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(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

(72) Inventor: **YUMURA, Takashi**
Tokyo 100-8310 (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastraße 4
81925 München (DE)

(54) **ELEVATOR CONTROL DEVICE**

(57) Provided is an elevator control device having a learning function, with enhanced reliability of the result of learning and high performance.

An elevator control device for optimizing variable-speed driving includes: a learning function section for updating running control parameters based on a result of identification of running state quantities during a normal operation after an elevator is installed; and a learning-function check section for performing one of stop of elevator service and rated running using predetermined running control parameters when the running control parameters obtained by the learning function section are out of allowable ranges of the running control parameters, which are estimated from allowable fluctuation rates of basic apparatus specification values of the elevator, and for determining that the learning function section is normal when the running control parameters are within the allowable ranges of the running control parameters.

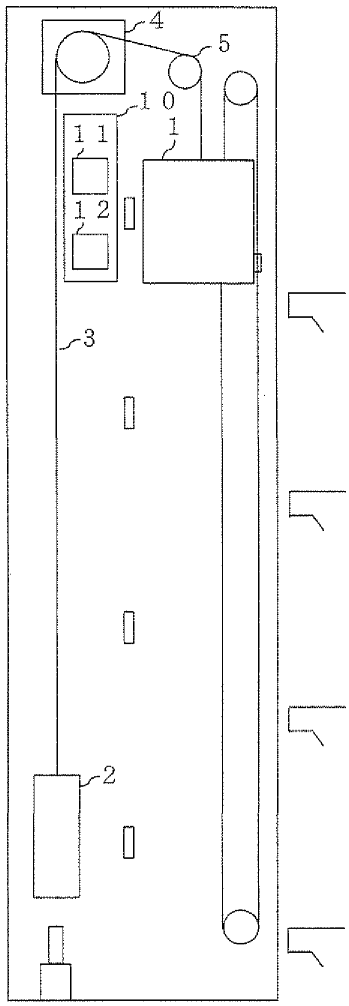

Fig. 1

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Description

Technical Field

[0001] The present invention relates to an elevator control device having a learning function for updating running control parameters in accordance with a load.

Background Art

[0002] There exists an elevator control device for optimizing variable-speed driving, which has a learning function for updating running control parameters based on the result of identification of running state quantities during a normal operation after an elevator is installed (for example, see Patent Literature 1). In the conventional elevator control device described above, the running control parameters for computing a speed command value are dynamically adjusted in accordance with the result of comparison between the running state quantities detected while a car is running and a threshold value. As a result, the running control parameters are automatically adjusted within the range of allowable capability of driving equipment regardless of a difference in state of elevator equipment for each building in which the elevator equipment is operated and in conditions of installation. Therefore, the car can be operated with high efficiency.

Citation List

Patent Literature

[0003] [PTL 1] JP 2009-149425 A

Summary of Invention

Technical Problem

[0004] However, the related art has the following problem.
When the speed command value obtained by the computation using the automatically adjusted running control parameters erroneously becomes an excessive value, an abnormal low-speed value, or a value corresponding to stop for some reasons, measures to deal with the above-mentioned values are not defined. In other words, validity of a learning algorithm or a state of an elevator apparatus is not determined based on the values of the running control parameters obtained with the learning function.

[0005] The present invention has been made to solve the problem described above, and has an object to provide an elevator control device having a learning function, with enhanced reliability of the result of learning and high performance.

Solution to Problem

[0006] According to the present invention, there is provided an elevator control device for optimizing variable-speed driving, comprising: a learning function section for updating running control parameters based on a result of identification of running state quantities during a normal operation after an elevator is installed; further comprising: a learning-function check section for performing one of stop of elevator service and rated running using predetermined running control parameters when the running control parameters obtained by the learning function section are out of allowable ranges of the running control parameters, which are estimated from allowable fluctuation rates of basic apparatus specification values of the elevator, and for determining that the learning function section is normal when the running control parameters are within the allowable ranges of the running control parameters.

Advantageous Effects of Invention

[0007] According to the elevator control device of the present invention, the function of determining validity of the learning function and a state of an elevator apparatus based on the learned parameter values is added. As a result, the elevator control device having the learning function, with enhanced reliability of the result of learning and high performance, can be obtained.

Brief Description of Drawings

[0008]

[FIG. 1] An overall configuration diagram of an elevator apparatus including an elevator control device of a first embodiment of the present invention.
[FIG. 2] A flowchart illustrating an operation series of the elevator control device of the first embodiment of the present invention.

Description of Embodiment

[0009] Hereinafter, an elevator control device according to a preferred embodiment of the present invention is described with reference to the drawings.

First Embodiment

[0010] FIG. 1 is an overall configuration diagram illustrating an elevator apparatus including an elevator control device of a first embodiment of the present invention. The elevator apparatus illustrated in FIG. 1 includes a car 1, a counterweight 2, a rope 3, a hoisting machine 4, a deflector sheave 5 (provided as needed), and an elevator control device 10.

[0011] The elevator control device 10 includes a parameter learning section (learning-function section) 11 and a learning-function check section 12. As described in Patent Literature 1, running control for optimizing variable-speed driving is performed by updating running control parameters based on running state quantities detected during a normal operation after an elevator is installed.

[0012] The elevator control device 10 of the present invention has a technical feature that the elevator control device 10 includes the learning-function check section 12, and is mainly described for the function with reference to the flowchart. FIG. 2 is a flowchart illustrating an operation series of the elevator control device in the first embodiment of the present invention. In the following description, the description of the contents executed by the learning-function check section 12 is included in the description of the elevator control device 10.

[0013] First, basic state quantities are stored after the installation of the elevator. In Step S201, basic apparatus specification values of the installed elevator, such as a weight of the counter weight 2, a capacity of the car 1, and a raising/lowering step, are stored in the parameter learning section 11 included in the elevator control device 10 as basic state quantities after the installation of the elevator.

[0014] More specifically, after the installation of the elevator, for example, the counterweight 2 installed by a maintenance engineer is verified. In addition, the basic apparatus specification values such as the capacity of the car 1 and the raising/lowering step of the installed elevator are stored in the parameter learning section 11 as the basic state quantities. The basic apparatus specification values described above may be stored in the parameter learning section 11 at the time of shipping from a factory. In this case, a storage operation is not required to be performed at a location of installation. On the other hand, in the case where the basic apparatus specification values are stored at the location of installation, the basic state quantities with higher precision can be set in accordance with the environment of installation. Further, a method of previously storing the basic state quantities before shipping from the factory and then confirming and correcting the basic state quantities at the location of installation after the installation of the elevator may also be used.

[0015] Next, in Step S202, a predetermined test run is performed in a state in which the car 1 is empty so that the elevator control device 10 learns initial running state quantities such as a driving current and stores the initial running state quantities in the parameter learning section 11. It is only after the elevator is installed that a precise car weight, inertia weight, and running resistance are determined. Therefore, it is desirable to perform the test run to learn the initial running state quantities in view not only of the result of learning in the empty state but also of the result of learning in a full-load state.

[0016] Next, in Step S203, the elevator control device 10 calculates running control parameters based on the initial running state quantities identified in the previous Step S202 and determines whether or not the calculated running control parameters fall within allowable ranges of the running control parameters, which are estimated based on the basic state quantities stored in the previous Step S201.

[0017] Specifically, the elevator control device 10 can estimate the allowable running control parameters which are reliable at a certain level from allowable fluctuation rates of the basic state quantities. Therefore, the elevator control device 10 verifies whether or not the running control parameters calculated based on the initial running state quantities obtained by the learning performed at the time of the test run after the installation fall within the allowable ranges of the running control parameters estimated from the basic state quantities so as to determine the validity of the learning algorithm for calculating the running control parameters based on the result of identification of the running state quantities at the test run stage.

[0018] As a method of learning the running control parameters based on the running state quantities, for example, the method described in Patent Literature 1 can be used.

[0019] Then, when it is determined in Step S203 that the running control parameters calculated based on the initial running state quantities are out of the allowable ranges of the running control parameters, the elevator control device 10 determines that some abnormality occurs in the elevator or the detection algorithm of the running control parameters is not valid and therefore, stops elevator service.

[0020] On the other hand, when it is determined in Step S203 that the running control parameters calculated based on the initial running state quantities are within the allowable ranges of the running control parameters, the elevator control apparatus 10 determines that the elevator is in a normal state and the detection algorithm of the running control parameters is valid. Then, the processing proceeds to Step S204 where the elevator control device 10 uses the running control parameters obtained as the result of learning to start normal elevator service (normal operation).

[0021] After the normal operation is started, the elevator control device 10 learns, in Step S205, running control parameters for the normal operation during running after the start of the normal operation. Even as a method of learning the running control parameters based on the running state quantities, which is used in Step S205, the method described in Patent Literature 1 can be used, for example.

[0022] The learning of the running control parameters performed in Step S205 is not necessarily required to be performed sequentially. For example, a running pattern can be obtained from a weighing-device signal on the basis of the running control parameters obtained based on the initial running state quantities after the installation. In this case, although the degree of optimization is not as high as in the case of the sequential identification, the running control parameters are optimized at a certain level because the running control parameters are identified at the test run stage after the installation. In addition, there is an advantage in a simplified algorithm used at the time of running. Moreover, it is conceivable to update the running control parameters serving as a basis at each appropriate timing.

[0023] Then, in Step S206, the elevator control device 10 determines whether the respective running control parameters for the normal operation, which are identified in the previous Step S205, fall within predetermined allowable parameter fluctuation ranges. A method for the determination in this step is the same as that used in the previous Step S203.

[0024] Then, when it is determined in Step S206 that the running control parameters are out of the predetermined allowable parameter fluctuation ranges, the elevator control device 10 determines that some abnormality occurs in the elevator or the detection algorithm of the running control parameters is not valid and therefore, stops the elevator service.

[0025] The validity of the detection algorithm of the running control parameters is already verified at the test run stage in Step S203. Therefore, when it is determined that the running control parameters are out of the predetermined allowable parameter fluctuation ranges, the elevator control device 10 can also determine that there is a high possibility of occurrence of some abnormality in the elevator.

[0026] When the occurrence of abnormality is determined in Step S206, no maintenance engineer is present because the normal operation is performed. Therefore, it is desirable to perform display or recording, or alarm a maintenance center (make an operator call) so that a maintenance engineer can know the occurrence of the abnormality.

[0027] When it is determined in Step S206 that the running control parameters are out of the predetermined allowable parameter fluctuation ranges, the elevator control device 10 can alternatively invalidate the learning function to continue the elevator service by using predetermined rated running control parameters instead of immediately stopping the elevator service because the normal operation of the elevator is being performed. The predetermined rated running control parameters are determined in view of changes assumed as being a change with time, a change in temperature, and a variation in measurement.

[0028] Alternatively, instead of immediately stopping the elevator service, for example, the elevator service may be stopped after the elevator is stopped at the nearest floor to let all the passengers deboard with an announcement or the like.

[0029] Further, after the deboarding of the passenger (s), the elevator control device 10 can also invalidate the learning function to perform the test run in a no-load state (predetermined rated running) and then start the normal operation with the predetermined rated running in a state in which the learning function is still invalidated if the running control parameters obtained as the result of the test run do not have any problem.

[0030] On the other hand, when it is determined in Step S206 that the running control parameters fall within the predetermined allowable parameter fluctuation ranges, the elevator control device 10 determines that the elevator is in the normal state and the result of learning of the running control parameters is correct. Then, the elevator control device 10 continuously performs an appropriate normal operation based on the identified running control parameters and the processing proceeds to Step S207.

[0031] As a result, the running control parameters are automatically adjusted within the range of allowable capability of driving equipment regardless of a difference in a state of the elevator equipment for each building in which the elevator equipment is operated and in conditions of installation. Therefore, the car can be operated with high efficiency.

[0032] Further, in Step S207, the elevator control device 10 determines whether or not the elevator control device 10 is to regularly perform the test run in the no-load state at predetermined intervals so as to determine the validity of the learning function for the running control parameters. The test run can be realized, for example, by performing a maintenance-mode operation in the middle of the night, and allows the determination of the validity of the learning function for the running control parameters in the ensured no-load state.

[0033] When determining that it is time to perform the test run, the elevator control device 10 performs the test run in Step S208 to learn the running control parameters in the no-load state. Even as a method of learning the running control parameters based on the running state quantities in Step S208, the method described in Patent Literature 1 can be used, for example.

[0034] Then, in Step S209, the elevator control device 10 determines the validity of the result of learning of the running control parameters identified in the previous Step S208. When the validity of the learning function for the running control parameters is determined during the maintenance-mode operation, a method of determining whether or not the running control parameters fall within the allowable ranges of the running control parameters, as performed in the previous Step S203 or Step S206, can be used. Further, as another method for the determination, whether or not the running control parameters are different from the initial running control parameters calculated in the previous Step S202 prior to the normal operation by a predetermined value or larger can be determined.

[0035] As a result, the test can be performed in a state in which the no-load state is ensured and therefore, the initial state can be reproduced. As a result, a fluctuation can be verified reliably. The test run may be performed or is not required to be performed at the time of regular maintenance. When the test run is performed at the time of regular maintenance, the test run can be more reliably performed because the maintenance engineer can directly verify the fluctuation. Further, at the time of regular maintenance, it is conceivable to perform the previous Steps S201 to S203 again so that the maintenance engineer determines the occurrence of an abnormality in the elevator apparatus from the basic state quantities and the values of the ranges of the running control parameters or updates the above-mentioned values.

[0036] The test run and the verification of the result of learning described above may be performed remotely through a network. In this case, the reliable verification can be performed without sending the maintenance engineer to the location of installation. Therefore, a frequency of the test can be increased to enhance the reliability of the result of learning. In addition, test cost can be reduced.

[0037] By the operation series described above, the validity of the result of detection of the learning algorithm can be verified, while a problem of the elevator apparatus in terms of hardware can be predicted. Further, when it is determined that the result of learning is not valid, the elevator service is stopped or the operation is switched to the rated running mode. At the same time, the operator can be informed of the necessity of maintenance.

[0038] When the parameter identification described referring to FIG. 2 is performed, a maximum speed or an acceleration which can be output is precisely determined based on the result of learning performed after the installation at the location of installation. Therefore, the above-mentioned values may be different from those at the shipping stage. Therefore, it is considered to provide an elevator safety device such as an emergency stopper, a buffer or a governor under an assumed maximum speed and acceleration. By defining the elevator safety device based on the maximum rating without depending on the result of learning as described above, the installation is simplified.

[0039] An application for the installation of the elevator at an office is made based on the maximum speed. Alternatively, an application relating to the governor may be made based on the maximum speed and, then the setting of the governor may be changed so that the governor operates at a lower speed by, for example, replacing a spring of the governor based on the running control parameters initially learned at the time of installation of the elevator. In this case, a speed abnormality at a lower speed can be detected in a more practical manner. As a result, a function of detecting the abnormal state is improved.

[0040] As described above, according to the first embodiment, the validity of the learning algorithm and the state of the elevator device can be determined based on the learned parameter values. Further, the validity of the learning algorithm can be determined at the test run stage prior to the normal operation, the normal operation stage, the maintenance-operation stage in the middle of the night, and the regular inspection stage by the maintenance engineer. As a result, the elevator control device having the learning function, which has enhanced reliability of the result of learning and high performance, can be obtained.

Claims

1. An elevator control device for optimizing variable-speed driving, comprising:

    a learning function section for updating running control parameters based on a result of identification of running state quantities during a normal operation after an elevator is installed,
    the elevator control device further comprising:

        a learning-function check section for performing one of stop of elevator service and rated running using predetermined running control parameters when the running control parameters obtained by the learning function section are out of allowable ranges of the running control parameters, which are estimated from allowable fluctuation rates of basic apparatus specification values of the elevator, and for determining that the learning function section is normal when the running control parameters are within the allowable ranges of the running control parameters.

2. An elevator control device according to claim 1, wherein:

    the learning function section calculates initial running control parameters at a time of a test run performed in a no-load state after the installation; and
    the learning-function check section stops the elevator service when the initial running control parameters are out of the allowable ranges of the running control parameters, which are estimated from the allowable fluctuation rates of the basic apparatus specification values of the elevator, in a stage prior to start of the normal operation, and determines that the learning function section is normal and starts the normal operation when the initial running control parameters fall within the allowable ranges of the running control parameters.

3. An elevator control device according to claim 2, wherein:

    the learning function section calculates the running control parameters during running after the normal operation is started; and
    the learning-function check section performs

one of the stop of the elevator service and the rated running using the predetermined running control parameters when the calculated running control parameters are out of the allowable ranges of the running control parameters and determines that the learning function section is normal and continues the normal operation by using the running control parameters when the running control parameters fall within the allowable ranges of the running control parameters.

4. An elevator control device according to claim 2 or 3, wherein:

the learning function section calculates the running control parameters during running in a maintenance-mode operation performed after the start of the normal operation; and
the learning-function check section stops the elevator service when the running control parameters calculated during the running in the maintenance-mode operation are one of out of the allowable ranges of the running control parameters and different from the initial running control parameters by a predetermined value or larger.

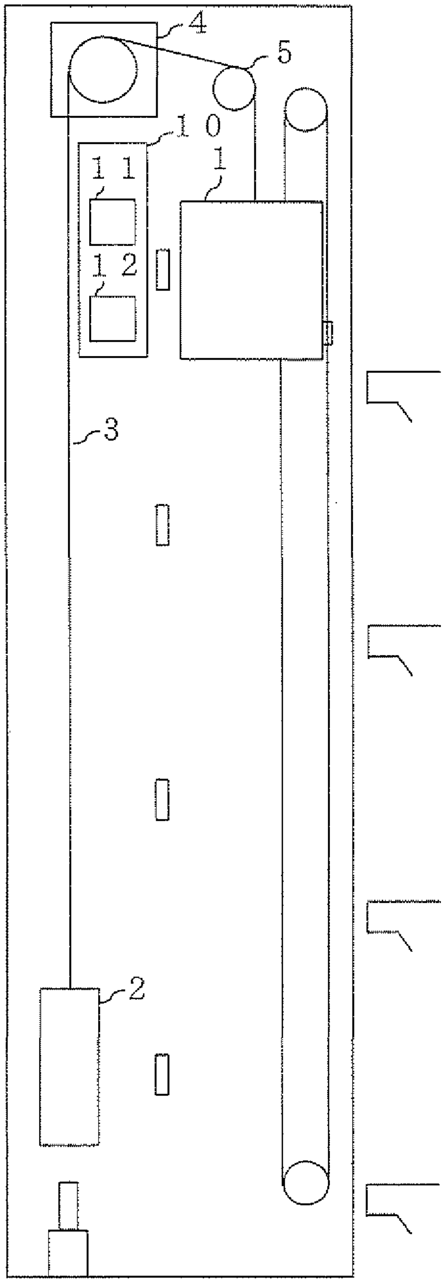

Fig. 1

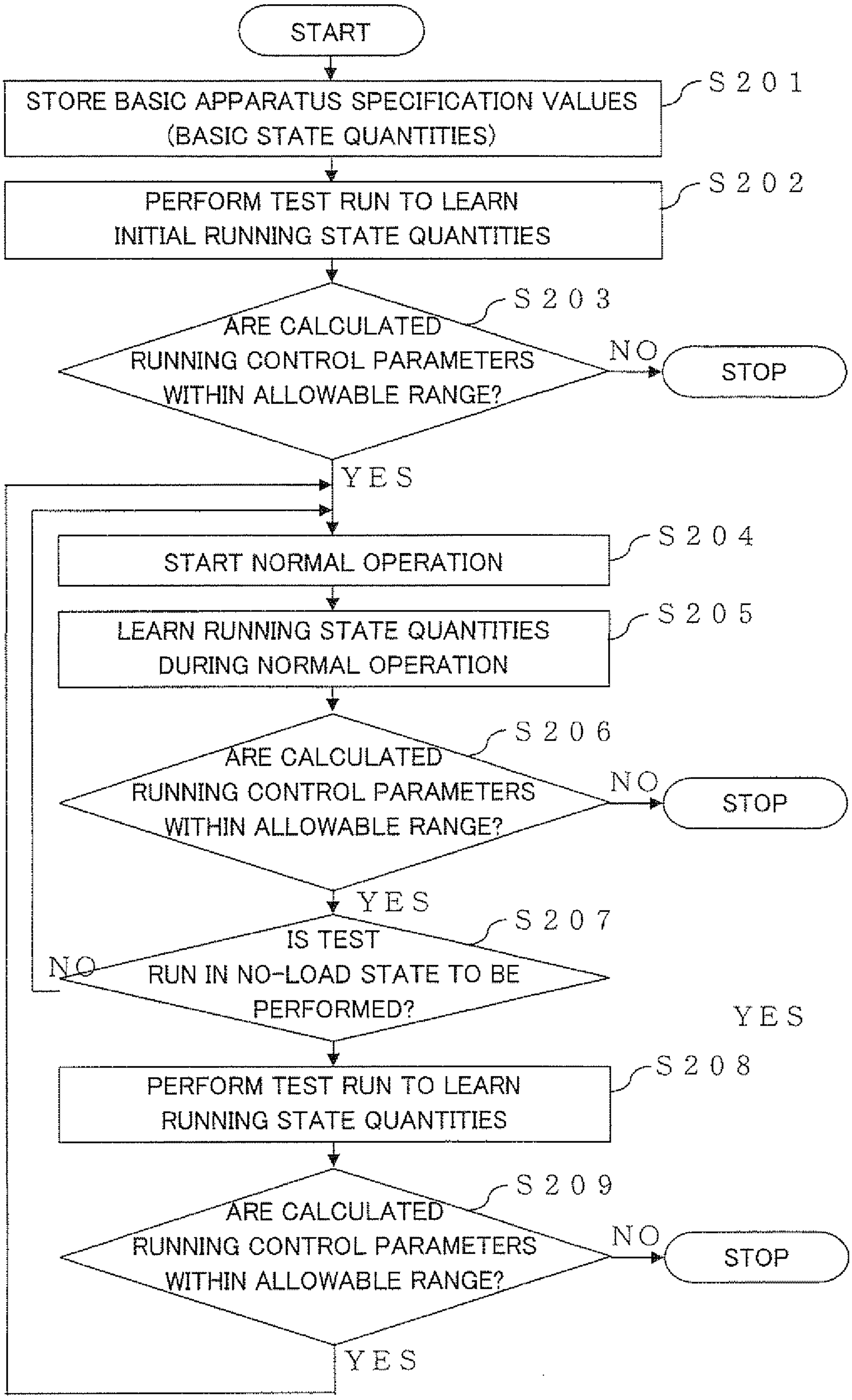
START
STORE BASIC APPARATUS SPECIFICATION VALUES (BASIC STATE QUANTITIES)
S201
PERFORM TEST RUN TO LEARN INITIAL RUNNING STATE QUANTITIES
S202
ARE CALCULATED RUNNING CONTROL PARAMETERS WITHIN ALLOWABLE RANGE?
S203
NO
STOP
YES
START NORMAL OPERATION
S204
LEARN RUNNING STATE QUANTITIES DURING NORMAL OPERATION
S205
ARE CALCULATED RUNNING CONTROL PARAMETERS WITHIN ALLOWABLE RANGE?
S206
NO
STOP
YES
IS TEST RUN IN NO-LOAD STATE TO BE PERFORMED?
S207
NO
YES
PERFORM TEST RUN TO LEARN RUNNING STATE QUANTITIES
S208
ARE CALCULATED RUNNING CONTROL PARAMETERS WITHIN ALLOWABLE RANGE?
S209
NO
STOP
YES

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/065509

A. CLASSIFICATION OF SUBJECT MATTER
B66B1/30(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B66B1/00-B66B1/52

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-149425 A (Mitsubishi Electric Corp.), 09 July 2009 (09.07.2009), paragraphs [0008] to [0081]; fig. 1 to 10 (Family: none)	1-4
A	WO 2005/92764 A1 (Mitsubishi Electric Corp.), 06 October 2005 (06.10.2005), description, page 2, line 18 to page 5, line 15; fig. 1 to 8 & EP 1731466 A1 & CN 1902116 A	1-4
A	JP 2008-114931 A (Toshiba Elevator and Building Systems Corp.), 22 May 2008 (22.05.2008), paragraphs [0016] to [0039]; fig. 1 to 6 (Family: none)	1-4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
24 November, 2009 (24.11.09)

Date of mailing of the international search report
08 December, 2009 (08.12.09)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/065509

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 56-351 B2 (Fujitec Co., Ltd.), 07 January 1981 (07.01.1981), claims (Family: none)	1-4

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009149425 A **[0003]**