

SAFETY ELEVATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an elevator having an elevator car operating to move up and down in a hoistway. Particularly, it is preferably applied to an elevator having position sensors for detecting the position of an elevator car (arrival detection) and a door zone.

2. Description of the Related Art

In an elevator according to the background art, for example, a photoelectric position detector is disposed on an elevator car and detects a detection target plate which is disposed for each floor to thereby the position of the elevator car in a hoistway is detected. The position detector is used for aligning the floor surface of the elevator car with the floor surface of a landing (arrival detection) and detecting a door zone (an opening/closing allowable region of an elevator car door relative to a landing door) to prevent the elevator car from running with the car door opened.

It has been known and described in JP-A-2004-224529 that an arrival detection plate (detection target plate) is attached to a landing door sill to prevent the photoelectric arrival detection switch (position detector) from operating by mistake, and that a mistaken operation preventing cover is provided to prevent light except light of the arrival detection switch from being incident on the arrival detection plate.

It has been known and described, for example, in JP-A-2004-142882 (Fig. 2) that operation plates having different arrangement patterns for each operating position are attached in the up/down direction of the car to detect breaking of conducting wire connecting each detection sensor portion and a detection circuit portion to each other, and that four detection sensor portions are provided in the car to detect the operation plates to thereby it is determined as a failure when a code based on a signal undetectable in normal operation does not coincide with any one of the arrangement patterns.

SUMMARY OF THE INVENTION

In the background art described in JP-A-2004-224529, mistaken operation due to external light is merely prevented. Accordingly, not only is it impossible to detect failure of the position detection sensor per se, but also it is difficult to give multifunctional property to the sensor for detecting the door zone and realigning the floor to adjust a fine level difference.

Therefore, the number of sensors must be increased.

In the background art described in JP-A-2004-142882 (Fig. 2), there is no consideration about detection of failure of each detection sensor per se. When the detection sensor has ON or OFF failure to form a pattern which is even possible in normal operation, abnormality cannot be determined. Therefore, for example, the number of detection sensors must be doubled to improve safety and reliability, so that the system configuration is complicated.

An object of the invention is to solve the problem in the background art and particularly to provide a position detection sensor which has a function capable of identifying each floor, which can detect each specific position (various kinds of limit switches, etc.) to attain multifunctional property by using only the position detection sensor and which can perform failure detection of the detection sensor itself and failure detection of an elevator system to thereby improve safety and reliability.

Another object of the invention is to simplify the configuration of an elevator system even with improved multifunctional property, safety and reliability to thereby improve redundancy of the whole system inclusive of mistaken detection, etc.

Incidentally, the invention intends to achieve at least one of the above objects.

To solve the aforementioned problem, the invention provides a safety elevator in which the position of an elevator car operating to move up/down in a hoistway is detected so that operation is controlled based on the detected position, the safety elevator including: a position detection sensor which outputs an output pattern having a plurality of outputs in accordance with the position of the elevator car moving up/down; a position database which stores a specific output pattern corresponding to each specific position in an up/down direction; a car position data portion which stores the output pattern whenever the output pattern of the position detection sensor changes; and a transition database which stores the specific output pattern expected in accordance with the specific position as predicted transition data; wherein when the output pattern does not coincide with any one of the predicted transition data at the time of arrival of the elevator car at the specific position, it is determined as a failure and an operation is controlled.

According to the invention, when the output pattern of the position detection sensor does not coincide with any one of specific output patterns expected in accordance with a specific position at the time of arrival of the elevator car at the specific position, it is determined as a failure. Accordingly, the number of functions capable of identifying respective floors and the number of specific positions to be detected can be increased to give multifunctional property to the elevator system and perform failure detection to thereby improve safety and reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing overall configuration of an embodiment of the invention;

Fig. 2 is a perspective view showing details of a landing door sill portion in an
5 embodiment of the invention;

Fig. 3 is a block diagram showing a logic-arithmetic unit in an embodiment of the invention;

Fig. 4 is a list showing the relations among position detection sensors, operation plates and specific output patterns when each floor is provided as a specific position in an
10 embodiment of the invention;

Fig. 5 is a block diagram showing details of the logic-arithmetic unit in an embodiment of the invention;

Fig. 6 is a state transition diagram showing output transition of a position detection sensor in an embodiment of the invention;

Fig. 7 is a view showing the relation between specific output patterns and predicted transition data in an embodiment of the invention;

Fig. 8 is a flow chart showing failure detection in an embodiment of the invention;

Fig. 9 is a list showing the relation among position detection sensors, operation
20 plates and specific output patterns when each floor is provided as a specific position in another embodiment of the invention;

Fig. 10 is a block diagram showing details of a logic-arithmetic unit in another embodiment of the invention; and

Fig. 11 is a flow chart showing failure detection in another embodiment of the
25 invention.

DETAILED DESCRIPTION OF THE INVENTION

An embodiment of the invention will be described below in detail with reference to the drawings.

Fig. 1 is an overall configuration view showing an elevator system. The
30 reference numeral 102 designates a landing door sill, and the reference numeral 115 designates a floor surface. An elevator car 100 is connected to a weight 111 through a rope 101 so as to move between a plurality of floors in a hoistway formed in a building. An elevator car door 110 is provided in the elevator car 100 so as to be opened and closed in conjunction with a

landing door 109. A sheave 103 is driven by an electric motor 105 to thereby move the elevator car 100. A power converter 107 supplies driving electric power to the electric motor 105.

A pulse generator 106 such as an encoder is attached to the electric motor 105.

A system controller 108 calculates the velocity of the electric motor 105 and the hoistway

5 moving direction, position, moving distance, etc, of the elevator car 100 by counting pulses generated in accordance with rotation of the electric motor 105.

A position detection sensor 4 (position detector) is composed of a plurality of sensors 11a, 11b, 11c and 11d which are provided at intervals of a predetermined distance on the elevator car 100 side. Respective outputs 12a, 12b, 12c and 12d of the plurality of sensors are
10 connected to the system controller 108 through a logic-arithmetic unit 5. A detection target plate 10 is disposed in the landing door sill 102 on the landing side opposite to the position detection sensor 4, so that the position detection sensor 4 detects the detection target plate 10 to thereby detect the position of the elevator car 100 in the hoistway. Alignment of the floor surface of the elevator car 100 with the floor surface 115 of each landing (arrival position),
15 detection of the door zone (door opening/closing allowable region of the elevator car door 110 relative to the landing door 109) and operation control are performed based on the detected result.

Although a non-contact detection sensor such as a photoelectric sensor, a magnetic sensor (e.g. using a magnet, using a high-frequency magnetic field, etc.), a capacitive
20 sensor, etc. may be used as each position detection sensor, a reflective photoelectric detection sensor which projects infrared light or the like onto the detection target plate 10 and detects reflected light from the detection target plate 10 is preferred because there is no possibility that a rope or the like will catch on the sensor itself or the detection target plate 10 at the time of occurrence of earthquakes or the like, and because the reflective photoelectric detection sensor
25 has such a high directivity that the detection target plate can be detected accurately. There is however a possibility that mistaken detection will be caused by ambient light chiefly including the sunlight, dust, dewdrops, etc. because reflective photoelectric detection sensor uses the infrared light or the like.

Particularly when the position detection sensor 4 which detects the door zone
30 performs mistaken detection or fails, there is a possibility that the elevator car door 110 will be opened by mistake because of false recognition that the elevator car door 110 is enabled to be opened/closed though the elevator car door 110 is located to be disabled from opening/closing or the elevator car door 110 will be closed to lock passengers into the elevator car by mistake because of false recognition that the elevator car door 110 is disabled from opening/closing

though the elevator car door 110 is located to be enabled to be opened/closed.

Fig. 2 shows details of the landing door sill 102. A toe guard 113 and the detection target plate 10 are attached to the landing door sill 102. The toe guard 113 protects passengers' toes and prevents passengers from falling into the hoistway. The detection target plate 10 is composed of operating plates 10a, 10b (not provided in Fig. 2), 10c and 10d which are made of metal such as iron or plastic to reflect light. The position detection sensor 4 composed of sensors 11a, 11b, 11c and 11d opposite to the operating plates 10a, 10b, 10c and 10d is attached to the elevator car 100. Outputs 12a, 12b, 12c and 12d of the respective sensors are inputted to the logic-arithmetic unit 5 which is a logic IC or a logic-arithmetic circuit made of arithmetic operation of micro-computers.

Fig. 2 shows the case where four sensors are provided but only three operating plates 10a, 10c and 10d are provided in the detection target plate 10. That is, three of the four sensors are enabled to detect the operating plates (e.g. the sensor 11a outputs "1" indicating "detection" in a position where the operating plate 10a and the sensor 11a face each other and the sensor 11b outputs "0" indicating "no detection" because there is no operating plate 10b in Fig. 2, that is, because there is no operating plate 10b facing the sensor 11b).

Fig. 3 shows the position sensor 4 and the logic-arithmetic unit 5. The logic-arithmetic unit 5 is composed of two micro-computers. Outputs of the position detection sensor 4 are inputted to each of the micro-computers. The two micro-computers are compared with each other to thereby detect software error and hardware error.

The logic-arithmetic unit 5 outputs a signal 14 to the system controller 108. The signal 14 contains door zone information, sensor failure diagnosis information, floor identification information, etc. When the elevator needs to be stopped because of sensor failure or arrival at a specific position, the logic-arithmetic unit 5 sends an output for breaking the power supply and executing a braking operation to stop the elevator and an output for notifying the system controller 108 of execution of the breaking process. Although use of the two micro-computers permits a more complex process, the invention is not limited to the case where two micro-computers are used. For example, high-speed processing may be performed by a simpler configuration advantageously when the aforementioned process is executed in the condition that the two micro-computers are replaced by one micro-computer and one logic IC, FPGA (Field Programmable Gate Array) or LSI (logic gate array semi-custom LSI) or replaced by a single micro-computer.

Fig. 4 shows configurations of detection target plate 10 (operating plates 10a, 10b, 10c and 10d) provided in respective floors for identifying first to sixth floors respectively. As

shown in Fig. 4, specific output patterns corresponding to a plurality of specific positions of respective floors in the up/down direction are outputted in the specific positions of the respective floors. The length of each detection target plate 10 is provided as a length corresponding to the door zone indicating a door opening/closing allowable region.

5 The length of each detection target plate 10 may be determined by a function executed based on a corresponding specific output pattern. For example, when the function of a final limit switch for detecting an overrun of the elevator car in the terminal floor is executed, the length of each detection target plate 10 may be provided as a length from a buffer to the lowest floor.

10 The specific positions are determined as fixed positions required in the hoistway not only in accordance with the door zone and the final limit switch but also in accordance with switches such as a maintenance limit switch for keeping a top space to make a maintenance worker perform work safely, a direction limit switch for detecting arrival of the elevator car at the terminal floor, and a terminal floor forced deceleration switch for making the elevator car
15 collide with the buffer at a speed not higher than a rating speed when the elevator car gets into an overspeed state for some reason.

Fig. 5 shows a block diagram of the logic-arithmetic unit 5. Outputs of the position detection sensor 4 are inputted to a position determination portion 21. The position determination portion 21 compares the output pattern of the position detection sensor 4 with
20 specific output pattern information which is stored in a position database 23 and which is necessary for the output pattern when the elevator car 100 arrives at a specific position corresponding to each floor. When the output pattern of the position detection sensor 4 consequently coincides with the specific output pattern stored in the position database 23, the position determination portion 21 updates current car position information of a car position data
25 portion 22, stores the updated current car position information and transmits information for executing a function determined by the car position data portion 22 to a function execution portion 26.

When the output pattern of the position detection sensor 4 is absent in the position database 23 and does not coincide with any specific output pattern, the position determination
30 portion 21 determines that the sensor has a failure, and transmits a signal indicating failure to the function execution portion 26.

Because the output pattern detected by the position detection sensor 4 is stored in the car position data portion 22 whenever the output pattern changes, an abnormal transition determination portion 25 determines that it is an abnormal transition when change or transition

of the current output pattern from the previous output pattern before updating does not coincide with predicted transition data stored in a transition database 24, and transmits information of the abnormal transition to the function execution portion 26.

The function execution portion 26 executes a function corresponding to the specific output pattern. When the specific position is a floor position, the function execution portion 26 transmits a door zone signal to a transmission portion 27 to execute the function of a door zone which is a door opening/closing allowable region. The transmission portion 27 executes a process of outputting a signal to the outside. For example, the transmission portion 27 is connected to an operation control system of the elevator.

Failure detection using state transition of the output pattern of the position detection sensor 4 and processing in the abnormal transition determination portion 25 will be described below in detail.

Fig. 6 is a state transition diagram showing output transition of the position detection sensor 4 in an example in which specific positions are six floor positions. The state transition of the position detection sensor 4 is provided as repetition of transition between a state in which each sensor detects nothing, that is, outputs of all sensors are zero and a state in which a specific floor is detected (specific output pattern). Accordingly, when the output pattern jumps from the first floor to the sixth floor suddenly or a specific output pattern indicating the fifth floor is detected as the output pattern of the position detection sensor 4, the abnormal transition determination portion 25 can determine that it is an abnormal transition because the second floor, the third floor and the fourth floor must be originally detected as next patterns successively after detection of the second floor.

Fig. 7 shows specific output patterns expected after detection of the second floor. In this case, specific output patterns of the first floor, the second floor and the third floor are expected to be detected as predicted transition data. Accordingly, when any other specific output pattern than these specific output patterns is detected, the abnormal transition determination portion 25 determines that there is a failure. The transition database 24 has such predicted transition data as shown in Fig. 7 in accordance with each floor. Fig. 8 is a flow chart of specific processing. In Fig. 8, the abnormal transition determination portion 25 reads the detected current and previous specific output patterns from the car position data portion 22, compares the data with predicted transition data, determines whether the sensor is normal or has a failure, and detects the failure of the sensor or the failure of the position determination portion 21.

According to the aforementioned configuration, a position detection sensor 4

having a plurality of sensors (11a, 11b, 11c, 11d) provided on the elevator car side and each detection target plate 10 having operation plates provided on the landing side make it possible to identify specific positions and floors and to detect failure of the sensor, etc.

Although it is preferable in the viewpoint of effective use of a space that reflective
5 photoelectric sensors are used, transmissive photoelectric sensors or magnetic sensors may be used likewise.

Fig. 9 shows another embodiment in which the configuration of the detection
target plate 10 (operation plates 10a, 10b, 10c and 10d) provided in each floor is changed.
Detection of the failure of the position detection sensor 4 will be described in detail with
10 reference to Fig. 9.

There is a high possibility that ON failure caused by failure of a sensor element or
OFF failure caused by breaking of wire or failure of the element will occur as failure of each of
sensors 11a, 11b, 11c and 11d forming the position detection sensor 4. Specifically, output "0"
between floors is changed to output "1" in the case of ON failure, and output "1" in a specific
15 floor is changed to output "0" in the case of OFF failure.

In the configuration shown in Fig. 9, operation plates 10a, 10b, 10c and 10d are
provided so that each specific output pattern only has an even number of outputs "1" (ON).
Accordingly, when the number of sensors turned ON is an add number, failure of any sensor can
be found immediately, that is, from the output pattern of the position detection sensor 4.
20 Alternatively, operation plates 10a, 10b, 10c and 10d may be provided so that each specific
output pattern has an odd number of outputs "1" (ON). In this case, when the number of
sensors turned ON is an even number, failure of any sensor can be found.

Specifically, the following description will be made. In the configuration shown
in Fig. 9, when the position detection sensor 4 is normal, the number of sensors having outputs
25 "1" (ON) based on a specific output pattern is two or four. Outputs of all the sensors of the
position detection sensor 4 between floors are "0" (OFF). When at least one of the sensors of
the position detection sensor 4 has ON failure or OFF failure, the number of sensors having
outputs "1" based on a specific output pattern becomes one or three. When one sensor of the
position detection sensor 4 has ON failure between floors, the number of sensors having outputs
30 "1" (ON) becomes one. Accordingly, when an output pattern in which an even number of
sensors of the position detection sensor 4 have outputs "1" (ON) is regarded as normal while an
output pattern in which an odd number of sensors have outputs "1" (ON) is regarded as failure,
failure of any one of the sensors in the position detection sensor 4 can be detected. Because this
failure detecting method can be applied to failure detection between floors, failure of the position

detection sensor can be determined immediately when the position detection sensor 4 sends out an output pattern.

The aforementioned failure detection means that a hamming distance of 2 or more is taken between two kinds of output patterns "normal" and "failure". The hamming distance shows the number of different characters in corresponding position between two codes each having an equal number of data. For example, the humming distance between data A "1100" and data B "1101" is 1 because the two data A and B are different only in the least significant digit. In this embodiment, a hamming distance of 2 or more is taken between an output pattern "the position detection sensor 4 is normal" and an output pattern "the position detection sensor 4 has a failure", so that failure of at least one sensor in the position detection sensor 4 can be detected. Although this embodiment has been described in the case where configuration in which two output patterns are separated into an odd number and an even number and a humming distance of 2 or more is taken between the two output patterns is used as a configuration for detecting failure of one sensor in the position detection sensor 4, configuration may be made so that a humming distance of 3 or more is taken if simultaneous failure of sensors in the position detection sensor needs to be detected.

Although failure detection using state transition can be executed, for example, only when a specific output pattern is detected in each floor, failure detection can be always executed when failure detection is executed while a number of the output pattern of the sensor is limited to an even number or an odd number of sensors. Accordingly, failure can be detected early.

Fig. 10 is a block diagram showing a logic-arithmetic unit 5 which is formed by addition of a position determination portion 20 to Fig. 5. Fig. 11 is a flow chart showing processing in the position determination portion 20. Sensor failure can be detected by a simple logic of acquiring the output pattern of the position detection sensor 4 and determining whether the number of outputs "1" in the position detection sensor is an odd number or not. Accordingly, when the position determination portion 20 is provided as a logic IC or an FPGA, failure detection can be performed more rapidly.

In addition, when this failure detection for the detection sensor per se is combined with failure detection using state transition, system configuration can be double-checked so that more great improvement of safety and reliability can be attained.

CLAIMS:

1. A safety elevator in which a position of an elevator car operating to move up/down in a hoistway is detected so that operation is controlled based on the detected position, the safety elevator comprising:
 - a position detection sensor (4) which outputs an output pattern having a plurality of outputs in accordance with the position of the elevator car (100) moving up/down;
 - a position database (23) which stores a specific output pattern corresponding to each specific position in an up/down direction; and
 - a car position data portion (22) which updates current car position information and stores the updated current car position information, when the elevator car arrives at the specific position and the output pattern coincides with the specific output patternwherein the specific output pattern is set to have an even number of ON outputs in the plurality of outputs, and when an odd number of ON outputs are included in the output pattern at the specific position and between specific positions, it is determined as a failure of the position detection sensor
2. A safety elevator according to Claim 1, further comprising: a transition database (24) which stores the plurality of specific output patterns expected after the specific position is detected, as predicted transition data in accordance with each of the specific position;
 - wherein when the detected current output pattern does not coincide with any one of the plurality of predicted transition data in accordance with the previous specific position at the time of arrival of the elevator car (100) at the specific position, it is determined as a failure and an operation is controlled.
3. A safety elevator according to Claim 1 or 2, wherein the specific position shows a floor at which the elevator car arrives.
4. A safety elevator according to Claim 1 or 2, wherein the specific position shows a final limit switch which detects an overrun of the elevator car in the terminal floor.

5. A safety elevator according to Claim 1 or 2, wherein the specific position shows a maintenance limit switch for keeping a top space.
6. A safety elevator according to Claim 1 or 2, wherein the specific position shows a direction limit switch which detects arrival of the elevator car at the terminal floor.
7. A safety elevator according to Claim 1 or 2, wherein the specific position shows a terminal floor forced deceleration switch.
8. A safety elevator according to Claim 1 or 2, wherein the position detection sensor has a plurality of sensors provided in the elevator car to detect a detection target plate having operation plates provided on a landing side opposite to the plurality of sensors to thereby output the output pattern.
9. A safety elevator according to Claim 1 or 2, wherein the specific position shows a floor at which the elevator car arrives; the position detection sensor has a plurality of sensors provided in the elevator car to detect a detection target plate having operation plates provided on a landing side opposite to the plurality of sensors to thereby output the output pattern; and the length of each operation plate in the up/down direction is a length corresponding to a door zone.
10. A safety elevator according to Claim 1 or 2, wherein the specific position shows each floor and at least one of a final limit switch, a maintenance limit switch, a direction limit switch and a terminal floor forced deceleration switch.
11. A safety elevator according to Claim 1 or 2, wherein when the output pattern does not coincide with anyone of the specific output patterns stored in the position database at the time of arrival of the elevator car at the specific position, failure of the position detection sensor is determined,
12. A safety elevator according to Claim 1 or 2, wherein the outputs of the position detection sensor are inputted to two micro-computers.

13. A safety elevator according to Claim 1 or 2, wherein the outputs of the position detection sensor are inputted to a micro-computer and an FPGA (Field Programmable Gate Array),