

AN APPARATUS FOR CONTROLLING A MOVABLE OBJECT.

AND AN ELEVATOR SYSTEM HAVING SUCH AN APPARATUS

The present invention relates to an apparatus for
5 controlling a movable object, for example an elevator.

A rotary pulse encoder and a counter are used for detecting the position of an elevator, as disclosed in, for example, (1) JP-B-57-72582, (2) JP-A-61-94984 (USP 4,673,062), (3) JP-A-61-145091, (4) JP-A-1-321272, etc. That is, the rotary pulse encoder is rotated through a rope having opposite ends which are connected with an elevator cage in an endless manner. Pulses, the number of which is proportional to the amount of the movement of the elevator cage is generated by the encoder. The pulses are added or subtracted when the elevator is ascending or descending so that the count value is used as a position signal of the cage.

In order not to loose the position of the elevator cage on a power failure, an uninterruptible power supply for supplying both the encoder and the counter with electric power is provided as is disclosed in the above-mentioned specification (1). Specifications (2) and (4) disclose that a plurality of sets of the pulse encoder and counter are provided to compensate for miscount.

Specification (3) discloses that the pulse encoder and the counter are applied to correcting of the

1 landing position of the elevator cage.

Reference may further be made to JP-A-3-38874 which discloses a position correction method.

In the prior art, an uninterruptible power
5 supply is necessary for both the rotary encoder and the counter in order not to lose the position of the elevator cage at the time of a power failure. In other words, if a power failure occurs while the elevator is running, it is also necessary to accurately count or
10 measure the length of the movement of the elevator from the occurrence of the power failure until the stop of the elevator. If a power failure occurs while the cage door is opened, the weight of the cage is changed due to boarding or unboarding of passengers thereafter so that
15 the elongation amount of the rope is changed to move the cage. The movement length of the cage should be also positively counted or measured.

However, the uninterruptible power supply provides a problem in maintenance and cost. It is
20 preferable to use a power supply having a minimum possible capacity.

On the other hand, a combination of the pulse encoder and the counter may cause miscounting which will accumulatively counts the pulses unidirectionally if the
25 cage is vibrated in a vertical direction due to boarding or unboarding of passengers to or from the elevator cage and stepping of passengers in the cage. Since this error continues until next correction of the positional

data, it is necessary to frequently perform the correction of the data. This error may hinder the precise landing of the elevator.

5 According to a first aspect of the present invention there is provided an apparatus for controlling a movable object, comprising:

 an absolute encoder for outputting an encoded
 positional data corresponding to the rotational angle
10 of a rotator caused by the movement of said movable
 object;

 means for storing said positional data when said
 movable object is in a previously set reference
 position;

15 means for determining the position of said
 movable object from the positional data which is an
 output of said encoder and said stored positional
 data; and

 means for moving the movable object in dependence
20 in the position thus determined.

 According to a second aspect of the present
 invention there is provided an elevator system
 comprising:

 means for being capable of being correspondingly
25 rotated by the movement of a cage and for outputting
 the absolute value of its rotational angle in a
 digital value;

 means for detecting that said cage is in a

previously set reference position;

means for storing said digital value at the time when said position detecting means provides an output;

5 means for calculating the position of the cage from the current output digital value and said stored digital value;

means for generating a speed command of the cage depending upon the position of the cage;

10 means for controlling a torque generated by an elevator driving motor depending upon a deviation between the speed command and the actual speed signal.

According to a third aspect of the present invention there is provided a method of controlling
15 the position of a movable object including preparing an absolute encoder for outputting a positional data which is encoded in accordance with the rotational angle of a rotator caused by the movement of said movable object, comprising the steps of:

20 presetting the data on a desired stop position;
storing the output of said encoder at the time when the movable object is in a previously set reference position;

comparing said desired stop position with the
25 difference between the current value of the output of said encoder and said stored value; and

stopping said movable object at a position at which a result of the comparison shows coincidence

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therebetween.

The present invention permits data on the position of a movable object to be obtained with a high reliability.

1 The output of the absolute encoder at the time
when the movable object is at the reference position is
stored and the length from the reference position to
the moveable object is determined from the difference
5 between the current output of the absolute encoder and
the stored value. Even if the movable object is
vibrated forward or rearward along the travelling path,
no error is generated in subsequent positional data.

 Once only the output of the encoder at the
10 reference position is stored, accurate current
positional data of the movable object can be obtained by
comparison of the stored output with the output of the
absolute encoder even when a power failure occurs.

 An uninterruptible power supply which is
15 expensive and requires maintenance is necessary in the
prior art in which the pulse encoder and the counter
have to be operated even at the time of power failure.
In contrast to this, a memory to store the output of the
absolute encoder in the reference position may be one
20 area of the other memory usually used for recording data
on failure, which is a commercially available C-RAM
having a low power consumption backed up by a battery of
the size of a rubber eraser. No battery back-up is
necessary only for implementation of the present
25 invention.

 Fig. 1 is a schematic diagram showing the
entire structure of an embodiment in which the present
invention is applied to an elevator system;

1 Fig. 2 is a plan view showing encoding performed by a serial absolute rotary encoder;

 Fig. 3 is a waveform diagram showing encoding performed by the serial absolute rotary encoder;

5 Fig. 4 is a schematic block diagram showing the detailed structure of a control 12 shown in Fig. 1;

 Fig. 5 is a flow chart showing the operation executed in a microcomputer in the above-mentioned embodiment; and;

10 Fig. 6 is a flow chart showing the operation executed in the microcomputer in the above-mentioned embodiment.

 An embodiment of the present invention will be described.

15 Fig. 1 is a schematic diagram showing an embodiment of an elevator system of the present invention.

 An elevator cage 1 and a counterweight are suspended from both sides of a sheave via a rope 3. The sheave 4 is driven by a three-phase induction motor 5 to ascend the cage 1 and to descend the counterweight and vice versa. The induction motor 5 is supplied with a three-phase a.c. power having a variable voltage and a variable frequency via a power converter 6 from a three-phase power source.

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 A rope 7 is connected with the cage 1 at the opposite ends thereof. The rope 7 is tensioned between tension pulleys 8 and 9 which are disposed at the upper

1 and lower ends of the elevator path.

The upper tension pulley 8 is coupled with a serial absolute rotary encoder 10 and an incremental rotary pulse encoder 11.

5 Fig. 2 shows an example of the serial absolute rotary encoder 10 (hereinafter abbreviated as SAE) made up of a code plate having various slits thereon which outputs various signals as shown in Fig. 3 when it is rotated.

10 The SAE 10 encodes one rotation of the pulley 8 into 2^{11} binary codes for outputting an encoded absolute value depending upon the current rotational angle as shown in Figs. 2 and 3 (Fig. 3 shows only values 2^0 to 2^4). As to counting of the number of
 15 rotations, encoders which output absolute values up to 2^{13} are commercially available. If the SAE 10 is applied for the elevator system, absolute positional signals are generated at a resolution which is the full
 length of the elevator path divided by 2^{24} ($=2^{11} \times$
 20 2^{13}).

An incremental rotary pulse encoder 11 outputs a pulse depending upon the rotational angle of the upper pulley 8 as is well known.

A control 21 receives the outputs from the
 25 encoders 10 and 11, a cage reference position detector 13 and a landing zone detector 14 and the other control devices 15 for providing a control command to a power controller converter 16.

1 Fig. 4 shows the structure of the controller
 12. The controller is substantially a microcomputer
 having a microprocessing unit (MPU) 121, a read only
 memory (ROM) 122, a random access memory (RAM) 123 and
 5 an input/output buffer 124 for inputting and/or out-
 putting various signals, a control register 125 for
 controlling the execution timing, etc.

 The serial-encoded absolute positional data
 which are generated as the elevator cage ascends or
 10 descends are converted into absolute positional data
 which are parallel-encoded at short intervals by a
 serial/parallel converter 126. The converted data are
 consecutively latched in a latch 122 for updating the
 content therein at the time when the conversion timing
 15 of the serial/parallel converter 126 coincides with the
 timing from the control register 125.

 When the reference position detector 13
 disposed in, for example, a first floor 1F is activated
 by the elevator cage 1, an output from the detector 13
 20 is accepted by the control 12 via the input/output
 buffer 124. The content stored in the latch 127 at this
 time is stored in a C-RAM 129 which is backed up by a
 battery 128.

 The C-RAM is a C-MOS RAM as is well known and
 25 which has a very low power consumption and is provided
 for recording data on failures such as power failure.

 The data on the position of the elevator cage
 which is necessary in operation of the elevator is

1 obtained by subtracting the reference positional data stored in the C-RAM 129 from the data latched in the latch 127.

Fig. 5 is a flow chart of an operation to
5 obtain the data on the position of the elevator.

When an instruction for reading the positional data is given in step 501, determination whether or not the reference positional signal is present is made in step 502. If the reference positional signal is
10 present, control proceeds to step 503 to read out the latched content in the latch 127. The reference positional data is then stored in the C-RAM 129 in step 504.

Control returns to step 502. If the reference
15 positional data is not present, that is, the elevator cage 1 leaves the first floor which is the reference position, the latched content in the latch 127 is read out in step 505. The read output is the current output of the SAE. The difference between the current output
20 of the SAE and the reference positional data stored in C-RAM 129 is calculated to obtain the data on the current position of the cage in step 506 and the program is terminated in step 507.

A positional data which is accurately
25 representative of the absolute value of the distance L shown in the lower portion in Fig. 4 can be obtained in the above-mentioned manner. The thus obtained data on the position of the elevator cage represents the

1 accurate position of the cage even after a power
failure. In other words, the output of the SAE 10
represents the absolute value of the rotational angle of
the tension pulley 8 caused by the movement of the cage
5 1 and is not changed or lost by a power failure. This
holds true even after occurrence of vertical vibrations
of the cage. There is no possibility that a miscount is
made. Involatility of the C-RAM 129 is maintained by
the battery 128 having a very small capacity as mention-
10 ed above. If data on the reference position is stored
in the RAM once, the data on the position of the cage 1
which is accurate and may not be lost is obtained.

The control 12 is capable of providing a speed
command for the elevator in accordance with the cage
15 position data which are successively obtained as
mentioned above. Various controls other than providing
the speed command are carried out by inputting or
outputting signals to and from the other control 15 such
as hall calling button or cage calling button 151,
20 various registration relay 152 or response lamp 153,
etc. in Fig. 4. The incremental rotary pulse encoder 11
is coupled with the tension pulley 8 as shown in Figs. 1
and 4. The frequency of the generation of the output
pulses from the encoder 11 is proportional to the
25 running speed of the elevator cage 1. Accordingly, by
comparing a speed command which continuously changes in
response to the output from the SAE 10 with the speed
signal which is obtained based upon the output pulse

1 from the pulse encoder 11, an torque command which
eliminate the difference therebetween can be obtained.
The controller 12 performs a calculation for vector-
controlling the induction motor 5 and, based on the
5 result of the calculation, provides the power converter
controller with an output frequency command, a position-
al angle command and a primary current (absolute value)
command depending upon the torque command.

Landing error correction operation (herein-
10 after referred to as micro-levelling) will be described
with reference to the lower portion of Fig. 4 and Fig. 6.

In Fig. 4, the landing zone detector 14
detects in a normal landing zone of each floor a plate
141 to be detected which is disposed in the side of the
15 elevator path. The landing zone detector may be means
disposed in the elevator cage 1 for detecting the zone
in which doors of the platform and the cage can be
opened or closed. The correct stop position of the cage
1 is such that the detector 14 is located in the center
20 of the plate 141 to be detected. Accordingly, the
output of the landing zone is monitored to detect the
change thereof, thereby to determine whether the edge of
the landing zone is reached in step 602 in Fig. 6. If
reached, the content in the latch 127 is read at the
25 edge of the landing zone in step 603. In step 604, a
value corresponding to a half of the length of the plate
141 to be detected is added or subtracted to or from the
read content when the elevator cage descends or ascends

1 so that data on a desired normal landing position is
preset. Then the control returns to step 602. If the
determination step 602 is NO, the current value of the
SAE 10 is read from the latch 127 in step 605. The
5 difference between the data on the normal landing
position and the current value of the SAE 10 provides a
level error in step 606. Speed control is performed by
generating, based upon the level error, a speed command
which enables the landing error to become zero.

10 Generally, if a power failure occurs, the
movement of the cage due to boarding or unboarding of
passengers is not memorized. Accordingly, the cage
cannot be returned to the normal landing position after
recovery of power. In contrast to this, micro-levelling
15 to the normal landing level can be achieved in the
present embodiment.

 Since the data on the position of the elevator
cage can be obtained by reading the output of the
absolute encoder and calculating the difference between
20 the read output and the stored reference positional data
only when the data is necessary, required processing
capacity of the microcomputer can be remarkably reduced.

 The data on the position of a movable object
can be obtained at a high reliability in accordance with
25 the present invention.

 The data on the position of a movable object,
which is not be lost even if a power failure occurs can
be obtained in accordance with the embodiment of the

1 present invention.

The data on the position of a movable object which is not lost even if a power failure occurs can be obtained by merely providing a low capacity uninterruptible power source in accordance with the embodiment of the present invention.

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CLAIMS

1. An apparatus for controlling a movable object, comprising:

an absolute encoder for outputting an encoded
5 positional data corresponding to the rotational angle
of a rotator caused by the movement of said movable
object;

means for storing said positional data when said
movable object is in a previously set reference
10 position;

means for determining the position of said
movable object from the positional data which is an
output of said encoder and said stored positional
data; and

15 means for moving the movable object in dependence
in the position thus determined.

2. An apparatus according to claim 1, also having:

a further encoder having means for generating
pulses in accordance with the rotational angle of said
20 rotator and a counter for counting the pulses; and

means for detecting the speed of said movable
object based upon the output of said further encoder.

3. An apparatus for controlling a movable object,
comprising:

25 an absolute encoder for outputting an encoded
positional data corresponding to the rotational angle
of the movable object;

storing means having an uninterruptible power



source, for storing said positional data at the time when said movable object is in a previously set reference position;

means for calculating the position of said
5 movable object from the positional data which is the output of said encoder and said stored positional data; and

means for moving the movable object in dependence on the position thus calculated.

10 4. An elevator system comprising:

means for being capable of being correspondingly rotated by the movement of a cage and for outputting the absolute value of its rotational angle in a digital value;

15 means for detecting that said cage is in a previously set reference position;

means for storing said digital value at the time when said position detecting means provides an output;

means for calculating the position of the cage
20 from the current output digital value and said stored digital value;

means for generating a speed command of the cage depending upon the position of the cage;

means for controlling a torque generated by an
25 elevator driving motor depending upon a deviation between the speed command and the actual speed signal.

5. An elevator system, comprising:

an encoder correspondingly rotated by the



movement of a cage for outputting an absolute value of its rotation angle in a digital value;

means for detecting a landing zone for generating an output when said cage is in an intended landing
5 zone;

means for storing the output of said encoder in response to switching of the output of the landing zone detecting means;

means for calculating a difference between the
10 stored value and the current value of the output of said encoder; and

means for correcting the landing position of the elevator in accordance with the output of the calculating means.

15 6. An elevator system, comprising:

an encoder correspondingly rotated by the movement of a cage for outputting the absolute value of its rotational angle in a digital value;

means for detecting that said cage is in a
20 previously set reference position;

a first storing means for storing the output of said encoder in response to the operation of the reference position detecting means;

means for determining the position of the cage
25 from the output of said encoder and said stored value;

means for generating a speed command of the elevator depending upon the position of the cage;

landing zone detecting means for generating an



output when the cage is in an intended landing zone;

second storing means for storing the output of said encoder in response to switching of the output of the landing zone detecting means;

5 means for calculating a difference between the value stored in the first storage means and the output of said encoder; and

means for generating an elevator landing error correcting instruction depending upon the output of
10 the output difference calculating means.

7. An elevator system, comprising:

an encoder correspondingly rotated by the movement of a cage for outputting an absolute value of its rotational angle in a digital value;

15 means for storing the output of said encoder when the cage is in the landing position in a lowermost floor; and

means for comparing the output of said encoder with said stored value.

20 8. An elevator system as defined in claim 7 in which said storing means is formed to store the outputs of said encoder when said cage is in the landing positions of a plurality of different floors.

9. An apparatus for controlling a movable object,
25 comprising:

an absolute encoder for outputting a serial positional data which is encoded in accordance with the rotational angle of a rotator caused by the



movement of a movable object;

means for converting the output of the encoder into a parallel data;

means for periodically latching the output of the
5 converting means to update the same;

means for storing said latched data at the time when said movable object is in a previously set reference position;

means for calculating the position of said
10 movable object from the positional data which is the output of said latching means and said stored positional data; and

means for moving the movable object in dependence on the position thus calculated.

15 10. A method of controlling the position of a movable object including preparing an absolute encoder for outputting a positional data which is encoded in accordance with the rotational angle of a rotator caused by the movement of said movable object,
20 comprising the steps of:

presetting the data on a desired stop position;

storing the output of said encoder at the time when the movable object is in a previously set reference position;

25 comparing said desired stop position with the difference between the current value of the output of said encoder and said stored value; and

stopping said movable object at a position at



which a result of the comparison shows coincidence therebetween.

11. An elevator system substantially herein as described with reference to and as illustrated in the
5 accompanying drawings.



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