first embodiment.

10 The elevator 1 comprises a hoistway 2 provided in a building. A car 11 and a counter weight 12 are supported in the hoistway 2 via a guide rail such that they are capable of moving up and down. Further, a traction machine 14 comprising a traction sheave 13 is provided in the upper part of the hoistway 2.

15 The car 11 and the counter weight 12 are suspended in the hoistway 2 via a plurality of main ropes 10. FIG. 1 shows only one main rope 10. The other main ropes 10 are omitted in FIG. 1.

20 The main rope 10 comprises an end portion 3a and the other end portion 3b secured to the upper end of the hoistway 2 via rope hitches 4a and 4b, respectively. The main rope 10 comprises an intermediate portion 3c successively rolled over sheaves 15 provided in the car 11, the traction sheave 13 provided in the traction machine 14 and sheaves 16
25 provided in the counter weight 12. In this way, the car 11 and the counter weight 12 are supported with 2:1 roping. When the traction sheave 13 is rotated by driving the traction machine 14, the car 11 and the counter weight 12 move up and down in the hoistway 2
30 via the main rope 10 in accordance with a traction system due to the rotation of the traction sheave 13.

A governor 17 is provided in the hoistway 2. FIG. 1 shows a governor rope 18 for rotating the governor 17. The governor 17 detects the position and
35 speed of the car 11 via the governor rope 18 moving in

connection with the ascent/descent operation of the car 11. When the speed of the car 11 exceeds a setting speed due to an abnormal condition, the governor 17 activates a brake.

5 In a machine room-less elevator, which does not comprise a machine room, the traction machine 14 is provided in the hoistway 2. However, the present embodiment is not limited to this structure, and may be an elevator comprising a machine room. In an elevator
10 comprising a machine room, the traction machine 14 is provided in the machine room. The roping system is not limited to the 2:1 roping shown in FIG. 1, and may be a different system such as 1:1 roping.

 The rope inspection system of the present
15 embodiment comprises a sensor 21, an encoder 22, a calculation device 23 and a display device 24.

 The sensor 21 detects a plurality of marks 20 (see FIG. 3) provided at regular intervals in the longitudinal direction of the main rope 10 to be
20 inspected. The encoder 22 generates pulse signals in synchronization with the movement of the main rope 10. The calculation device 23 calculates the intervals between the marks 20 on the main rope 10 based on the detection timing of the marks 20 by the sensor 21 and
25 the count values of the pulse signals output from the encoder 22. Based on the result of calculation, the calculation device 23 determines the state of degradation of the rope 10. The display device 24 displays the distances between the marks 20 calculated
30 by the calculation device 23. The calculation device 23 and the display device 24 are general-purpose computers.

 When the strength of the main rope 10 is less than a defined value in the elevator, the rope needs to be
35 replaced. The main rope 10 can be safely used by

setting, as the basis of exchange, an amount of elongation of the main rope 10 corresponding to the defined reduction in strength.

5 Now, this specification explains the structure of the main rope 10 with reference to FIG. 2 and FIG. 3.

A wire rope is used for the main rope 10. As shown in FIG. 2, the main rope 10 comprises a rope main body 31 as a tensile strength member, and an external covering layer 32 which entirely covers the rope main
10 body 31. These elements are provided as the main components of the main rope 10.

The rope main body 31 is formed by twisting a plurality of steel strands 33 with predetermined pitches. The external covering layer 32 is formed of a
15 thermoplastic resin material which is resistant to abrasion and has a high coefficient of friction, such as polyurethane. The external covering layer 32 comprises an outer circumferential surface 32a defining the external surface of the main rope 10. The outer
20 circumferential surface 32a is circular in a cross-sectional view. When the main rope 10 is rolled over sheaves 13, 15 and 16, the outer circumferential surface 32a is in contact with sheaves 13, 15 and 16 with friction.

25 The resin material of the external covering layer 32 fills each gap between adjacent strands 33. Thus, the external covering layer 32 comprises a plurality of filling portions 34 between strands 33 adjacent to each other in the circumferential direction of the rope main
30 body 31. The filling portions 34 are provided inside the outer circumferential surface 32a of the external covering layer 32.

As shown in FIG. 3, the marks 20 are provided on the surface of the main rope 10 (specifically, the
35 outer circumferential surface 32a of the external

covering layer 32). The marks 20 are elements used to detect the amount of elongation caused by degradation of the main rope 10. The marks 20 are arranged at regular intervals (for example, at an interval of 500 mm) in the longitudinal direction of the main rope 10 over the entire length of the main rope 10. Each of the marks 20 is a continuous line or a dashed line in the circumferential direction of the main rope 10.

In the main rope 10, the sizes of the gaps between the strands 33 and the gaps between the wires of each strand 33 are reduced based on use. The strands 33 and the wires repeat friction between each other. In this way, the strands 33 and the wires are abraded and broken.

In particular, in the main rope 10, the portions which are in contact with sheaves 13, 15 and 16 are repeatedly subjected to friction. Thus, in the main rope 10, these portions are abraded or broken more severely than the portions which do not pass sheave 13, 15 or 16. In this manner, the radius of the main rope 10 is decreased, or the main rope 10 is locally elongated. In consideration of these factors, the strength of the main rope 10 can be managed by clarifying the relationship between the elongation of the main rope 10 and the rate of decrease in strength and detecting the elongation of the portion which has degraded most severely in the main rope 10.

For example, the sensor 21 is secured so as to face the main rope 10 near the traction machine 14. The encoder 22 is a rotary encoder. For example, the encoder 22 is secured onto the car 11. The rotor is pressed onto a guide rail 5. When the car 11 moves up and down between the highest floor and the lowest floor in inspection operation, the most part of the entire length of the rope 10 passes the sensor 21, excluding

portions near rope hitches 4a and 4b. Thus, the marks
20 can be successively detected when they pass the
sensor 21. Since the encoder 22 outputs pulse signals
in synchronization with the movement of the car 11, the
5 pulse output substantially corresponds to the amount of
delivered rope.

Every time a mark detection signal is output from
the sensor 21, the calculation device 23 calculates the
distance between marks based on the count value of
10 pulse signals output from the encoder 22 during a
period from the current mark detection signal and the
previous mark detection signal.

Near the traction machine 14, the sensor 21 may be
secured to either the car 11 side or the counter weight
15 12 side. When the sensor 21 is secured to the counter
weight 12 side, the tension of the rope does not rely
on the loading state of the car 11. Thus, the
threshold for determination of exchange is constant for
a specific structure, and operation is convenient.
20 Because of the difference in mass between the car 11
and the counter weight 12, the elastic elongation of
the main rope 10 differs. Thus, the amount of
elongation varies with respect to a constant
degradation. However, the threshold for determination
25 of exchange can be changed based on the tension of the
rope. Therefore, this is not an essential problem in
the measurement of the intervals between the marks.

The sensor 21 is preferably a photoelectric sensor
using reflected laser light in terms of responsiveness.
30 Recently, as commercially available photoelectric
sensors, sensors which irradiate the target object with
laser light and detect the change in the color of the
surface based on the difference in the intensity of
reflected light have become widely used.

35 FIG. 4 and FIG. 5 show a basic structure when the

sensor 21 optically detects the marks 20 on the main rope 10. In FIG. 4, the sensor 21 is laterally viewed. In FIG. 5, the sensor 21 is obliquely viewed from behind. The drawings show a structure in which the sensor 21 is provided on only one side of the main rope 10. However, as described later, a pair of sensors 21 is preferably provided on the two sides of the main rope 10 in consideration of a case where a part of a mark 20 is defective.

The sensor 21 comprises an irradiation unit 25 for irradiation with laser light, and a photoreceiver 26 for receiving reflected light. The photoreceiver 26 has sensitivity of detection for reflected light in the range shown by dashed line A in the longitudinal direction of the main rope 10. When a mark 20 is irradiated with laser light, the photoreceiver 26 is capable of detecting high-intensity reflected light and determining the presence or absence of the mark 20 based on the intensity of the reflected light.

When the moving speed of the main rope 10 is less than or equal to 1 m/s in inspection operation, the responsiveness is sufficient. Further, the cost is lower than that of a detection method using an image processing camera. In a detection method using an image processing camera, the main rope 10 must be captured in a wide range by providing the camera in a place distant from the main rope 10 to measure the intervals between marks from the captured image. In the present embodiment, the sensor 21 may be provided near the main rope 10. Thus, there is no need to set a wide range as the environment used to inspect the rope.

The threshold for determining the intensity of reflected light in the sensor 21 may be changed at the time of inspection since the state of the marks 20 and the state of the surface of the rope affecting the

intensity of reflected laser light vary across the ages.

For example, when a part of a mark 20 is defective, the intensity of reflected light is decreased. Thus, the sensitivity of detection needs to be increased. When a substance which easily reflects light (in other words, a substance of a light color) is firmly attached to the surface of the rope, the sensitivity of detection needs to be decreased. The state of the surface of the rope differs depending on the use conditions of the elevator. Thus, when the threshold for determination can be adjusted based on the state of each building, it is possible to prevent the false detection of the marks 20 and certainly detect the marks 20.

In the above description, this specification explains that the marks 20 provided on the surface of the main rope 10 have a high intensity of reflected light. However, what is important is that the intensity of reflected light must differ between the portions to which the marks 20 are applied in the main rope 10 (in other words, mark portions) and the portions to which the marks 20 are not applied (in other words, non-mark portions). Thus, the intensity of reflected light may be decreased in the mark portions.

Since the main rope 10 rotates with respect to its longitudinal axis, the sensitivity of detection needs to cover the whole circumference of the rope to certainly detect a mark 20 which is partially defective with time. For this reason, as shown in FIG. 6, a pair of sensors 21 is preferably provided such that the main rope 10 is interposed between the sensors 21.

In this case, to prevent increase in the number of sensors, as shown in FIG. 5, it is preferable that the

range of the main rope 10 irradiated by a single sensor 21 with laser light in the diametrical direction of the main rope 10 and the range of reflected light received by a single sensor 21 in the horizontal direction of the main rope 10 be substantially equal to diameter B of the main rope 10. The reasons are as follows. To certainly detect the marks 20, the sensitivity of each sensor 21 needs to cover at least the width of the rope. However, when the cover range of the sensitivity of each sensor 21 exceeds the width of the rope, the sensor 21 may be influenced by reflection from structures, etc., provided behind the main rope 10. Thus, the possibility of false detection will increase.

Now, this specification explains a more preferable structure which can prevent false detection of the marks 20 and certainly detect the marks 20 in the actual maintenance site.

FIG. 7 shows the structure of guide devices for guiding the main rope 10.

Each guide device 40 is used as a guide member for guiding the main rope 10 near a corresponding sensor 21. Each guide device 40 comprises a U-shaped guide main unit 41. The guide main unit 41 comprises an upper end portion 41a and a lower end portion 41b. Rollers 42a and 42b are rotatably attached to the upper and lower end portions 41a and 41b, respectively.

As shown in FIG. 7, the guide devices 40 are provided near the pair of sensors 21 provided on the two sides of the main rope 10. The main rope 10 is held between the upper rollers 42a and between the lower rollers 42b. In this way, the movement of the main rope 10 is controlled. As described above, each sensor 21 comprises the irradiation unit 25 for irradiation with laser light, and the photoreceiver 26 for receiving reflected light.

An attached substance removing unit 44a comprising a brush 43a is provided in the upper end portion 41a of each guide main unit 41. An attached substance removing unit 44b comprising a brush 43b is provided in the lower end portion 41b. Attached substance removing units 44a and 44b are members for removing the dust attached to the main rope 10 near a corresponding sensor 21. Each guide main unit 41 comprises a central portion 41c comprising a shielding plate 45. The shielding plate 45 is a member for preventing outside light (for example, sunlight) from entering the sensor 21. For example, a pair of shielding plates 45 is provided on the two sides of the sensor 21.

When the main rope 10 swings in inspection operation, and further particularly when a part of a mark 20 is defective, the sensors 21 may fail to detect the mark 20. Therefore, the main rope 10 is preferably guided so as to always pass through the range of detection of the sensors 21. As shown in FIG. 7, a pair of guide devices 40 is provided on the two sides of the main rope 10. Further, rollers 42a and 42b extending in the same direction as the direction of laser irradiation above and below the sensors 21 are brought into direct contact with the main rope 10. In this way, the movement of the main rope 10 which rotates with respect to its longitudinal axis can be stabilized in the range of detection of the sensors 21. Thus, each mark 20 can be correctly detected.

Concrete pieces or dust may be attached to the surface of the rope during operation. When they pass the sensors 21, false detection may occur. Therefore, attached substances which change the color of the surface of the rope are preferably removed excluding the portions of the marks 20 on the surface of the rope. When each guide device 40 shown in FIG. 4 is

used, substances attached to the main rope 10 such as dust are removed by brushes 43a and 43b before they pass the sensors 21. Thus, it is possible to prevent false detection caused by the attached substances.

5 The structure to remove attached substances is not limited to brushes 43a and 43b. Similar effects can be obtained by, for example, a structure which presses cloth such as felt as long as the surface of the rope is not damaged.

10 Even when the sensor 21 is provided on only one side of the main rope 10, a pair of guide devices 40 is preferably provided such that the main rope 10 is interposed between them as shown in FIG. 7.

15 In general, in elevators, three or more main ropes 10 are used. When the sensor 21 is provided for each of the ropes, and the signals of the sensors 21 are input to the calculation device 23 (FIG. 1), the intervals between the marks of the ropes can be simultaneously measured. When the sensor 21 is
20 provided for each of the ropes, the light emitted from the sensors of the ropes may interfere with each other. Thus, false detection may occur. However, when each guide device 40 shown in FIG. 7 is used, the light of adjacent sensors can be blocked by the shielding plates
25 45. In this manner, false detection can be prevented.

 Now, this specification explains the operation of the system.

 FIG. 8 is a flowchart shown for explaining the operation of the system. The flowchart shows a process
30 for automatically measuring the intervals between the marks 20 in inspection operation and determining the state of degradation of the main rope 10.

 The car 11 is moved to the lowest floor. Subsequently, inspection operation from the lowest
35 floor to the highest floor is started (step S11).

Alternatively, the car 11 may be moved from the highest floor to the lowest floor in inspection operation. By this inspection operation, the main rope 10 with which the car 11 and the counter weight 12 are suspended slowly moves at a certain speed. At this time, pulse signals are output from the encoder 22 in synchronization with the movement of the main rope 10. The calculation device 23 sequentially counts the number of pulse signals output from the encoder 22 (step S12).

In connection with the movement of the main rope 10, the marks 20 provided on the surface of the main rope 10 are optically detected by the sensor 21. When each mark 20 is detected by the sensor 21, the calculation device 23 confirms the current count value of the pulse signal, and calculates the distance between marks based on the count value (step S14). Data indicating the calculated distance between the marks is stored in a memory 23a (FIG. 1) provided in the calculation device 23.

This process is sequentially performed until the car 11 reaches the highest floor. Specifically, when each mark 20 is detected, the calculation device 23 confirms the count value of the pulse signal, calculates the distance between marks based on the count value, and stores data indicating the calculated distance in the memory 23a (steps S12 to S15).

To count the number of pulse signals, the count value may be incremented by one pulse from an initial value (for example, "0000"). Alternatively, the count value may be reset to an initial value every time a mark is detected. In this way, the number of pulse signals may be repeatedly counted from the initial value. In the former case, the difference between the integrated value of pulses when a mark 20 is detected

and the integrated value of pulses when a mark 20 is previously detected is obtained. The distance between the marks is obtained based on the difference.

5 To associate a rope position with a car position, the former method is preferable. Specifically, the count value is preferably incremented by one pulse from the initial value. In this case, the integrated value of pulses when each mark 20 is detected may be sequentially stored. Subsequently, the car 11 may be
10 moved based on the integrated value as an index. In this way, the portion to be checked in the main rope 10 can be visually confirmed at the position of the sensor 21. When the roping system is 2:1 roping, the speed of the car is half the speed of the rope. In this case,
15 to obtain the interval between marks from the count value of the pulse signal, the rate of roping at that time should be considered.

Note that, when the elevator is installed, the marks 20 are arranged at regular intervals in the
20 longitudinal direction of the main rope 10. Therefore, when there is no elongation caused by degradation of the main rope 10, the above count value of the pulse signal is substantially equal to a reference value corresponding to each interval between marks at the
25 time of installation. When the main rope 10 is elongated because of degradation of the main rope 10, the count value of the pulse signal exceeds a reference value corresponding to each interval between marks at the time of installation.

30 This state is shown in FIG. 9A, FIG. 9B and FIG. 9C.

FIG. 9A, FIG. 9B and FIG. 9C are shown for explaining the relationship between pulse signals and the intervals between marks. FIG. 9A shows pulse
35 signals output in synchronization with the movement of

the main rope 10. FIG. 9B shows the intervals between marks at the time of installation. FIG. 9C shows the intervals between marks when the rope is elongated with time.

5 It is assumed that the reference value obtained when the number of pulse signals is counted with the intervals between the marks applied at the time of installation is n . When the main rope 10 is not degraded, the count value obtained in inspection
10 operation is substantially equal to n obtained at the time of installation within a small margin. When the main rope 10 is elongated because of degradation, the count value obtained in inspection operation is greater than n corresponding to the intervals between the marks
15 applied at the time of installation.

 After the inspection operation, the calculation device 23 determines the state of elongation of the main rope 10 based on each distance between marks stored in the memory 23a as a result of measurement
20 (step S16). The calculation device 23 performs a process based on the result of measurement (step S17).

 Specifically, the calculation device 23 determines whether there is a portion in which the interval between marks exceeds a predetermined threshold based
25 on the result of measurement stored in the memory 23a. When such a portion is detected, for example, the calculation device 23 displays an alert message in the display device 24 or emits alarm sound. In this way, the calculation device 23 notifies the maintenance
30 worker that the time for replacing the rope is approaching. Thus, it is possible to reduce the number of steps of inspection for the maintenance worker and know the time for replacing the rope.

 The measurement values of the intervals between
35 the marks in each unit can be easily associated with

the amount of movement of the rope in inspection operation from the count values of pulse signals. The rope position of a portion which exceeds the threshold may be displayed on the display device 24. The portion
5 in which the interval between marks exceeds the threshold is severely damaged. To clarify the cause of damage, it is preferable that the level of damage be visually confirmed by external observation. The confirmation can be easily conducted by displaying the
10 rope position of the portion which exceeds the threshold.

Alternatively, the portion which shows the greatest amount of elongation in the main rope 10, in other words, the rope position which has the greatest
15 interval between marks, may be displayed on the display device 24. In general, a severely degraded portion in the main rope 10 is associated with a floor at which the car 11 frequently stops, and has the largest bending load. However, for example, if a portion is
20 accidentally damaged at the time of installation, the damaged portion may degrade faster than the other portions. By displaying the rope position of the portion having the greatest amount of elongation, the portion which degrades in a manner different from that
25 of normal degradation can be easily confirmed.

The result of measurement of the marks may be stored in the memory 23a as history information. The history information may be graphically displayed based on each inspection date. In this way, the state of
30 degradation of the rope can be easily recognized from the change in the intervals between the marks.

When the history information is regularly transmitted to an elevator monitoring center in a remote place (not shown), the elevator monitoring
35 center can unify the management of the state of

degradation of the main rope 10 of each building, and notify a maintenance worker of a building in which the rope should be replaced soon.

5 According to the first embodiment, it is possible to accurately measure the intervals between the marks 20 provided in the longitudinal direction of the main rope 10 with an inexpensive structure. The state of elongation caused by degradation of the main rope 10 can be recognized from the result of measurement.
10 Thus, the degradation of the main rope 10 can be appropriately dealt with.

(Second Embodiment)

Now, this specification explains a second embodiment.

15 In the first embodiment, the encoder 22 is provided in the car 11. The number of pulse signals output from the encoder 22 is counted. A rotary encoder is used for the encoder 22 in the first embodiment. However, for example, a linear encoder
20 (not shown) which magnetically or optically outputs pulses in the ascent/descent direction of the car 11 may be provided in the hoistway 2.

The effect of the device for generating pulses is the same as long as it generates pulse signals in
25 substantially synchronization with the amount of the delivered main rope 10, in other words, as long as it generates pulse signals in connection with the ascent/descent operation of the car 11 and the counter weight 12. Thus, an existing encoder incorporated into
30 the elevator 1 to detect the position and speed of the car may be used.

This specification hereinafter explains a structure when an existing encoder is used for the device for generating pulses in this system.

35 FIG. 10 shows the general structure of a machine

room-less elevator according to the second embodiment.

Normally, a governor 17 is incorporated into the elevator 1 as a safety mechanism for preventing a car 11 from abnormally moving. An encoder 17a which
5 generates pulse signals in synchronization with the movement of the car 11 is provided in the governor 17. A control panel 50 is provided in a hoistway 2 as a device for controlling the elevator. The control panel 50 detects the position and speed of the moving car 11
10 based on the pulse signals output from the encoder 17a. For example, the control panel 50 stops the car 11 when an abnormality occurs.

As shown in FIG. 10, when a calculation device 23 is connected to the control panel 50 in inspection
15 operation, and the count values of pulse signals output from the encoder 17a in connection with the movement of the car 11 are transmitted from the control panel 50 to the calculation device 23, the intervals between marks 20 can be calculated from the count values of pulse
20 signals. The process of the calculation device 23 is the same as that of FIG. 8, detailed description thereof being omitted.

Even when the encoder 17a of the governor 17 originally incorporated into the elevator 1 is used,
25 the intervals between the marks 20 provided in the longitudinal direction of a main rope 10 can be accurately measured with an inexpensive structure in a manner similar to that of the first embodiment. It is possible to confirm the state of elongation caused by
30 degradation of the main rope 10 from the result of measurement. Thus, the degradation can be appropriately dealt with.

Further, there is no need to separately prepare the encoder 22 used in the first embodiment. A
35 maintenance worker only connects the calculation device

23 and the control panel 50 as inspection operation. Thus, the burden on the maintenance worker is dramatically reduced.

5 In the encoder 22 having the rotary structure shown in FIG. 1, the rotor rotates in association with the movement of the main rope 10 in a state where the rotor is pressed onto the guide rail 5. In this way, pulse signals are output. Normally, in the guide rail 5, a plurality of rail members having a predetermined
10 length are patched together in a perpendicular direction. The guide rail 5 is secured in the hoistway 2 by brackets (not shown). The sliding of the rotor of the encoder 22 is easily affected by the intervals between the brackets or the joints of the rail members.
15 Thus, the encoder 22 having the rotary structure needs to be repeatedly adjusted by test operation to accurately synchronize the encoder 22 with the movement of the main rope 10, in other words, the movement of the car 11. However, the governor 17 is not in contact
20 with the guide rail 5. Thus, the governor 17 does not require adjustment by test operation.

According to at least one of the above embodiments, when marks are applied to manage the strength of the rope in which the damage of the tensile
25 strength member cannot be visually confirmed, the intervals between the marks can be measured without placing a burden on a maintenance worker at the time of inspection. By determining the state of degradation from the intervals between the marks, the maintenance
30 time can be reduced, and further, the reliability of the management of the strength of the rope can be improved.

While certain embodiments have been described, these embodiments have been presented by way of example
35 only, and are not intended to limit the scope of the

inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein
5 may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

WHAT IS CLAIMED IS:

1. A system for inspecting a rope of an elevator, comprising:

5 a mark detection unit which detects a plurality of marks provided at regular intervals in a longitudinal direction of the rope to be inspected;

a pulse generation unit which generates a pulse signal in synchronization with movement of the rope; and

10 a calculation unit which calculates intervals between the marks based on detection timing of the marks by the mark detection unit and count values of pulse signals output from the pulse generation unit, and determines a state of degradation of the rope from
15 a result of calculation.

2. The system of Claim 1, wherein

the mark detection unit includes an optical sensor irradiating a resinous covering surface of the rope with laser light, optically detecting presence or
20 absence of each of the marks based on intensity of reflected light, and having a sensitivity of detection for a width of a diameter of the rope.

3. The system of Claim 2, wherein

each of the marks is continuously or
25 intermittently provided in a circumferential direction of the rope, and

the mark detection unit includes at least two optical sensors provided with respect to the circumferential direction of the rope.

30 4. The system of Claim 2, wherein

the optical sensor is allowed to change a threshold of the intensity of the reflected light for determining the presence or absence of each of the marks.

35 5. The system of Claim 2, wherein

a guide member for guiding the rope is provided near the optical sensor.

6. The system of Claim 2, wherein
a shielding member for shielding the optical
5 sensor from disturbance light is provided around the
optical sensor.

7. The system of Claim 2, wherein
a removing member for removing dust attached to a
surface of the rope is provided near the optical
10 sensor.

8. The system of Claim 1, wherein
an existing encoder incorporated into the elevator
to detect a position or speed of a car is used for the
pulse generation unit.

15 9. The system of Claim 1, wherein
the calculation unit detects a rope position in
which a distance between the marks exceeds a
predetermined threshold.

10 20 10. The system of Claim 1, wherein
the calculation unit detects a rope position which
has a greatest distance between the marks.