

ELEVATOR ROPE INSPECTION SYSTEM

FIELD

Embodiments described herein relate generally to an elevator rope inspection system.

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BACKGROUND

Machine room-less type elevators in which elevator machines such as a traction machine are accommodated in a shaft are common for space efficiency. In the machine room-less type elevator, a sheave (traction
10 sheave) of the traction machine is made small. Thus, as a main rope resistant against a bending wear and with a high strength rope structure, a wire rope having the surface formed of a tensile strength member coated with a resin material of wear resistant and high
15 coefficient of friction such as polyurethane will be used.

The wire rope of this type cannot be subjected to a strength inspection by visually inspecting the wear and tear of the wire as in a conventional wire rope
20 because the inner tensile strength member cannot be checked visually. Thus, there is a proposed rope inspection system in which marks are put on the surface of the rope at certain intervals, and a gap between the marks with respect to a feeding amount of the rope is
25 measured as a rope stretch, and the wear condition is determined based on the measured result to perform the strength inspection.

The rope inspection is generally performed in a night time when there is no user onboard. However,
30 when the elevator is activated after a long stop, there may be a possibility of creep occurring because of a tensile difference in the rope. The term "creep" means a slip phenomenon occurring between the rope and the sheave. With such a slip phenomenon, the number of
35 pulses with respect to the feeding amount of the rope

does not accurately synchronize, and it affects the accuracy of the measurement of gaps between the marks.

The present application would like to provide an elevator rope inspection system which can measure gaps
5 between marks on a rope with high accuracy to perform a strength management with high credibility.

SUMMARY

According to one embodiment, a rope inspection system inspects a rope of an elevator where a car and a counter weight are held with a traction sheave of a traction machine, and a wear condition of a plurality of ropes having a resin coated surface are inspected by
10 measuring gaps between a plurality of marks on the surface of each rope. The rope inspection system includes a controller configured to perform a preliminary drive to average the tensile between the ropes and to subsequently perform a measurement drive to measure gaps between the marks.
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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating a schematic structure of an elevator of a first embodiment.
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FIG. 2 is a cross-sectional view illustrating the structure of a main rope used in the elevator of the first embodiment.

FIG. 3 is a perspective view illustrating the exterior of the main rope used in the elevator of the first embodiment.
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FIG. 4 illustrates a relationship between pulse signals and gaps between marks of the first embodiment.

FIG. 5 is a graph illustrating a relationship between a stretch ratio and remaining strength of a rope according to deterioration of the rope of the first embodiment.
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FIG. 6 illustrates a measurement method of gaps between marks using a sensor of the first embodiment.
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rope in the horizontal axis. Since it is classified, a specific value is not mentioned here; however, λ in the figure is a few %, that is, a few mm. The strength of the rope (which will be referred to as remaining
5 strength ratio) is shown in the vertical axis. As the rope is gradually stretched as the time goes by, the strength decreases accordingly. In general, 80% of the strength ratio is defined as reference strength, and the rope is replaced when the stretch ratio of the rope
10 becomes λ for better safety.

The measurement of the rope stretch is performed by feeding the rope by a certain length in an inspection drive, detecting marks put on the surface of the rope in the feeding, and counting a pulse signal of
15 the encoder at the detection timing.

If a rotary encoder in which a revolution member is pressed against the guide rail is used in a method of generating pulse signals for the mark measurement, the pulse numbers with respect to a predetermined rope
20 feeding length vary because of a bump at a rail joint, an adhesive substance, and the like, and there may probably be an error in the measurement of the gaps between the marks. Furthermore, an encoder may be provided with a governor; however, an additional space
25 including the inspection working space will be required.

Thus, a use of an encoder for traction machine revolution control which synchronizes the revolution of the traction sheave will be considered. Such an
30 encoder does not require an additional space in the governor to accommodate the encoder, and is cost effective.

However, when the main rope is fed from the car side to the counter weight side (hereinafter will be
35 referred to as C/W side), or is fed from the C/W side

to the car side, there is a change in the tension, and the elastic stretch of the rope changes because of the change in the tension, and thus, slipping occurs between the rope and the traction sheave. Because of
5 slipping, the pulse number does not synchronize with the feeding, and the accuracy of the measurement of the gaps between the marks is affected.

Hereinafter, a method of acquiring gaps between the marks with high accuracy will be explained in
10 consideration of the slipping action between the main rope and the traction sheave caused by a change in the tension.

(First embodiment)

FIG. 1 is a diagram illustrating the schematic
15 structure of an elevator of a first embodiment. In the example of FIG. 1, a machine room-less type elevator having no machine room is considered.

A car 20 and a counter weight 21 are supported by guide rails 11 and 12, respectively, to be movable
20 upward/downward in an elevator shaft 10. Furthermore, a traction machine 23 including a traction sheave 22 is disposed in the upper part of the elevator shaft 10. The car 20 and the counter weight 21 are suspended in the elevator shaft 10 by several main ropes 24. Note
25 that, in FIG. 1, only a single main rope 24 is shown, and the other main ropes 24 are omitted.

Both ends of the main rope 24 are fixed to the upper end of the elevator shaft 10 via rope hitches 25a and 25b. Furthermore, the main rope 24 is continuously
30 wound to a car sheave 26, traction sheave 22, and counter weight sheave 27 in its middle parts. Thus, the car 20 and the counter weight 21 are supported in a 2:1 roping format. When the traction sheave 22 is rotated by the drive of the traction machine 23, the
35 car 20 and the counter weight 21 are moved

upward/downward in a traction manner in the elevator shaft 10 via the main rope 24 in accordance with the traction sheave 22.

5 Note that, in the machine room-less type elevator, the traction machine 23 is disposed in the elevator shaft 10; however, the present invention is not limited to such a structure, and it may be applied to an elevator with a machine room. In the elevator with a machine room, the traction machine 23 is disposed in
10 the machine room. Furthermore, the roping format is not limited to the 2:1 roping as in FIG. 1 but may be another format such as 1:1 roping.

The rope inspection system of the present embodiment includes a sensor 28, encoder 29,
15 calculation device 30, display device 31, and controller 40.

The sensor 28 is disposed in the proximity of the main rope 24 which is a target of inspection, and detects marks 45 (cf. FIG. 3) provided with the
20 longitudinal direction of the main rope 24 at regular intervals. The encoder 29 generates a pulse signal in synchronization with the revolution of the traction sheave 22. The encoder 29 is an encoder incorporated with the elevator to detect a car position and a speed.
25 With the encoder 29 used for the measurement of the gaps between the marks, a layout problem of installing the encoder in a speed controller can be avoided, for example.

The calculation device 30 counts a pulse signal
30 generated from the encoder 29 at a detection timing of each mark 45 by the sensor 28, calculates the gaps between the marks from the counted value, and acquires a stretch amount of the main rope 24. The display device 31 displays the gaps between the marks and the
35 rope stretch amount obtained by the calculation device

30. Note that the calculation device 30 and the display device 31 are a conventional computer including a CPU, a ROM, a RAM and the like.

5 The controller 40 is a control device for the general control of the elevator including drive control of the traction machine 23. The controller 40 detects the position of the car 20 based on the pulse signal of the encoder 29, and moves the car 20 to a target floor at a predetermined speed. In the present embodiment,
10 the calculation device 30 is connected to the controller 40 to obtain the pulse signal of the encoder 29 from the controller 40. Furthermore, the controller 40 includes a function to perform a preliminary drive to average the tensile of each of the main ropes 24
15 wound around the traction sheave 22 and subsequently perform a measurement drive to measure the gaps between the marks.

The controller 40 is connected to a monitoring center 51 via communication network 50. The monitoring
20 center 51 remotely monitors the condition of elevator of each building which is a target via the communication network 50, and dispatches a serviceman to a location in case of some kind of abnormality therein, for example. The serviceman has a terminal
25 device 52 for maintenance. The terminal device 52 has a function to perform wireless communication between the controller 40 and the monitoring center 51.

Reference number 32 in the figure indicates a landing detection member. The landing detection member
30 32 may be referred to as an arrival detection plate, and is provided with each floor alongside the upward/downward direction of the car 20 in the elevator shaft 10. The landing detection member 32 is used to detect a stop position of the car 20 in cooperation
35 with a contact-less switch 33 when the car 20 stops at

each floor.

The structure of the main rope 24 will be explained with reference to FIGS. 2 and 3.

5 The main rope 24 is a resin-coated wire rope. As in FIG. 2, the main rope 24 includes, as its main components, a rope main body 41 as a tensile strength member and an outer coating layer 42 which covers the entirety of the rope main body 41.

10 The rope main body 41 is formed by twisting a plurality of steel strands 43 at predetermined pitch. The outer coating layer 42 is a thermoreversible resin material having wear resistivity and high coefficient of friction such as polyurethane. The outer coating layer 42 includes an outer peripheral surface 44a which
15 defines the outer surface of the main rope 24. The outer peripheral surface 44a has a circular cross-sectional view, and contacts each of the sheaves 22, 26, and 27 with friction when it is wound thereto.

20 Furthermore, a resin material used in the outer coating layer 42 is filled in the gaps between the strands 43. Thus, the outer coating layer 42 includes a plurality of charge portions 44 between the strands 43 adjacent to each other in the circumferential direction of the rope main body 41. The charge
25 portions 44 are positioned inside the outer peripheral surface 44a of the outer coating layer 42.

30 As in FIG. 3, a plurality of marks 45 are provided with the surface of the main rope 24 (that is, the outer peripheral surface 44a of the outer coating layer 42). The marks 45 are the elements to detect a stretch amount of the main rope 24 caused by the deterioration, and are aligned at certain intervals (for example, at every 500 mm) in the longitudinal direction in the entire length of the main rope 24. Each of the marks
35 45 is a continuous line or an intermittent line in the

circumferential direction of the main rope 24.

Note that, as the use time of the main rope 24 goes by, gaps between the strands 43 and gaps between wires forming the strands 43 decrease. Thus, the strands 43 and the wires are repeatedly rubbed to each other, and the wear and tear of the strands 43 and the wires progress.

Specifically, the friction is repeated in the parts where the main rope 24 contacts each of the sheaves 22, 26, and 27. Thus, the wear and tear of the main rope 24 progress more in the parts as compared to parts where the main rope 24 does not contact the sheaves 22, 26, and 27, and thus, the rope diameter decreases, and a local stretch occurs. Thus, the strength of the main rope 24 can be controlled by clarifying a relationship between the rope stretch and a strength decrease rate, and detecting the stretch in the part where is most deteriorated in the main rope 24.

The sensor 28 is fixed in the proximity of the traction machine 23 to face the main rope 24. Thus, when the car 20 is driven between the uppermost floor and the lowermost floor in the inspection drive, the majority of the entire length of the main rope 24, except for the parts close to the rope hitches 25a and 25b, passes the sensor 28, and the marks 45 are detected successively therein.

The encoder 29 outputs a pulse signal in synchronization with the movement of the car 20, and thus, a pulse output substantially corresponds to a rope feeding amount. The calculation device 30 uses a mark detection signal output from the sensor 28 as a trigger, and counts the number of pulse signals output from the encoder 29 to calculate the gaps between the marks from the counted value as the rope stretch

amount.

The sensor 28 is, preferably, a photoelectric sensor using laser reflection light in consideration of the responsibility. Or, the sensor 28 may be a photomicrosensor which uses a more reasonable LED reflection light. A commercially available photoelectric sensor irradiates the laser light onto a target and detects a change in the surface color based on the strength of the reflection light strength.

When installing the elevator, the marks 45 are arranged in the longitudinal direction of the main rope 24 at regular intervals. Thus, if there is no stretch in the main rope 24 because of the deterioration, the count value of the pulse signal becomes substantially the same as the reference value corresponding to the gaps between the marks at the installing time. On the other hand, if the main rope 24 is stretched because of the deterioration, the count value of the pulse signal exceeds the reference value corresponding to the gaps between the marks at the installing time.

This will be shown in FIG. 4.

FIG. 4 illustrates a relationship between pulse signals and gaps between the marks. FIG. 4(a) indicates the pulse signals output in synchronization with the movement of the main rope 24. FIG. 4(b) indicates the gaps between the marks in the installing time, and FIG. 4(c) indicates the gaps between the marks when the rope is stretched because of aging.

If a reference value measured when the pulse signal is counted with the gaps between the marks in the installing time is given n pulse, and the main rope 24 is not deteriorated, the count value obtained in the inspection drive is substantially the same as n pulse in the installing time only with a slight difference. However, if the main rope 24 is stretched because of

the deterioration, the count value obtained in the inspection drive becomes greater than n pulse corresponding to the gaps between the marks in the installing time.

5 FIGS. 6 to 8 illustrate results of measurement of gaps between marks in a test performed by inventors and the like. Note that the marks 45 on the surface of the main rope 24 are manually put by participants using a laser marker. Thus, strictly speaking, there may be a
10 slight difference from the reference value (500 mm interval, for example); however, such a difference does not affect the test results.

 FIG. 6 illustrates a method of measuring gaps between marks using the sensor 28, wherein FIG. 6(a)
15 indicates an output voltage of the sensor 28, and FIG. 6(b) indicates a relationship between the output voltage of the sensor 28 and a mark position P.

 Now, a case where the main rope 24 is fed in the arrow A direction of FIG. 1 is considered. The sensor
20 28 includes an analogue voltage output function, and outputs voltage V corresponding to a reflection ratio of a non-marked portion and a marked portion of the main rope 24. At a rise of the signal measured when the voltage V exceeds a predetermined threshold voltage
25 Vs, the number of pulses counted during that time will be sequentially stored as mark positions P1, P2, P3, . . . , and Pn. Thus, the elevation position of the car 20 and the gaps between the marks will be acquired as follows.

30 Elevation position = accumulated pulse number × pulse rate

 Mark interval L1 = |P1 - P2|

 Mark interval L2 = |P2 - P3|

 Mark interval Ln = |Pn-1 - Pn|

35 FIG. 7 illustrates a result of measurements of

gaps between marks, wherein the measurement of gaps between the marks with respect to the same rope is performed for three consecutive times. FIG. 8 illustrates variations of the gap between the marks with respect to the measurement number, wherein the horizontal axis indicates the number of measurements, and the vertical axis indicates a range of variations of the gaps of the marks obtained in each measurement.

5 In the first measurement, the gaps between the marks are varied; however, the variation decreases in each time the measurement is repeated, and the gaps between the marks become closer to that of the installing time. It is considered that a slipping phenomenon caused by a tensile difference between the ropes naturally resolves during the repeated drive. 10 From such a result, it is concluded that, if the drive of the traction machine 23 is stopped for a certain period of time in a night time, for example, the measurement of the gaps between the marks should be performed after a preliminary drive which reciprocates the elevator between the uppermost floor and the 15 lowermost floor by at least once. 20

Now, the operation of the system will be explained.

25 FIG. 9 is a flowchart of the operation of the rope inspection system of the first embodiment, and indicates a process of automatic measurement of the gaps between the marks 45 on the main rope 24.

As initial setting, the controller 40 includes 30 various conditions related to the measurement of marks such as an elevation range, and a drive speed (step S101). The measurement of the gaps between the marks is performed after the drive of the elevator for users is ended, that is, during a night time, for example. 35 When the traction machine 23 is stopped for a certain

period of time or more, slipping occurs on the traction sheave 22 because of a tensile difference between the ropes when it is activated. Thus, the number of pulses does not accurately synchronize with the feeding amount of the rope, and the accuracy of measurement is affected. Thus, the controller 40 performs a preliminarily drive before measuring the gaps between the marks (step S102). Specifically, the controller 40 drives the traction machine 23, and elevates the car 20 at a predetermined speed while feeding the main rope 24 wound around the traction sheave 22.

The preliminary drive is, preferably, performed by at least one cycle. It is considered because that the tensile difference between the ropes is naturally flattened during the drive. The preliminary drive may be performed at a rated speed, or may be performed at a speed lower than the rated speed. If the preliminary drive is performed at a rated speed, the drive can be shifted to the measurement drive faster, and thus, the measurement time can be shorted.

When the preliminary drive within a predetermined elevation range (for example, one cycle) ends, the controller 40 performs the measurement drive to measure the gaps between the marks (step S104). Specifically, the controller 40 drives the traction machine 23, and elevates the car 20 at a predetermined speed while feeding the main rope 24 wound around the traction sheave 22.

The measurement drive may be performed at a rated speed as with the measurement drive, or may be performed at a speed lower than the rated speed. Note that, if the measurement drive is performed at a rated speed, the feeding speed of the main rope 24 is increased, and misdetection of the marks 45 tends to occur. Thus, the lower speed is preferred in order to

increase the accuracy of measurement.

Furthermore, in consideration of the tensile difference between the ropes, a balanced condition where the weight of the car 20 and the weight of the counter weight 21 are the same is preferred. It is because that the tensile difference does not easily occur in the balanced condition. Note that, in the operation of the rope inspection system, in order to reduce the workload, a method of inspection which does not require loading to the car 20, that is, inspection in a no-loading condition is preferred. In the present embodiment, since the tensile difference between the ropes is resolved by the preliminary drive, and thus, the measurement drive may be performed in the no-loading condition.

During the drive of the car 20, the calculation device 30 acquires the pulse signals output from the encoder 29 via the controller 40, and the number of the pulse signals is counted successively (step S105).

Furthermore, along with the movement of the main rope 24, the marks 45 on the surface of the rope are optically detected by the sensor 28 (step S106). The calculation device 30 checks a currently counted count value of the pulse signal at a time when the marks 45 are detected by the sensor 28, and calculates gaps between the marks based on the count value (step S107).

Specifically, the calculation device 30 has a pulse rate defining a length of the main rope 24 fed per pulse. The calculation device 30 counts the number of pulse signals generated from the encoder 29 during the detection of the marks 24 by the sensor 28, and multiplies the pulse rate with the counted value to derive the gaps between the marks. The gaps between that marks calculated at that time are displayed on the display device 31 as a result of measurement, and are

stored in a memory 30a in the calculation device 30 (step S108).

5 In that case, if the main rope 24 is not stretched, the calculated gaps between the marks are the same as the gaps between the marks (500 mm, for example) put on the main rope 24 in the installing time. When the main rope 24 extends by aging, the calculated gaps between the marks become greater than the gaps between the marks.

10 Thereinafter, in the similar manner, the calculation device 30 acquires the count value of the pulse signal at the detection timing of the marks 45 in the measurement drive, and stores the gaps between the marks sequentially calculated from the count values in
15 the memory 30a (steps S105 to S109).

Note that, as a count method of the pulse signal, there is a method of adding pulses one-by-one from an initial value (for example, 0000), or a method of repeating counts while resetting the count to an
20 initial value every time the mark is detected. In the first method, a difference between the total value of the pulses when the mark 45 is detected and the total value of the pulse when the mark 45 is detected last is derived, and the gaps between the marks are acquired
25 from the difference.

In order to associate the rope position with the car position, the method to adding up the pulses one-by-one from the initial value as in the first method is preferred. In that case, if the total value of the
30 pulses when the marks 45 are detected is stored sequentially, and the car 20 is moved using the total value as an index, the part to be checked in the main rope 24 can be visually checked at the position of the sensor 28.

35 Here, in the installing time of the elevator, the

marks 45 are arranged at regular intervals in the longitudinal direction of the main rope 24. Thus, if there is no stretch of the main rope 24 because of deterioration, the count value of the pulse signal becomes substantially the same as the reference value corresponding to the gaps between the marks in the installing time. On the other hand, if the main rope 24 is stretched by the deterioration, the count value of the pulse signal exceeds the reference value corresponding to the gaps between the marks (cf. FIG. 4).

When the measurement drive ends, the calculation device 30 calculates a stretch amount of the main rope 24 based on the gap between the marks stored in the memory 30a as a result of measurement, and displays the result on the display device 31. Note that the calculation device 30 may not calculate a stretch amount, and only the gaps between the marks may be displayed on the display device 31.

Furthermore, if the gap between the marks exceeds the reference value, a warning message may be displayed on the display device 31, or an alarm sound may be sent to notify to a serviceman that a rope change time is approaching. Or, a warning message may be sent to the terminal device 52 of the serviceman from the controller 40. Thus, inspection of the serviceman can be reduced, and a time of rope change can be estimated clearly.

Furthermore, if the result of measurement is periodically sent to a remote monitoring center 51, the deterioration of the main rope of each building can be managed by the monitoring center 51, and a building rope of which should be changed soon can be notified to a serviceman.

Thus, in the first embodiment, the preliminary

drive is performed before the measurement of the gaps between the marks, and thus, the tensile difference between the ropes which appears in the stop time of the elevator can be resolved, and then, the gaps between
5 the marks can be measured with high accuracy in the measurement drive.

(Second embodiment)

Now, the second embodiment will be explained.

In the second embodiment, measurement of the gaps
10 between the marks is performed in the preliminary drive, and if the result of measurement is within a predetermined range, the result is handled as valid.

FIG. 10 is a flowchart of the operation of a rope inspection system of the second embodiment, as to a
15 process of automatically measuring gaps between marks 45 put on a main rope 24.

A controller 40 includes, as initial setting, various conditions related to a mark measurement such as an elevation range, and a drive speed (step S201),
20 and starts the preliminary drive at a predetermined speed (step S202).

In the second embodiment, a process of measuring gaps between marks is executed in the preliminary drive. That is, while a car 20 is in the preliminary
25 drive at a predetermined speed, the calculation device 30 acquires pulse signals output from the encoder 29 via a controller 40, and the successively counts the number of the pulse signals (step S203).

Furthermore, along with the movement of the main
30 rope 24, the marks 45 on the surface of the rope are optically detected by a sensor 28 (step S204). A calculation device 30 checks a currently counted count value of the pulse signal at a time when the marks 45 are detected by the sensor 28, and calculates gaps
35 between the marks based on the count value (step S205).

The gaps between that marks calculated at that time are displayed on a display device 31 as a result of measurement, and are stored in a memory 30a in the calculation device 30 (step S206).

5 Thereinafter, in the similar manner, the calculation device 30 acquires the count value of the pulse signal at the detection timing of the marks 45 in the preliminary drive, and stores the gaps between the marks sequentially calculated from the count values in
10 the memory 30a (steps S203 to S207).

 When the preliminary drive ends (Yes in step S207), the controller 40 checks a result of the measurement stored in the memory 30a (step S208). As a result, if the gap between the marks obtained as a
15 result of measurement in the preliminary drive is within a predetermined range (Yes in step S209), and the controller 40 handles the result of measurement as valid (step S210). That is, the gap between the marks measured in the preliminary drive is kept in the memory
20 30a as the valid result of measurement. In that case, the measurement drive is not performed.

 The above-mentioned "predetermined range" is defined in consideration of a difference of measurement caused by a tensile difference between the ropes. For
25 example, if it is clear that the tensile difference between the ropes produces the difference of measurement of 10 mm or more, valid/invalid is determined within a range of the gaps between marks (for example, 500 mm) put on the main rope 24 ± 10 mm.

30 If the gap between the marks obtained from the result of the measurement in the preliminary drive exceeds the predetermined range (No in step S209), the controller 40 determines that there is an influence by the tensile difference between the ropes, and
35 determines the measurement result as invalid (step

S211). That is, the result of measurement stored in the memory 30a is removed. Then, the controller 40 remeasures the gap between the marks by performing the measurement drive at the predetermined speed (step
5 S212). In that case, since the tensile difference between the ropes is considered to be resolved by the preliminary drive, the gap between the marks obtained as a result of measurement in the measurement drive can be handled as proper data to which the current rope
10 stretch condition is reflected.

Here, in step S212, if the gap between the marks is measured in the measurement drive, the drive is performed slower than the preliminary drive to maintain the accuracy of the measurement of the gaps between the
15 marks.

Note that if the time of sampling the output voltage V of the sensor 28 is changeable, and the gap between the marks is measured in the measurement drive, the accuracy of the measurement of the gaps between the
20 marks is maintained by the sampling time of the sensor 28 is set faster than the preliminary drive.

As above, in the second embodiment, the measurement of gap between the marks is performed in the preliminary drive, and the result of measurement
25 within the predetermined range is handled as valid. Thus, if influence by the tensile difference between the ropes is less, a workload to perform the measurement drive can be omitted.

Furthermore, if the result of measurement in the preliminary drive is out of the predetermined range,
30 the gap between the marks is remeasured in the measurement drive. At that time, the remeasurement can be performed with higher accuracy by decreasing the speed slower than that in the preliminary drive, or
35 shortening the sampling time of the sensor 28.

(Third embodiment)

Now, the third embodiment will be explained.

In the third embodiment, a rope inspection system includes a preliminary drive and a measurement drive, and includes a function to count the number of marks in the measurement drive, wherein a rope inspection is requested if the number of marks finally obtained after the drive ends is abnormal.

FIG. 11 is a flowchart of the operation of a rope inspection system of the third embodiment, as to a process of automatically measuring gaps between marks put on a main rope 24.

A controller 40 includes, as initial setting, various conditions related to a mark measurement such as an elevation range, and a drive speed (step S301), and starts the preliminary drive at a predetermined speed (step S302).

When the preliminary drive ends (Yes in step S303), the controller 40 performs the measurement drive at a predetermined speed (step S304). While a car 20 is moving in the measurement drive, a calculation device 30 acquires pulse signals output from an encoder 29 via the controller 40, and successively counts the number of pulse signals (step S305). Furthermore, along with the movement of the main rope 24, marks 45 on the surface of the rope are optically detected by the sensor 28 (step S306).

Here, in the third embodiment, the calculation device 30 includes a function to count the number of marks. When the marks 45 are detected by the sensor 28, the calculation device 30 adds one to the count value of the number of marks (step S307).

On the other hand, the calculation device 30 checks a currently counted count value of the pulse signal at a time when the marks 45 are detected by the

sensor 28, and calculates a gap between the marks based on the count value (step S308). The gap between the marks calculated is displayed on the display device 31 as a result of measurement, and stored in the memory 5 30a in the calculation device 30 (step S309).

Thereinafter, in the similar manner, the calculation device 30 acquires the count value of the pulse signal in the measurement drive, acquires a count value of the pulse signal at the detection timing of the marks 45, and stores the gaps between the marks 10 sequentially calculated from the count values in the memory 30a (steps S305 to S310).

When the measurement drive ends, the calculation device 30 calculates a stretch amount of the main rope 24 based on the gaps between the marks stored in the 15 memory 30a as a result of measurement, and displays the result on the display device 31. Note that, the calculation device 30 may not calculate the stretch amount, and only the gaps between the marks may be 20 displayed on the display device 31.

Furthermore, the controller 40 checks the number of marks counted by the calculation device 30 in the measurement drive (step S311). If, for example, a dirt or the like is adhered to the surface of the main rope 24, such a substance may be erroneously detected as a 25 mark 45. In that case, the number of marks finally obtained after the drive becomes above a rated value (the number of marks actually on the rope). On the other hand, if the marks 45 put on the surface of the 30 main rope 24 are partially or entirely removed, the removed parts may be undetected. In that case, the number of marks finally obtained after the drive becomes below the rated value.

Thus, an upper limit value and a lower limit value 35 which include a slight difference are set to the rated

value. Specifically, if the rated number of marks 45 is 100, and a difference is set to ± 5 , the upper limit value is set to 105, and the lower limit value is set to 95. If the number of marks finally obtained after the drive is above the upper limit or below the lower limit (Yes in step S312), the controller 40 determines that there is some kind of abnormality in the main rope 24, and requests the rope inspection by notifying the monitoring center 51 or the terminal device 52 of a serviceman (step S313). In that case, the current result of measurement (gaps between marks stored in the memory 30a) may be discarded, and remeasurement may be performed after the rope inspection.

As above, in the third embodiment, the number of marks is checked in the measurement drive, and thus, a case where the number of marks is above or below the rated value for some reason can be dealt with, and credibility of the measurement of gaps between marks can be improved.

Note that, in the third embodiment, based on the first embodiment, checking the number of marks in the measurement drive. However, the above-mentioned advantage can be obtained by checking the number of marks when performing the measurement drive in the second embodiment (cf. step S212 of FIG. 10).

(Fourth embodiment)

Now, a fourth embodiment will be explained.

In the fourth embodiment, a rope inspection system includes a preliminary drive and a measurement drive, and includes a function to count the number of marks in the preliminary drive, wherein a rope inspection is requested if the number of marks finally obtained after the drive is abnormal.

FIG. 12 is a flowchart to explain the operation of the rope inspection system of the fourth embodiment, as

to a process to automatically measure gaps between marks 45 on a main rope 24.

As with the second embodiment, a controller 40 includes, as initial setting, various conditions
5 related to a mark measurement such as an elevation range, and a drive speed (step S401), and starts the preliminary drive at a predetermined speed (step S402).

In the preliminary drive, a process of measuring the gaps between the marks is executed. That is, while
10 a car 20 is in the preliminary drive in the rated speed, a calculation device 30 acquires pulse signals output from an encoder 29 via a controller 40, and sequentially counts the number of pulse signals (step S403). Furthermore, along with the movement of the
15 main rope 24, marks 45 put on the surface of the rope are optically detected by a sensor 28 (step S404).

Here, in the fourth embodiment, the calculation device 30 includes a function to count the number of marks. When the marks 45 are detected by the sensor 28
20 in the preliminary drive, the calculation device 30 adds one to the count value of the number of marks (step S405).

On the other hand, the calculation device 30 checks a currently counted count value of the pulse
25 signal at a time when the marks 45 are detected by the sensor 28, and calculates a gap between the marks based on the count value (step S406). The gap between the marks calculated is displayed on the display device 31 as a result of measurement, and stored in the memory
30 30a in the calculation device 30 (step S407).

Thereinafter, in the similar manner, the calculation device 30 acquires the count value of the pulse signal in the preliminary drive, acquires a count
35 value of the pulse signal at the detection timing of the marks 45, and stores the gaps between the marks

sequentially calculated from the count values in the memory 30a (steps S403 to S408).

When the preliminary drive ends, the calculation device 30 checks the number of marks counted by the calculation device 30 in the measurement drive (step S409). As explained in the third embodiment, if a dirt or the like is adhered to the surface of the main rope 24, or if the marks 45 on the surface of the main rope 24 are partially or entirely removed, the number of marks obtained after the drive may be different from the rated value.

Here, if the number of marks finally obtained after the drive is above an upper limit value or is below a lower limit value (Yes in step S410), the controller 40 requests rope inspection by notifying to the monitoring center 51 or the terminal device 52 of a serviceman (step S411). In that case, the current result of measurement (gaps between marks stored in the memory 30a) may be discarded, and remeasurement may be performed after the rope inspection.

Furthermore, if the number of marks is within a range between the upper limit value and the lower limit value (No in step S410), the process is the same as with the second embodiment. That is, the controller 40 checks a result of measurement stored in the memory 30a (step S412). As a result, if the gaps between marks obtained as a result of measurement in the preliminary drive are within the predetermined range (Yes in step S413), the controller 40 handles the result of measurement as valid (step S414).

If the gaps between marks obtained as a result of the measurement in the preliminary drive exceed the predetermined range (No in step S413), the controller 40 determines that there is an influence of a tensile difference between the ropes, invalidates the result of

measurement (step S415), and remeasures the gaps between marks by performing the measurement drive at the predetermined speed (step S416).

5 As above, in the fourth embodiment, by checking the number of marks in the preliminary drive, a case where the number of marks is above or below the rated value for some reason can be smoothly dealt with before entering the measurement drive, and the credibility of the measurement between marks can be improved.

10 Note that, in the fourth embodiment, based on the second embodiment, checking the number of marks in the preliminary drive. However, the above-mentioned advantage can be obtained by checking the number of marks when performing the preliminary drive in the
15 first embodiment (cf. step S102 of FIG. 9).

 According to at least one of the above embodiments, a rope inspection system of an elevator which can measure gaps between marks on a rope with high accuracy and can perform management of strength
20 with high credibility is provided.

 While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described
25 herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their
30 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. An elevator rope inspection system in which a car and a counter weight are held with a traction sheave of a traction machine, and a wear condition of a plurality of ropes having a resin coated surface is inspected by measuring gaps between a plurality of marks on the surface of each rope, the system comprising:

a controller configured to perform a preliminary drive to average the tensile between the ropes and then perform a measurement drive to measure the gaps between the marks,

wherein the controller measures the gaps between the marks in the preliminary drive, and if a result of measurement is within a predetermined range, keeps the result of measurement as a valid result of measurement for inspecting the wear condition of the ropes and does not perform the measurement drive.

2. The rope inspection system of claim 1, wherein the controller performs the preliminary drive when the drive of the traction machine is stopped for a certain period of time or more.

3. The rope inspection system of claim 1, wherein the controller reciprocates the car between the lowermost floor and the uppermost floor by at least once in the preliminary drive.

4. The rope inspection system of claim 1, wherein the controller performs the preliminary drive at a rated speed of the elevator.

5. The rope inspection system of claim 1, wherein the controller invalidates a result of measurement obtained in the preliminary drive if the result of measurement exceeds the range, and remeasures the gaps

between the marks by the measurement drive.

6. The rope inspection system of claim 1, wherein
the controller performs the measurement drive at a
speed slower than that of the preliminary drive, and
5 remeasures the gaps between the marks.

7. The rope inspection system of claim 1, wherein
the controller performs the measurement drive by
shortening a sampling time of a sensor to detect each
mark than a sampling time of the preliminary drive, and
10 remeasures the gaps between the marks.

8. The rope inspection system of claim 1, further
comprising:

a calculator to count the number of the marks
during the preliminary drive or the measurement drive,
15 wherein

the controller requests, if the number of the
marks counted by the calculator after the drive is
greater than a predetermined upper limit value or is
fewer than a predetermined lower limit value, a rope
20 inspection by notifying to a monitoring center or to a
terminal device of a serviceman.