

TITLE OF THE INVENTION

ELEVATOR SYSTEM AND CAR POSITION DETERMINATION METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001]

The present invention relates to an elevator system and a car position determination method, and is suitable for application to, for example, an elevator system and a car position determination method for determining the position of an elevator car.

2. Description of the Related Art

[0002]

A remote monitoring system for detecting abnormalities in an elevator detects an abnormality in the position of the car, an abnormality in the speed of the car, a confinement failure, etc., using information from a control apparatus controlling the elevator, and notifies a control center of the elevator, a terminal of maintenance personnel, or the like of the detected condition. The remote monitoring system acquires car position information output from the control apparatus controlling the elevator, thereby determining the current position of the elevator car.

[0003]

However, for an elevator for which control information output from an elevator control apparatus cannot be used, such as a relay-type elevator that is an old-style elevator, control information cannot be collected. Consequently, a remote monitoring system remotely monitoring the operation of the elevator cannot collect control information on the elevator including the floor where the car is stopped etc., and cannot find the current position of the car. Therefore, a technique is used which determines the position of a car based on output values from an external atmospheric pressure sensor, an external acceleration sensor, etc., instead of control information output from a control apparatus (see JP 2019-199347 A).

[0004]

A car position determination apparatus described in JP 2019-199347 A detects the movement and current position of a car, based on output values from an atmospheric pressure sensor and an acceleration sensor, and counts the number of times the door is opened and closed at each floor using the acceleration sensor. The car position determination apparatus sets a reference floor based on the number of times the door has been opened and closed, and corrects atmospheric pressure for detecting a floor if atmospheric pressure at the reference floor varies.

[0005]

Here, the detection of the current position of the car using the external sensors has a disadvantage that the position of the car after the elevator is restored from a power failure cannot be detected reliably.

[0006]

In this respect, the car position determination apparatus described in JP 2019-199347 A detects travelling and stopping of the elevator using the acceleration sensor after the elevator is restored from a power failure, and performs processing to update atmospheric pressure for detecting a floor at the point in time when the measurement of atmospheric pressure at all floors is completed, thereby allowing the detection of the position of the car after restoration from a power failure.

SUMMARY OF THE INVENTION

[0008]

In the technique described in JP 2019-199347 A, the car needs to stop at all the floors after restoration from a power failure in order to detect the position of the car after the restoration from the power failure. However, elevators have various uses, and there are cases where an elevator does not stop at all floors, for example, does not stop at specific floors. In those cases, the position of

the car after restoration from a power failure cannot be detected.

[0009]

The present invention has been made in consideration of the above point, and is intended to propose an elevator system or the like that can properly detect the position of a car.

[0010]

In order to solve such a problem, according to the present invention, an elevator system including an identifier provided in a shaft of an elevator, and a detection unit provided on a car of the elevator to detect the identifier is provided with a storage unit that stores heights of floors of the elevator, an atmospheric pressure measuring unit provided on the car to measure atmospheric pressure at a height where the identifier detected by the detection unit is located, a calculation unit that calculates atmospheric pressure at each floor of the elevator, based on the atmospheric pressure at the height where the identifier is located, and the heights of the floors stored in the storage unit, and a determination unit that determines a position of the car from the atmospheric pressure at each floor calculated by the calculation unit, and atmospheric pressure measured by the atmospheric pressure measuring unit.

[0011]

In the above configuration, when the identifier provided in the shaft is detected, the atmospheric pressure at the height where the identifier is located is measured, and the atmospheric pressure at each floor is calculated based on the measured atmospheric pressure and the heights of the floors stored in the storage unit. According to the above configuration, by the identifier being detected, the position of the car can be determined by comparing the measured atmospheric pressure with the calculated atmospheric pressure at each floor. Consequently, for example, when the elevator is restored from a power failure, the position of the car can be easily detected.

[0012]

According to the present invention, a highly reliable elevator system or the like can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a diagram illustrating an example of the configuration of an elevator system according to a first embodiment;

Fig. 2 is a diagram illustrating an example of a manner in which magnets are placed according to the first embodiment;

Fig. 3 is a diagram illustrating an example of the configuration of a position determination apparatus according to the first embodiment;

Fig. 4 is a diagram illustrating an example of a flowchart of atmospheric pressure calculation processing according to the first embodiment;

Fig. 5 is a diagram illustrating an example of a flowchart of atmospheric pressure correction processing according to the first embodiment;

Fig. 6 is a conceptual diagram illustrating the relationship between calculated atmospheric pressure and actual atmospheric pressure according to the first embodiment; and

Fig. 7 is a diagram illustrating an example of a flowchart of abnormality detection processing according to the first embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014]

Hereinafter, an embodiment of the present invention will be described in detail with reference to the drawings. In the present embodiment, a technique for detecting the position of an elevator car will be mainly described.

[0015]

In an elevator system described in the present

embodiment, for example, an identifier that allows identification of a specified floor of an elevator is provided at the specified floor, and the identifier is detected by a sensor provided on a car, thereby facilitating detection of the position of the car.

[0016]

Here, as the specified floor, any floor can be used. As the specified floor, a floor through which the car often passes is suitable. Furthermore, as the specified floor, a floor where the car often stops is suitable. The specified floor may be one of a plurality of specified floors. In the present embodiment, the floor located at the top (top floor), the floor located midway (middle floor), and the floor located at the bottom (bottom floor) will be described as examples of the specified floors, but the present invention is not limited to this.

[0017]

The identifier, which allows identification of the specified floor, is a magnet, a radio-frequency (RF) tag, a slit, a marker, or the like. As the sensor, for example, a magnetic sensor is used if the identifier is a magnet, a scanner or a reader/writer for RF if the identifier is an RF tag, a photoelectric sensor if the identifier is a slit, or an image sensor if the identifier is a marker. In the present embodiment, a magnet will be described as an

example of the identifier, but the present invention is not limited to this.

[0018]

In the following description, when elements of the same type are described without distinction, a common portion of reference numerals including branch numbers (a portion other than branch numbers) may be used, and when elements of the same type are described distinctively, reference numerals including branch numbers may be used. For example, when magnets are described without clear distinction, they may be described as "magnets 107", and when individual magnets are described distinctively, they may be described as a "magnet 107-1", "magnets 107-2", and the like.

[0019]

(1) First embodiment

In Fig. 1, reference numeral 100 denotes an elevator system as a whole according to a first embodiment. Fig. 1 is a diagram illustrating an example of the configuration of the elevator system 100.

[0020]

The elevator system 100 includes an elevator car 101, a hoist 102, a counterweight 103, a pulley 104, a main rope 105, a position determination apparatus 106, and magnets 107.

[0021]

The hoist 102 is a device for raising and lowering the car 101. The counterweight 103 is a weight for reducing load when the car 101 is raised or lowered. The pulley 104 is for preventing contact between the car 101 and the counterweight 103. The main rope 105 is a rope connecting the car 101 and the counterweight 103. The position determination apparatus 106 is installed on the car 101 to detect the magnets 107 and determining the position (floor, altitude, or the like) of the car 101. The following describes a case where the position determination apparatus 106 determines the floor of the car 101 as an example.

[0022]

The magnet 107-1 for detecting the top floor is placed at the top floor. The magnets 107-2 for detecting the middle floor are placed at the middle floor. A magnet 107-3 for detecting the bottom floor is placed at the bottom floor.

[0023]

Fig. 2 is a diagram illustrating an example of a manner in which the magnets 107 are placed.

[0024]

The magnet 107-1 for detecting the top floor is placed near a landing door 201-1 on the top floor in a

shaft through which the car 101 moves up and down, such that the north-pole side is on the shaft side. The magnet 107-1 for detecting the top floor is placed at a position closest to the position determination apparatus 106 when the car 101 stops at the top floor.

[0025]

The magnets 107-2 for detecting the middle floor includes a magnet 107-2A for detecting the middle floor placed such that the north-pole side is on the shaft side, and a magnet 107-2B for detecting the middle floor placed such that the south-pole side is on the shaft side. The magnet 107-2A for detecting the middle floor and the magnet 107-2B for detecting the middle floor are placed near a landing door 201-2 on the middle floor in the shaft. The magnet 107-2A for detecting the middle floor and the magnet 107-2B for detecting the middle floor are placed at positions closest to the position determination apparatus 106 when the car 101 stops at the middle floor.

[0026]

The magnet 107-3 for detecting the bottom floor is placed near a landing door 201-3 on the bottom floor in the shaft through which the car 101 moves up and down, such that the south-pole side is on the shaft side. The magnet 107-3 for detecting the bottom floor is placed at a position closest to the position determination apparatus

106 when the car 101 stops at the bottom floor.

[0027]

The positions where the magnets 107 are placed are an example, and the present invention is not limited to the positions illustrated in Fig. 2. For example, the magnets 107 may be placed above the landing doors 201, or may be placed to the side of the landing doors 201, or may be placed at other positions.

[0028]

Fig. 3 is a diagram illustrating an example of the configuration of the position determination apparatus 106.

[0029]

The position determination apparatus 106 includes a storage unit 301, detection units 302, a temperature measuring unit 303, an atmospheric pressure measuring unit 304, and a computer unit 305.

[0030]

The storage unit 301 is, for example, a storage device such as read-only memory (ROM) or a hard disk drive (HDD), and stores information regarding the car 101. The storage unit 301 stores, for example, the altitudes of all floors in association with the floors.

[0031]

The detection units 302 include a north-pole detection unit 302-1 and a south-pole detection unit 302-2.

The north-pole detection unit 302-1 is, for example, a magnetic sensor that detects the north pole of the magnets 107, and detects the magnet 107-1 for detecting the top floor and the magnet 107-2A for detecting the middle floor placed in the shaft. The south-pole detection unit 302-2 is, for example, a magnetic sensor that detects the south pole of the magnets 107, and detects the magnet 107-2B for detecting the middle floor and the magnet 107-3 for detecting the bottom floor.

[0032]

The temperature measuring unit 303 is, for example, a temperature sensor, and measures (detects) the temperature around the car 101.

[0033]

The atmospheric pressure measuring unit 304 is, for example, an atmospheric pressure sensor, and measures (detects) the atmospheric pressure around the car 101.

[0034]

The computer unit 305 is, for example, a computer, and includes a central processing unit (CPU) 310, memory 320, and a communication interface 330.

[0035]

Functions of the computer unit 305 (a calculation unit 321, a determination unit 322, etc.) may be implemented by, for example, the CPU 310 reading a program

into the memory 320 and executing it (software), or may be implemented by hardware such as a dedicated circuit, or may be implemented by a combination of software and hardware. Part of the functions of the computer unit 305 may be implemented by another computer that can communicate with the computer unit 305.

[0036]

The calculation unit 321 calculates (estimates) atmospheric pressure that will be detected by the atmospheric pressure measuring unit 304 when the car 101 stops at each floor, based on information from the storage unit 301, the north-pole detection unit 302-1, the south-pole detection unit 302-2, the temperature measuring unit 303, and the atmospheric pressure measuring unit 304.

[0037]

The calculation unit 321 detects where the car 101 is stopped, the top floor, the middle floor, or the bottom floor, using information (measured values) from the north-pole detection unit 302-1 and the south-pole detection unit 302-2. The calculation unit 321 identifies a floor using the combination of the north-pole magnet 107 and the south-pole magnet 107 detected, such that when only the north-pole magnet 107 is detected, it is the top floor, when the north-pole magnet 107 and the south-pole magnet 107 are detected, it is the middle floor, and when only the south-

pole magnet 107 is detected, it is the bottom floor.

[0038]

The calculation unit 321 further has a data storage function of storing atmospheric pressure (atmospheric pressure data) at each floor used for the detection of the position of the car 101 in a predetermined storage area (such as the storage unit 301, the memory 320, or another computer), and a reference data storage function of storing atmospheric pressure and temperature when the car 101 arrives at the top floor, the middle floor, or the bottom floor in a predetermined storage area.

[0039]

The determination unit 322 compares atmospheric pressure measured by the atmospheric pressure measuring unit 304 with atmospheric pressure at each floor calculated by the calculation unit 321, and determines (detects) a floor with the closest atmospheric pressure as the floor where the car 101 is currently located. For example, if atmospheric pressure measured by the atmospheric pressure measuring unit 304 is "1009.75 (hPa)", atmospheric pressure at the first floor calculated by the calculation unit 321 is "1010.00 (hPa)", and atmospheric pressure at the second floor calculated by the calculation unit 321 is "1009.70 (hPa)", the determination unit 322 determines that the floor where the car 101 is currently located is the second

floor.

[0040]

Next, processing to calculate atmospheric pressure at each floor for the determination of the position of the car 101 (atmospheric pressure calculation processing) will be described with reference to the flowchart illustrated in Fig. 4.

[0041]

Fig. 4 is a diagram illustrating an example of a flowchart of the atmospheric pressure calculation processing. The atmospheric pressure calculation processing refers to processing after the position determination apparatus 106 is powered on, and the position determination apparatus 106 is activated. The atmospheric pressure calculation processing is executed at predetermined timings (for example, periodically until processing in step S404 or step S408 is performed).

[0042]

In step S401, when powered on, the position determination apparatus 106 determines whether or not the magnet 107-1 for detecting the top floor, the magnets 107-2 for detecting the middle floor, or the magnet 107-3 for detecting the bottom floor placed in the shaft has been detected for the first time (whether or not one of the top floor, the middle floor, or the bottom floor has been

detected for the first time) by the north-pole detection unit 302-1 and the south-pole detection unit 302-2. If the position determination apparatus 106 determines that the magnet(s) 107 has/have been detected for the first time, it proceeds to processing in step S402, and if it determines that no magnet 107 has been detected for the first time, it proceeds to processing in step S405.

[0043]

In step S402, the position determination apparatus 106 stores temperature measured by the temperature measuring unit 303 and atmospheric pressure measured by the atmospheric pressure measuring unit 304 in association with the floor detected (detected floor). For example, if the detected floor is the bottom floor, the position determination apparatus 106 stores temperature and atmospheric pressure measured in association with the bottom floor.

[0044]

In step S403, the position determination apparatus 106 calculates atmospheric pressure at each floor from the temperature measured by the temperature measuring unit 303 and the atmospheric pressure measured by the atmospheric pressure measuring unit 304, and the respective altitudes of the floors stored in advance in the storage unit 301 by a maintenance tool (not illustrated).

[0045]

Here, the position determination apparatus 106 calculates atmospheric pressure at each floor, using a hypsometric formula indicating the relationship between atmospheric pressure, temperature, and altitude, for example, the following (Equation 1):

[0046]

$$P = P_0 \times ((1 - 0.0065 \times h) / (T + 0.0065 \times h + 273.14))^{5.257} \dots \quad (\text{Equation 1})$$

P: atmospheric pressure, P₀: sea-level pressure, h: altitude, and T: temperature

[0047]

More specifically, first, the position determination apparatus 106 substitutes the measured temperature (T) and atmospheric pressure (P) and the altitude (h) of the detected floor stored in the storage unit 301 into (Equation 1) to calculate sea-level pressure (P₀). Next, for each floor, the position determination apparatus 106 substitutes the measured temperature (T), the calculated sea-level pressure (P₀), and the altitude (h) of the floor stored in the storage unit 301 into (Equation 1) to calculate atmospheric pressure at the floor. Here, the temperature is assumed to be constant at all the floors, and the measured temperature (T) is used.

[0048]

In step S404, in order to determine a floor based on the calculated atmospheric pressure, the position determination apparatus 106 performs setting such as storing the calculated atmospheric pressure at each floor. Based on the setting, the position determination apparatus 106 can determine the floor of the car 101 by comparing atmospheric pressure measured by the atmospheric pressure measuring unit 304 with the atmospheric pressure at each floor calculated by the calculation unit 321.

[0049]

In step S405, the position determination apparatus 106 determines whether or not the magnet(s) 107 placed at a different floor other than the floor detected in step S401 has/have been detected by the north-pole detection unit 302-1 and the south-pole detection unit 302-2 (whether or not a floor other than the floor detected first has been detected). If the position determination apparatus 106 determines that the magnet(s) 107 placed at a different floor has/have been detected, it proceeds to processing in step S406. If it determines that the magnet(s) 107 placed at a different floor has/have not been detected, it finishes the atmospheric pressure calculation processing.

[0050]

In step S406, the position determination apparatus 106 stores temperature measured by the temperature

measuring unit 303 and atmospheric pressure measured by the atmospheric pressure measuring unit 304 in association with the floor detected (detected floor). For example, if the detected floor is the middle floor, the position determination apparatus 106 stores the measured temperature and atmospheric pressure in association with the middle floor.

[0051]

In step S407, the position determination apparatus 106 calculates atmospheric pressure at each floor from a straight line connecting the atmospheric pressure stored in step S402 and the atmospheric pressure stored in step S406.

[0052]

If there are three or more detected floors, the processing in step S407 may or may not be performed. If the processing in step S407 is performed, the position determination apparatus 106 determines, for example, an approximate straight line by the method of least squares to calculate atmospheric pressure at each floor.

[0053]

In step S408, in order to determine a floor based on the calculated atmospheric pressure, the position determination apparatus 106 performs setting such as storing the calculated atmospheric pressure at each floor. Based on the setting, the position determination apparatus

106 can determine the floor of the car 101 by comparing atmospheric pressure measured by the atmospheric pressure measuring unit 304 with the atmospheric pressure at each floor calculated by the calculation unit 321.

[0054]

Here, the atmospheric pressure at each floor calculated in step S403 is only a value calculated from the floor detected in step S401 and the temperature and atmospheric pressure at that time, on the assumption that the temperature is constant at each floor. Therefore, a deviation from actual atmospheric pressure at each floor can occur (see Fig. 6).

[0055]

In view of this point, if atmospheric pressures at two floors can be measured, the present elevator system 100 recalculates atmospheric pressure at each floor from a measured atmospheric pressure difference, thereby making the calculation results closer to actual atmospheric pressures.

[0056]

That is, atmospheric pressure changes with a change in environment such as temperature even at the same altitude. Therefore, it is preferable to perform processing to correct atmospheric pressure at each floor used for the detection of the position of the car 101

(atmospheric pressure correction processing) as atmospheric pressure changes.

[0057]

Fig. 5 is a diagram illustrating an example of a flowchart of the atmospheric pressure correction processing. The atmospheric pressure correction processing is performed at predetermined timings (for example, periodically or at times designated in advance). For example, by constantly performing the atmospheric pressure correction processing, atmospheric pressure can be corrected immediately when a change in atmospheric pressure occurs, thereby preventing an error in the detection of the position of the car 101.

[0058]

In step S501, the position determination apparatus 106 determines whether or not the magnet(s) 107 detected in step S401 or step S405 has/have been detected by the north-pole detection unit 302-1 and the south-pole detection unit 302-2 (whether or not the floor at which atmospheric pressure has been measured has been detected). If the position determination apparatus 106 determines that the floor at which atmospheric pressure has been measured has been detected, it proceeds to processing in step S502, and if it determines that the floor at which atmospheric pressure has been measured has not been detected, it

finishes the atmospheric pressure correction processing.

[0059]

In step S502, the position determination apparatus 106 compares the initial atmospheric pressure measured in step S402 or step S405 with current atmospheric pressure measured by the atmospheric pressure measuring unit 304, and determines whether or not the atmospheric pressure difference is greater than or equal to a threshold. If the position determination apparatus 106 determines that the atmospheric pressure difference is greater than or equal to the threshold, it proceeds to processing in step S503, and if it determines that the atmospheric pressure difference is less than the threshold, it finishes the atmospheric pressure correction processing.

[0060]

In step S503, the position determination apparatus 106 performs the atmospheric pressure calculation processing illustrated in Fig. 4 again to correct the atmospheric pressure at each floor used for the detection of the position of the car 101.

[0061]

If the amount of change in atmospheric pressure at the detected floor exceeds 50% of the difference in atmospheric pressure from the floor above or below the detected floor (for example, the third floor or the fifth

floor when the middle floor is detected in Fig. 6) due to a change in temperature or the like, measurement processing using the position of the car 101 is affected. Therefore, a predetermined value smaller than 50% (e.g., 30%) of that is set as the threshold. For example, if atmospheric pressure at the detected floor is 1009.10 (hPa), atmospheric pressure at the third floor is 1009.40 (hPa), atmospheric pressure at the fifth floor is 1008.80 (hPa), and the predetermined value is 30%, the threshold is 0.09 (hPa). If a threshold on the third floor side is different from a threshold on the fifth floor side, the smaller threshold is used.

[0062]

According to the above-described processing, even if atmospheric pressure changes due to a change in environment such as temperature, atmospheric pressure at each floor can be corrected by detecting the change in atmospheric pressure, so that the position of the car 101 can be properly determined.

[0063]

Further, since the present elevator system 100 can reliably detect the specified floors at which the magnets 107 are provided, a change in atmospheric pressure at the same floor can be detected. Consequently, update of atmospheric pressure for detecting a floor with changes in

atmospheric pressure can be performed reliably.

[0064]

Fig. 6 is a conceptual diagram illustrating the relationship between atmospheric pressure calculated in the position determination apparatus 106 and actual atmospheric pressure.

[0065]

Fig. 6 illustrates an example of a graph 601 connecting atmospheric pressures at the individual floors calculated from atmospheric pressure and temperature at the bottom floor and the respective altitudes of the floors, and a graph 602 showing actual atmospheric pressure. As illustrated in Fig. 6, calculated atmospheric pressure at each floor can deviate from actual atmospheric pressure at the floor. Thus, it is preferable to correct atmospheric pressure at each floor calculated based on atmospheric pressure at a specified floor. For example, atmospheric pressure at each floor calculated based on atmospheric pressure at a specified floor may be corrected to actual atmospheric pressure by measuring atmospheric pressure at part or all of the floors other than the specified floor. Alternatively, for example, atmospheric pressure at each floor calculated based on atmospheric pressure at a specified floor may be corrected when atmospheric pressure at a floor different from the specified floor is

calculated, by calculating atmospheric pressures at the other floors from the atmospheric pressure at the specified floor and the atmospheric pressure at the different floor.

[0066]

Next, processing to detect an abnormality in the elevator (abnormality detection processing) will be described with reference to the flowchart illustrated in Fig. 7.

[0067]

Fig. 7 is a diagram illustrating an example of a flowchart of the abnormality detection processing. The abnormality detection processing is executed at predetermined timings (for example, periodically or at times designated in advance).

[0068]

In step S701, the position determination apparatus 106 measures atmospheric pressure by the atmospheric pressure measuring unit 304.

[0069]

In step S702, the position determination apparatus 106 calculates the height of the car 101 based on the measured atmospheric pressure. For example, the position determination apparatus 106 calculates an altitude corresponding to the measured atmospheric pressure on the straight line calculated in step S407. The position

determination apparatus 106 may calculate the position of the car 101 in the shaft (for example, the height from the bottom surface of the shaft) based on the altitude.

[0070]

In step S703, the position determination apparatus 106 stores the calculated height of the car 101 in the memory 320.

[0071]

In step S704, the position determination apparatus 106 determines whether or not the car 101 has passed through a predetermined range. If the position determination apparatus 106 determines that the car 101 has passed through the predetermined range, it proceeds to processing in step S705. If it determines that the car 101 has not passed through the predetermined range, it finishes the abnormality detection processing.

[0072]

Whether or not the predetermined range has been passed through is determined by the position determination apparatus 106 based on information indicating a predetermined height range. For example, information indicating a predetermined height range (an upper-limit height and a lower-limit height) is stored for each floor in the memory 320. The magnet(s) 107 for each floor is included in each predetermined height range. In this case,

when the car 101 is ascending, the position determination apparatus 106 determines that the predetermined range has been passed through if the height of the car 101 exceeds the upper-limit height. When the car 101 is descending, the position determination apparatus 106 determines that the predetermine range has been passed through if the height of the car 101 falls below the lower-limit height.

[0073]

In step S705, the position determination apparatus 106 determines whether or not the magnet(s) 107 has/have been detected. If the position determination apparatus 106 determines that the magnet(s) 107 has/have been detected, it finishes the abnormality determination processing, and if it determines that no magnet 107 has been detected, it proceeds to processing in step S706.

[0074]

Although not illustrated, if the magnet(s) 107 is/are detected by the detection units 302 at an appropriate timing before step S704, the position determination apparatus 106 stores information indicating the detection of the magnet(s) 107 (detection information) in the memory 320, and deletes the detection information at an appropriate timing after determination in step S705.

[0075]

In step S706, the position determination apparatus

106 outputs information concerning an abnormality in the elevator. For example, the position determination apparatus 106 outputs information on an abnormality in the magnet(s) 107 or the detection units 302 (a fault condition) to the outside (such as an elevator control apparatus, a terminal of a control center, or a terminal of maintenance personnel) via the communication interface 330. [0076]

In this way, in the abnormality detection processing, if the position determination apparatus 106 cannot detect the magnet(s) 107 even though it has detected that the car 101 has passed through a height at which the magnet(s) 107 is/are considered to be placed, it determines that the magnet(s) 107 has/have fallen off, the detection units 302 have failed, or the like, and notifies the outside of the fault condition via the communication interface 330. [0077]

According to the present embodiment, for example, a magnet is placed at a floor that will serve as a reference for the detection of the position of a car, and the placed magnet is detected by a magnetic sensor installed on the car, so that the position of the car can be easily detected even when it has been restored from a power failure. Further, for example, update of atmospheric pressure at

each floor required for the detection of a floor can be facilitated by detecting a change in atmospheric pressure due to a change in environment such as temperature, so that erroneous detection of the position of the car can be prevented.

[0078]

(2) Additional notes

The above-described embodiment includes, for example, the following contents.

[0079]

In the above-described embodiment, the case where the present invention is applied to the elevator system has been described. However, the present invention is not limited to this, and can be widely applied to various other systems, apparatuses, methods, and programs.

[0080]

Further, in the above-described embodiment, the case where the position determination apparatus 106 is installed on the top of the car 101 has been described, but the present invention is not limited to this. The position determination apparatus 106 may be installed on the bottom of the car 101 or on the side of the car 101. In this case, the magnets 107 are placed at positions corresponding to the position of the position determination apparatus 106.

[0081]

Further, in the above-described embodiment, the case where the position determination apparatus 106 includes the storage unit 301 and the temperature measuring unit 303 has been described, but the present invention is not limited to this. The position determination apparatus 106 may not include the storage unit 301 and the temperature measuring unit 303. In this case, the storage unit 301 and the temperature measuring unit 303 are provided at desired places, and are provided in such a manner as to be able to communicate with the position determination apparatus 106. For example, the storage unit 301 may be provided at a control center. Further, for example, the temperature measuring unit 303 may be provided in the shaft.

[0082]

Furthermore, in the above-described embodiment, the case where a floor is identified using the combination of the north-pole magnet 107 and the south-pole magnet 107 detected has been described, but the present invention is not limited to this. A floor may be identified based on the number of the magnets 107 detected, or a floor may be identified based on the disposition of the magnet(s) 107 detected. The magnets 107 may be disposed in such a manner that the magnet(s) 107 is/are provided only on the left side at the top floor, on both sides at the middle floor,

and only on the right side at the bottom floor.

[0083]

Further, in the above-described embodiment, the case where it is determined in step S401, step S405, and step S501 whether or not the detection units 302 have detected the magnet(s) 107 has been described, but the present invention is not limited to this. It may be determined whether or not the detection units 302 have detected the magnet(s) 107 for a predetermined time and/or at a predetermined intensity (for example, whether or not the car 101 is stopped at a detected floor).

[0084]

Further, in the above description, information such as programs, tables, and files for implementing the individual functions can be placed in a storage device such as memory, a hard disk, or a solid-state drive (SSD), or a recording medium such as an IC card, an SD card, or a DVD.

[0085]

The above-described embodiment has, for example, the following characteristic configuration.

[0086]

An elevator system (e.g., the elevator system 100) including an identifier (e.g., the magnet 107) provided in a shaft of an elevator, and a detection unit (e.g., the detection unit 302) provided on a car (e.g., the car 101)

of the elevator to detect the identifier includes a storage unit (e.g., the storage unit 301) that stores heights of floors of the elevator (altitudes, heights in the shaft calculated based on the altitudes, or the like), an atmospheric pressure measuring unit (e.g., the atmospheric pressure measuring unit 304) provided on the car to measure atmospheric pressure at a height where the identifier detected by the detection unit is located (see step S402, for example), a calculation unit (e.g., the calculation unit 321) that calculates atmospheric pressure at each floor of the elevator, based on the atmospheric pressure at the height where the identifier is located and the heights of the floors stored in the storage unit (see step S403, for example), and a determination unit (e.g., the determination unit 322) that determines the position of the car from the atmospheric pressure at each floor calculated by the calculation unit, and atmospheric pressure measured by the atmospheric pressure measuring unit (see step S404, for example).

[0087]

In the above configuration, when the identifier provided in the shaft is detected, the atmospheric pressure at the height where the identifier is located is measured, and the atmospheric pressure at each floor is calculated based on the measured atmospheric pressure and the heights

of the floors stored in the storage unit. According to the above configuration, by the identifier being detected, the position of the car can be determined by comparing the measured atmospheric pressure with the calculated atmospheric pressure at each floor. Consequently, for example, when the elevator is restored from a power failure, the position of the car can be easily detected.

[0088]

For example, the calculation unit calculates atmospheric pressure at each floor of the elevator using a hypsometric formula indicating the relationship between atmospheric pressure, temperature, and altitude, based on atmospheric pressure at a specified floor, temperature at the elevator, and the altitudes stored in the storage unit. The temperature at the elevator may be measured by a temperature measuring unit provided on the car, or may be measured by a temperature measuring unit provided in the elevator shaft, or may be measured by a temperature measuring unit provided at each floor of the elevator.

[0089]

Determining the position of the car may be determining a floor where the car is located (stopped, for example), or may be determining an altitude at which the car is located. It may also be determining the position of the car 101 (current position) corresponding to measured

atmospheric pressure by creating a graph connecting calculated atmospheric pressures at the individual floors, or creating a graph connecting measured atmospheric pressures at two floors.

[0090]

The calculation unit, for example, calculates atmospheric pressure at the sea level using a hypsometric formula indicating the relationship between atmospheric pressure, temperature, and altitude, based on atmospheric pressure at a specified floor, temperature at the elevator, and the altitude of the specified floor stored in the storage unit, and calculates atmospheric pressure at each floor using the hypsometric formula, based on the calculated atmospheric pressure at the sea level, the temperature around the car, and the altitudes stored in the storage unit.

[0091]

The identifier is provided in the shaft near a landing on a floor through which the car is highly likely to pass. When the detection unit detects the identifier, the calculation unit calculates atmospheric pressure corresponding to the height of each floor stored in the storage unit, based on atmospheric pressure measured by the atmospheric pressure measuring unit, and updates atmospheric pressure at each floor stored in the storage

unit (see step S503, for example).

[0092]

In the above configuration, since the identifier is provided in the shaft near the landing on the floor through which the car is highly likely to pass, the atmospheric pressure at each floor stored in the storage unit can be updated according to changes in environment such as temperature.

[0093]

Another identifier is provided at a floor different from the specified floor. When the other identifier is detected by the detection unit, the atmospheric pressure measuring unit measures atmospheric pressure around the car (see step S406, for example), and the calculation unit corrects atmospheric pressure at the different floor calculated when the specified floor has been detected to the atmospheric pressure measured by the atmospheric pressure measuring unit when the different floor has been detected (see step S406, for example).

[0094]

In the above configuration, when the other identifier provided at the different floor is detected, atmospheric pressure at the different floor is measured, and atmospheric pressure at the different floor calculated when atmospheric pressure at the specified floor has been

detected is updated to the actually measured atmospheric pressure, so that the position of the car can be determined more accurately.

[0095]

Identifiers may be provided at a plurality of floors in addition to the different floor. In this case, atmospheric pressures at the plurality of floors are updated to actually measured atmospheric pressures, so that the position of the car can be determined more accurately.

[0096]

Further, based on the atmospheric pressure at the specified floor and the atmospheric pressure at the different floor, atmospheric pressures at the other floors may be corrected. In this case, the accuracy of the atmospheric pressures at the other floors is increased, so that the position of the car can be determined more accurately.

[0097]

The identifier is a magnet, and has a different polarity depending on a place where it is provided (see Fig. 2, for example).

[0098]

In the above configuration, the identifier is a magnet, and the place where it is provided is identified based on the polarity of the magnet, and thus the

identifier can be easily placed.

[0099]

A communication interface (e.g., the communication interface 330) is further included which outputs information on an abnormality in the identifier provided in a predetermined height range or the detection unit when the detection unit does not detect the identifier in the height range (see Fig. 7, for example).

[0100]

In the above configuration, if an abnormality in the identifier or the detection unit is detected, information on the abnormality in the identifier or the detection unit is output. Consequently, for example, maintenance personnel can quickly and properly find the cause of the abnormality, and can reduce the time required to deal with the abnormality.

[0101]

To the above-described configuration, alterations, rearrangements, combinations, and eliminations may be appropriately made without departing from the scope of the present invention.

CLAIMS

1. An elevator system comprising an identifier provided in a shaft of an elevator, and a detection unit provided on a car of the elevator to detect the identifier, the system comprising:

 a storage unit that stores heights of floors of the elevator;

 an atmospheric pressure measuring unit provided on the car to measure atmospheric pressure at a height where the identifier detected by the detection unit is located;

 a calculation unit that calculates atmospheric pressure at each floor of the elevator, based on the atmospheric pressure at the height where the identifier is located, and the heights of the floors stored in the storage unit; and

 a determination unit that determines a position of the car from the atmospheric pressure at each floor calculated by the calculation unit, and the atmospheric pressure measured by the atmospheric pressure measuring unit, wherein

 the identifier is provided in the shaft near a landing on a floor through which the car is capable to pass, and

 when the detection unit detects the identifier, the calculation unit calculates atmospheric pressure corresponding to the height of each floor stored in the storage unit, based on the atmospheric pressure measured by the atmospheric pressure measuring unit, and updates atmospheric pressure at each floor stored in the storage unit.

2. The elevator system according to claim 1, wherein the identifier is a magnet, and has a different polarity depending on a place where the identifier is provided.

3. The elevator system according to claim 1, further comprising:

a communication interface that outputs information on an abnormality in the identifier provided in a predetermined height range or the detection unit when the detection unit does not detect the identifier in the height range.

4. The elevator system according to claim 1, further comprising:

a communication interface,

wherein

the identifier is a magnet,

the elevator system determines whether or not the car has passed through a predetermined range based on information indicating a predetermined height range containing the magnet and the position of the car determined by the determination unit,

when the elevator system has determined that the car has passed through the predetermined range, the elevator system determines whether or not the detection unit has detected the magnet within the predetermined height range,

when the elevator system has determined that the detection unit has not detected the magnet in the predetermined height range, the communication interface outputs signal indicating that there is an abnormality where the magnet in the height range has fallen off,

magnets are installed on a top floor, a middle floor, and a bottom floor, and have different polarities depending on the floors where the magnets are provided, and

the detection unit includes a north-pole detection unit and a south-pole detection unit.

5. The elevator system according to claim 4, wherein the calculation unit detects, based on information from the north-pole detection unit and the south-pole detection unit, which floor of the top floor, the middle floor, and the bottom floor the car exists,

the calculation unit stores information indicating that the atmospheric pressure measured by the atmospheric pressure measuring unit in the storage unit by mapping the atmospheric pressure to the detected floor,

the calculation unit calculates the atmospheric pressure corresponding to the height of each floor based on the atmospheric pressure associated with the detected floor and the atmospheric pressure associated with a different floor detected in the past, and

the calculation unit updates the atmospheric pressure for each floor stored in the storage unit.

6. The elevator system according to claim 5, wherein the elevator system determines whether or not atmospheric pressure difference between the atmospheric pressure measured first for the detected floor and the current atmospheric pressure measured for the floor is greater than or equal to a threshold,

when the elevator system has determined that the atmospheric pressure difference is greater than or equal to the threshold, the atmospheric pressure measuring unit stores information indicating the current atmospheric pressure in the storage unit associated with the detected floor, and calculates the atmospheric pressure corresponding to the height of each floor based on the atmospheric pressure associated with the detected floor and the atmospheric pressure associated with the different floor detected in the past.

7. A car position determination method of determining a position of a car of an elevator, based on detection of an identifier provided in a shaft of the elevator by a detection unit provided on the car, the method comprising:

measuring, by an atmospheric pressure measuring unit provided on the car, atmospheric pressure at a height where the identifier detected by the detection unit is located;

calculating, by a calculation unit, atmospheric pressure at each floor of the elevator, based on the atmospheric pressure at the height where the identifier is located, and heights of floors stored in a storage unit;

determining, by a determination unit, the position of the car from the atmospheric pressure at each floor calculated by the calculation unit, and atmospheric pressure measured by the atmospheric pressure measuring unit, wherein

the identifier is provided in the shaft near a landing on a floor through which the car is capable to pass, and

when the detection unit detects the identifier, the calculation unit calculates atmospheric pressure corresponding to the height of each floor stored in the storage unit, based on the atmospheric pressure measured by the atmospheric pressure measuring unit, and updates atmospheric pressure at each floor stored in the storage unit.

8. The car position determination method according to claim 7,

(a) wherein the identifier is a magnet and magnets are installed on a top floor, a middle floor, and a bottom floor, and have different polarities depending on the floors where the magnets are provided;

(b) the detection unit includes a north-pole detection unit and a south-pole detection unit; and

(c) wherein the method further comprises:

determining whether or not the car has passed through a predetermined range based on information indicating a predetermined height range containing the magnet and the position of the car determined by the determination unit;

when the car has passed through the predetermined range, determining whether or not the detection unit has detected the magnet within the predetermined height range; and

when the detection unit has not detected the magnet in the predetermined height range, outputting via a communication interface a signal indicating that there is an abnormality where the magnet in the height range has fallen off.