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MECHANISM FOR MONITORING OPERATION OF PASSENGER TRANSPORT DEVICE

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An operation monitoring device for monitoring operation and drive conditions of a passenger transport device, including a drive control portion configured to control a drive source for driving the passenger transport device, and a datalogger portion connected to the drive control portion, wherein the datalogger portion is configured to generate and store a datalogger file based on

output data and control signals of the passenger transport device, wherein at least a part of the output data and control signals is obtained from the drive control portion, and provide the datalogger file to an external server for at least one of condition monitoring and fault search processing.

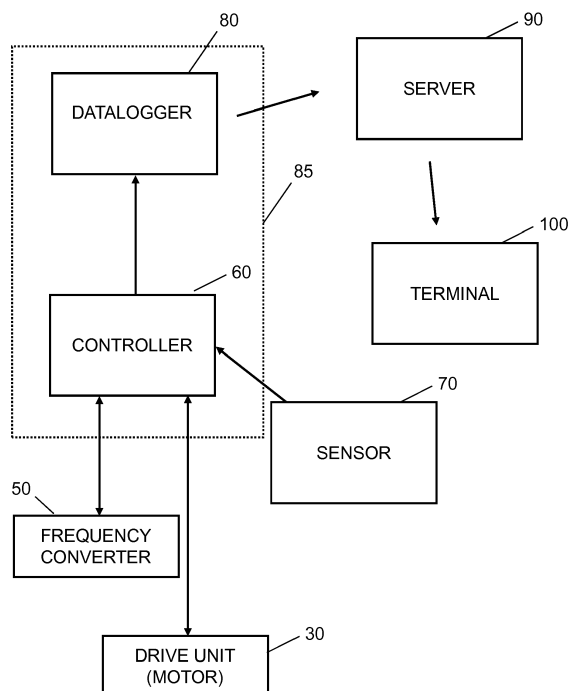


Fig. 2

Description

BACKGROUND

Field

[0001] The present invention relates to devices, methods, systems, and computer program products usable for monitoring an operation state and drive conditions of a passenger transport device, such as an elevator or escalator, and for controlling the operation of the passenger transport device.

Background Art

[0002] The following description of background art and examples may include insights, discoveries, understandings or disclosures, or associations, together with disclosures not known to the relevant prior art, to at least some examples of embodiments of the present invention but provided by the invention. Some of such contributions of the invention may be specifically pointed out below, whereas other of such contributions of the invention will be apparent from the related context.

[0003] Passenger transport systems are used in various environments and for different purposes. One typical example of such a passenger transport system is, for example, an elevator installed in a building and connecting a plurality of floors of the building. Another example is an escalator used for connecting two floors of a building or the like.

[0004] Such passenger transport system have usually a configuration comprising, in case of an elevator, a passenger transport member, such as a car located in a hoistway or elevator shaft, a drive member, such as a hoisting mechanism connected to the car and a motor for driving the car by means of the hoisting mechanism, and an operation and control portion including a processing means such as a CPU for controlling the car driving, sensors for determining drive conditions of the car, a position of the car etc., operation or control switches such as call buttons located in the car and the respective floors, and the like.

[0005] During the operation of a passenger transport system, such as of the elevator, there may be situations where a fault occurs, such as a fault in a door mechanism of the car, a fault in the drive operation of the car (e.g. inappropriate drive conditions like acceleration, speed etc. of the car), an unexpected stop of the car, and the like. In such a case, a service technician or troubleshooter is called who tries to repair the passenger transport system. For this purpose, the fault has to be identified.

[0006] In some cases, faults going to happen in the passenger transport system could be identified in advance, i.e. before a situation occurs which affects the normal operation of the passenger transport system. For example, in case the drive behavior of the drive member shows some changes indicating to a problem in any of

its parts (e.g. the motor or a control element of the motor), knowledge of such a problem when doing maintenance work at the elevator would help to overcome the problem before an actual fault happens. Also an unscheduled maintenance operation could be initiated in case the problem can be recognized beforehand.

[0007] Embodiments of the present invention are related to a mechanism, i.e. devices, methods, systems and computer program products, by means of which the operation and drive condition of the passenger transport system such as an elevator or an escalator, can be monitored and a control of such a passenger transport system can be facilitated.

15 SUMMARY

[0008] According to an example of an embodiment, there is provided, for example, an operation monitoring device for monitoring operation and drive conditions of a passenger transport device, including a drive control portion configured to control a drive source for driving the passenger transport device, and a datalogger portion connected to the drive control portion, wherein the datalogger portion is configured to generate and store a datalogger file based on output data and control signals of the passenger transport device, wherein at least a part of the output data and control signals is obtained from the drive control portion, and to provide the datalogger file to an external server for at least one of condition monitoring and fault search processing.

[0009] Furthermore, according to an example of an embodiment, there is provided, for example, a method for monitoring operation and drive conditions of a passenger transport device, including controlling a drive source for driving the passenger transport device, generating a datalogger file based on output data and control signals of the passenger transport device, wherein at least a part of the output data and control signals is obtained from a drive control portion used for controlling the drive source for the passenger transport device, storing the datalogger file, and providing the datalogger file to an external server for at least one of condition monitoring and fault search processing.

[0010] According to further refinements, these examples may include one or more of the following features:

- the drive control portion may be instructed, e.g. by a sample data obtaining portion, to execute a predetermined drive scheme of the passenger transport device, and the datalogger portion may be instructed to generate and store a sample datalogger file during the execution of the predetermined drive scheme and to provide the sample datalogger file to the server;
- the predetermined drive scheme may comprise a round-trip course of the passenger transport device in an empty state during a preset day time;
- the drive control portion may comprise a motion and

torque controller configured to calculate and control at least one of a position reference, a speed reference and a torque reference of a frequency converter controlling a drive motor of the passenger transport device, and the passenger transport device may one of an elevator and an escalator;

- the output data and control signals of the passenger transport device may comprise at least one of electrical signals indicating at least one of an intermediate circuit voltage, a drive motor current, and an electrical power at motor terminals, mechanical signals indicating at least one of a position of the passenger transport device, a load weight of the passenger transport device, a speed of the passenger transport device, and an acceleration of the passenger transport device, and function signals indicating at least one of a destination selection and a safety switch activation, wherein the datalogger file may further include time indications related to the output data and control signals used.

[0011] Furthermore, according to an example of an embodiment, there is provided, for example, a control system of a passenger transport device, including an operation monitoring device as described above, and a server configured to conduct an operation analysis of the passenger transport device, wherein the operation analysis comprises at least one of a behavior prediction processing of the passenger transport device and a fault detection processing in the passenger transport device, wherein the datalogger file provided by the datalogger portion is used as input data for the operation analysis.

[0012] Furthermore, according to an example of an embodiment, there is provided, for example, a method of controlling of a passenger transport device, including controlling a drive source for driving the passenger transport device, generating a datalogger file based on output data and control signals of the passenger transport device, wherein at least a part of the output data and control signals is obtained from a drive control portion used for controlling the drive source for the passenger transport device, storing the datalogger file, providing the datalogger file to an external server, and conducting an operation analysis of the passenger transport device, wherein the operation analysis comprises at least one of a behavior prediction processing of the passenger transport device and a fault detection processing in the passenger transport device, wherein the datalogger file provided by the datalogger portion is used as input data for the operation analysis.

[0013] According to further refinements, these examples may include one or more of the following features:

- the server may be further configured to output at least one of a result of the operation analysis and at least a part the datalogger file to an external terminal device communicating with the server;
- the server may be further configured to use a diag-

nostic model of physical components of the passenger transport device based on electrical and mechanical parameters for conducting the operation analysis;

- the server may be further configured to conduct a diagnostic model developing processing for creating or modifying the diagnostic model of the physical components of the passenger transport device, the developing processing comprising deriving an actual behavior of the passenger transport device from the datalogger file, calculating a simulated behavior by using a current version of a diagnostic model of the physical components of the passenger transport device, comparing the derived actual behavior and the simulated behavior, and deciding whether a sufficient match between the model and the passenger transport device is achieved, on the basis of the comparison, wherein in case the decision is that a sufficient match is not achieved, the current version of the diagnostic model may be modified.

[0014] In addition, according to embodiments, there is provided, for example, a computer program product for a computer, including software code portions for performing the steps of the above defined methods, when said product is run on the computer. The computer program product may include a computer-readable medium on which said software code portions are stored. Furthermore, the computer program product may be directly loadable into the internal memory of the computer or transmittable via a network by means of at least one of upload, download and push procedures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Some embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 shows a schematic diagram illustrating a configuration of an elevator system representing an example of a passenger transport device where some examples of embodiments are implementable;

Fig. 2 shows a block circuit diagram of a configuration of a monitoring and control mechanism and related equipment according to some examples of embodiments;

Fig. 3 shows a flow chart of a processing conducted in a monitoring processing according to some examples of embodiments;

Fig. 4 shows a flow chart of a processing conducted in a monitoring and control processing according to some examples of embodiments;

Fig. 5 shows a diagram illustrating an analysis model

processing according to some examples of embodiments;

Fig. 6 shows a flow chart of a processing conducted in an analysis model development processing according to some examples of embodiments; and

Fig. 7 shows a diagram of a configuration of a monitoring device according to some examples of embodiments.

DESCRIPTION OF EMBODIMENTS

[0016] In the following, different exemplifying embodiments will be described using, as an example of a passenger transport system to which the embodiments may be applied, an elevator system as depicted and explained in connection with Fig. 1. However, it is obvious for a person skilled in the art that principles of embodiments may also be applied to other kinds of passenger transport systems, such as an escalator. In this context, it is to be noted that the respective drive members may be of different types, such as electric drive systems, hydraulic drive systems, rack and pinion systems, and the like, wherein, for example, in case of an elevator system, types such as traction elevators, winding elevators, hydraulic elevators, as well as different kinds of suspension/roping configurations are applicable. Furthermore, in case of an elevator, the illustrated number of landings or floors being reachable by an elevator car is not limited to that indicated in the described embodiment. In addition, it is to be noted that also the number of passenger transport systems (i.e. elevators as described in the following embodiment) is not limited to the number (i.e. one) used in the embodiment, but more than one passenger transport system of the same type (e.g. elevators) or of difference types (e.g. elevators and escalators) may be subject of the processing according to examples of embodiments of the invention related to monitoring of operation and drive conditions and corresponding control processing. That is, examples of embodiments of the invention are applicable to a wide range of different kinds of passenger transport systems.

[0017] It is to be noted that the following examples and embodiments are to be understood only as illustrative examples. Although the specification may refer to "an", "one", or "some" example(s) or embodiment(s) in several locations, this does not necessarily mean that each such reference is related to the same example(s) or embodiment(s), or that the feature only applies to a single example or embodiment. Single features of different embodiments may also be combined to provide other embodiments. Furthermore, terms like "comprising" and "including" should be understood as not limiting the described embodiments to consist of only those features that have been mentioned; such examples and embodiments may also contain features, structures, units, modules etc. that have not been specifically mentioned.

[0018] Regarding the general elements and functions of the described elevator system representing an example of the passenger transport system, details thereof depend on the actual type of elevator system, wherein they are generally known to those skilled in the art, so that a detailed description thereof is omitted herein. However, it is to be noted that several additional devices and functions besides those described below may be employed in a passenger transport system such as an elevator system.

[0019] Furthermore, elevator system elements, in particular operation elements, control elements or detection elements, as well as corresponding functions as described herein, and other elements, functions or applications may be implemented by software, e.g. by a computer program product for a computer, and/or by hardware. For executing their respective functions, correspondingly used devices, elements or functions may include several means, modules, units, components, etc. (not shown) which are required for control, processing and/or communication/signaling functionality. Such means, modules, units and components may include, for example, one or more processors or processor units including one or more processing portions for executing instructions and/or programs and/or for processing data, storage or memory units or means for storing instructions, programs and/or data, for serving as a work area of the processor or processing portion and the like (e.g. ROM, RAM, EEPROM, and the like), input or interface means for inputting data and instructions by software (e.g. floppy disc, CD-ROM, EEPROM, and the like), a user interface for providing monitor and manipulation possibilities to a user (e.g. a screen, a keyboard and the like), other interface or means for establishing links and/or connections under the control of the processor unit or portion (e.g. wired and wireless interface means etc.) and the like. It is to be noted that in the present specification processing portions should not be only considered to represent physical portions of one or more processors, but may also be considered as a logical division of the referred processing tasks performed by one or more processors.

[0020] Fig. 1 shows a schematic diagram illustrating a configuration of an elevator system where some examples of embodiments are implementable. It is to be noted that examples of embodiments are not limited to an elevator system structure with the number of floors, elevator cars and elevator shafts as shown in Fig. 1. Rather, the number of elements, functions, and structures may be different to that indicated in Fig. 1, i.e. there may be implemented or present more (or less) of the corresponding floors, elevator cars and elevator shafts than those shown in Fig. 1.

[0021] In Fig. 1, reference sign 10 denotes an elevator car containing an elevator cabin for transporting persons between the floors of a building or the like. The elevator car 10 is located and travels in a hoistway or elevator shaft 20 which reaches e.g. from the lowest floor to the

highest floor and includes further spaces for accommodating, for example, devices used for driving and stopping the elevator car. Such devices comprise, without being limited thereto or being necessary in any system, for example, a drive system including e.g. a drive unit 30 including a motor, a counterweight, guiding rails, ropes or belts, brake systems, etc., which is used for moving the elevator car 10 and which may be installed in the elevator shaft or at the elevator car, for example. Furthermore, an elevator machinery room etc. (not shown) may be provided in which at least parts of the drive unit 30 are accommodated. That is, the drive unit 30 comprises parts or the entirety of mainly mechanical parts being used for physically moving the elevator.

[0022] At each floor or landing, a landing door 41, 42, 43 and 44 is provided for allowing entering or leaving the elevator cabin when the elevator car 10 has stopped at this floor. In the example illustrated in Fig. 1, it is assumed that the elevator car 10 has stopped on the second floor so that in a normal operation mode landing door 42 would be opened. In such a normal operation mode, the other landing doors are to be closed, which is indicated in Fig. 1 for landing doors 41, 43 and 44.

[0023] The elevator system shown in Fig. 1 further comprises a frequency converter 50 connected to the drive unit 30 (in particular the motor), which is used for controlling the hoisting mechanism.

[0024] Reference sign 60 denotes a controller. The controller 60 is used as an overall control entity of the elevator system and in particular of the drive unit 30 and the frequency converter 50. The controller 60 is responsible, for example, for operation of the elevator system, such as driving and braking control, power supply control, emergency control, safety procedure control, and the like. Moreover, operation panels (not shown) in the elevator cabin and at each floor are provided which are coupled to the controller 60 by suitable signaling links. Furthermore, several sensors are provided in the elevator system, such as a speed sensor, a door zone sensor, and the like. Based on the input signals, the controller determines a direction and speed of the driving of the elevator car 10, generates a corresponding control signaling towards the frequency converter 50, and controls start and stop of the elevator car 10 by controlling the drive unit 30 via the frequency converter 50.

[0025] For example, the controller 60 acts as a motion and torque controller calculating and controlling position, speed and torque references of the frequency converter 50, which in turn are used as control parameters for the actual driving of the elevator car 10 by the drive unit 30. Furthermore, the controller 60 receives and processes other input signals, such as operation and control signals from operation panels (e.g. call buttons) for conducting the drive control of the elevator system in a normal operation mode. Also other input signals, such as sensor signals indicating operation data such as a weight load transported by the elevator car 10, an acceleration of the car 10, an electric power consumed by the elevator sys-

tem, and the like are received and processed by the controller 60, for example.

[0026] It is to be noted that even though the controller 60 and the frequency converter 50 are indicated as separate parts in the configuration according to Fig. 1, it is also possible that at least parts of the controller 60 are included in the frequency converter 50 as an integrated controller.

[0027] In a passenger transport system such as the elevator system according to Fig. 1, the controller 50 handles, for example, events like "Car call button pressed at floor 42" or "Safety switch is activated". Furthermore, when acting as the motion and torque controller portion (e.g. a corresponding software portion), the controller 60 calculates and controls parameters like position, speed and torque references for the frequency converter 50 that controls the hoisting mechanism of the drive unit 30. That is, the controller 60 handles the power conversion from electrical power to mechanical power (i.e. the car movement), so that it is responsible for elevator availability and reliability.

[0028] In the controller 60, there is a plurality of electrical and mechanical signals and parameters available, such as a DC intermediate circuit voltage, a motor current, a car position, a load weight and the like, which are received, for example, from corresponding sensors.

[0029] As described above, when, during the operation of such a passenger transport system as indicated in Fig. 1, a fault occurs, such as an unexpected stop of the car, for example, a service technician or troubleshooter tries to find out why the elevator has stopped. In this situation, the knowledge about the operation situation in the elevator system at the time of the fault would be useful, i.e. how was the elevator system working and which operational parameters were valid and which operation related signals were transmitted before, during and/or after the fault event.

[0030] Consequently, according to some examples of embodiments of the invention, a monitoring mechanism is provided which monitors and stores operation and drive conditions of the passenger transport system, such as sensor and control signals available in a control software of the passenger transport system, such as an elevator system, which can be used for tracing the cause for a fault in the system. For this purpose, according to some examples of embodiments, suitable IO signals existing and being used in a passenger transport system are stored in a storage as a specific file format, which is also referred to hereinafter as datalogger file or condition file, where the operation and drive conditions of the passenger transport system over a predefined period of time are stored as a history of the operation of the passenger transport system. This datalogger file is augmented, for example, with control signals of the passenger transport system, allowing to identify the respective details of the operation and drive conditions at a selected point of time or period of time, so as to learn the conditions during specific events, such as a fault event.

[0031] Furthermore, according to some examples of embodiments of the invention, a condition monitoring procedure is implemented using the datalogger or condition file. That is, for example, the data provided in the datalogger file are used in a monitoring system running, for example, a simulation processing in order to estimate the future condition of the passenger transport system. In this way, possible faults in the passenger transport system can be identified in advance, i.e. before a situation occurs which affects the normal operation of the passenger transport system, and a maintenance can be triggered. Data included in the datalogger file may also be used for developing or refining a model of the passenger transport system used in the simulation processing

[0032] Fig. 2 shows a block circuit diagram of a configuration of a corresponding monitoring and control system according to some examples of embodiments. Specifically, the monitoring and control system according to Fig. 2 comprises an operation monitoring device 85 including a general control element of the passenger transport system, such as the controller 60 of Fig. 1, which is connected to elements being used for moving/driving the passenger transport system, such as to a drive motor of the passenger transport system included in drive unit 30 and/or frequency converter 50. Furthermore, the operation monitoring device 85 comprises a data processing and/or storing portion, such as a datalogger element or portion 80, which is used for processing and acquiring the data from the controller 60 to be stored in the datalogger file. It is to be noted that reference sign 70 denotes one or more sensors used for inputting signals and parameters to the processor 60, such a control signals input in a operation panel in the elevator car, weight signals obtained from a weight sensor, position/speed/acceleration signals obtained from a corresponding sensor, and the like. An output signal of the sensor 70 is sent to the controller 60 by means of a suitable connection (e.g. wireless or wired connection, like a network connection).

[0033] The datalogger 80 is also referred to as a data recorder and represents an electronic device that records data over time or in relation to location. The data can be acquired from an external or an internal source, such as a built in or external instrument or sensor. For example, the datalogger comprises a digital processor or microcomputer equipped with a microprocessor, internal memory for data storage, and interfaces. Some types of dataloggers may have an interface with a personal computer or the like, wherein internal processing using a software to activate the datalogger, to view collected data and/or to analyze the collected data can be provided. For example, a datalogger can be of a general purpose type for a variety of measurement applications, or of a specific type for measuring in one environment or application type only.

[0034] According to some examples of embodiments of the invention, the datalogger 80 is configured, for example, to comprise a routine located inside the control software of the controller that starts sampling configured

memory locations or variables or parameters into a local memory, such as a RAM memory, with a relative fast sampling rate (e.g. in the order of milliseconds). The sampling is stopped, for example, when a configured triggering condition occurs. This type of datalogger can also be referred to as an "internal software oscilloscope" the data of which is saved to a local file or transferred directly onwards in the monitoring system for data analysis and visualization.

[0035] For example, a rather simple usage of the datalogger file used for identifying a fault reason is when e.g. an electrical parameter of the elevator of Fig. 1, such as an electrical power signal, and a mechanical parameter, such as an operation speed of the elevator car, are stored on a common time basis. When the fault is caused by the elevator car stop, a parallel visualization of the two parameters may reveal, for example, that the cause for the fault was a cut off of the power supply for a period of time. Hence, a visualization of the stored signals can be used for finding the root cause of a problem. As a matter of course, the number and types of parameters used for the datalogger file is not limited to this example.

[0036] As indicated above, according to some examples of embodiments, the datalogger file may be used to get samples from various operation and drive signals being used for analysis purposes, which is based e.g. on a model based simulation processing.

[0037] Hence, according to some examples of embodiments, the monitoring and control system includes a server 90 to which the datalogger 80 is configured to transmit the datalogger file. For example, the server 90 includes a control element or function which is in charge of conducting an analysis processing for condition monitoring of the passenger transport system. The control element is, for example, a processing element like a microcomputer including a CPU (central processing unit), a memory (ROM, RAM), and an interface means for receiving and transmitting signals related to the monitoring processing control. For example, the control element (i.e. the server 90) is included in an external element, such as a laptop or maintenance device connectable to the monitoring device 80 of the elevator, or an internal part of the elevator. The datalogger file may be sent to the server 90 by means of a suitable connection (e.g. wireless or wired connection, like a network connection).

[0038] Reference sign 100 denotes a terminal device, such as a personal computer, a portable computer or communication device, such as a smart phone, a tablet computer or the like, which is configured to exchange data with the server and which is equipped with a processing element or function running a software or firmware allowing to process and visualize data obtained from the server 90, such as data obtained from the datalogger file of the monitoring device 85. The data are transmitted from the server 90 to the terminal device 100 by means of a suitable connection (e.g. wireless or wired connection, like a cellular network connection). The terminal device 100 is, for example, a portable user device,

such as a smart phone, a laptop or the like, with which a service technician is equipped when conducting maintenance work or troubleshooting work at the passenger transport system site, or a computer device for a operator or developer of the passenger transport system.

[0039] It is to be noted that according to some examples of embodiments, the datalogger 80 is configured to communicate directly with the terminal 100, e.g. by means of a corresponding interface, for providing the datalogger file to the terminal 100. This allows, for example, a direct communication between the service personal and the elevator system, for example, which is useful e.g. in case of difficult communication environments to the outside (e.g. a link to the server is disturbed or not present). According to examples of embodiments, the terminal 100 is then provided with corresponding means, functions and/or programs for processing the datalogger file in a suitable manner, such as data extraction, data processing and display functions.

[0040] That is, according to examples of embodiments, data contained in the datalogger files can be provided from the elevator system to the server and further to a trouble-shooter or service technician, wherein a data processing for selecting data and visualizing processing results can be done exclusively in one of the server and the terminal or conducted in a shared manner in both of these elements.

[0041] Regarding the contents of the datalogger file generated and stored by the datalogger 80, according to some examples of embodiments, a history file augmented with electrical signals or data (e.g. DC intermediate circuit voltage, motor current), mechanical signals or data (e.g. car position, load weight) and control signals or data (e.g. elevator call operation, emergency stop instruction) obtained from the controller 60 which represents a motion and torque controller configured to calculate and control parameters such as position, speed and torque references in the drive system of the passenger transport system, such as drive motor/drive unit 30 and/or frequency converter 50. According to further examples of embodiments, the electrical, mechanical and control signals or data can be obtained from another source or a plurality of sources, such as an operation control element or function used for controlling and processing user input, one or more sensors, such as sensor 70, and the like.

[0042] Fig. 3 shows a flow chart of a processing conducted in a monitoring processing for monitoring operation and drive conditions of a passenger transport device according to some examples of embodiments. Specifically, the example according to Fig. 3 is related to a procedure conducted by the monitoring device 85 of Fig. 2 when being used in a passenger transport system such as an elevator system as depicted in Fig. 1.

[0043] In S100, a drive control for controlling a drive source for driving the passenger transport device is conducted. Specifically, motion and/or torque control for the passenger transport system, such as the elevator system of Fig. 1, is conducted by controller 60 providing e.g. po-

sition, speed and torque references for the frequency converter 50 and/or the drive unit 30.

[0044] It is to be noted that instead of an elevator such as that shown in Fig. 1, also other passenger transport system may apply the drive control and monitoring processing, such as an escalator.

[0045] In S110, output data and control signals of the passenger transport system are obtained. For example, signals input or calculated in the processor 60 are obtained, and/or output data provided from sensors, such as sensor 60, are obtained. The numbers, sizes, types and the like of the output data and control signals being obtained, i.e. selected to be used for a datalogger file, can be variably set, e.g. in accordance with operator settings or preferences, in accordance with a time period, an operation state of the passenger transport system, and the like.

[0046] For example, according to some examples of embodiments, the output data and control signals of the passenger transport device being obtained and used for the datalogger file comprises at least one of electrical signals indicating at least one of an intermediate circuit voltage, a drive motor current, and an electrical power at motor terminals, mechanical signals indicating at least one of a position of the passenger transport device, a load weight of the passenger transport device, a speed of the passenger transport device, and an acceleration of the passenger transport device, and control or function signals indicating at least one of a destination selection and a safety switch activation.

[0047] It is to be noted that the respective output data and control signals can be obtained in combination with a corresponding time indication so that the datalogger file further includes time information based on these indication allowing to identify a point of time at which the respective output data and control signals are obtained.

[0048] In S120, the datalogger file is generated on the basis of the obtained output data and control signals of the passenger transport device. In detail, at least a part of the output data and control signals obtained from the drive control portion, i.e. from the portion responsible for the drive control of the drive source for driving the passenger transport system is used for generating the datalogger file. In addition, also other output data and control signals being different to those obtained from the drive control portion, such as signals from sensors, can be used for generating the datalogger file. The datalogger file is stored for further processing.

[0049] In S130, the datalogger file is provide to an external server (e.g. server 90) for further processing. The transmission of the datalogger file is conducted, for example, in regular intervals, upon request from the server 90 side, or in a specified event, e.g. in case of an emergency stop or the like. The datalogger file being provided to the server 90 is used, for example, in a further processing related to condition monitoring or fault search processing. As also indicated above, the datalogger file can be also provided, instead of the server 90, to another

destination, such as terminal 100.

[0050] According to some examples of embodiments, the processing of S110 for obtaining the output data and control signals is executed in various situations. One possibility is to obtain the output data and control signals arbitrarily, e.g. during a normal operation of the passenger transport system. Another possibility is to obtain the output data and control signals a specific sample data. For example, when such a sample data obtaining processing is conducted, the drive control portion is instructed to execute a predetermined drive scheme of the passenger transport device. For example, the predetermined drive scheme comprises a round-trip course of the passenger transport system in an empty state during a preset day time (e.g. night time). Then, an instruction is issued to generate and store a sample datalogger file during the execution of the predetermined drive scheme and to provide the sample datalogger file to the server 90, for example after completion of the predetermined drive scheme.

[0051] As indicated above, the datalogger file is usable in the server 90 (or in the terminal 100, as discussed above) as a tool for tracing a root cause for a fault in the passenger transport system.

[0052] Another application of the datalogger file is for using the same in a condition monitoring processing, in which the datalogger file is used as a filed indicating the current condition of the passenger transport system. Specifically, numerical data contained in the datalogger file, which are based on the output data and control signals used for generating the datalogger file, are recorded for monitoring the current condition of the passenger transport system. By using a suitably analysis function, these numerical data can then be used for determining a current and also an expected (i.e. future) condition of the passenger transport system, allowing for example to identify a potential weak point in the system due to a typical behaviour of some parameters during the operation of the passenger transport system.

[0053] According to some examples of embodiments, in order to provide a sufficient processing and storage capacity for conducting the analysis, which comprises e.g. a complex calculation processing using the numerical data, the datalogger file is provided outside of the controller 60 which may have limited capacity or is required for the normal operation of the passenger transport system. Hence, in particular in cases where e.g. complex model parameters are required to be iterated, the datalogger file including the samples of the output data and control signals being of interest is transferred to an external processing element or function, such as the server 90, where a higher capacity for the analysis processing can be provided. For example, the server 90 uses mathematical programs and libraries, such as Matlab or Octave, for processing the datalogger file data in a corresponding analysis processing.

[0054] Fig. 4 shows a flow chart of a processing conducted in a monitoring and control processing according

to some examples of embodiments. Specifically, the example according to Fig. 4 is related to a procedure conducted by a control and analysis element such as the server 90 of Fig. 2 when being used in a passenger transport system such as an elevator system as depicted in Fig. 1.

[0055] In S200, a control and analysis element or function, such as the server 90, obtains the datalogger file generated and stored as described in connection with Fig. 3 and provided by the monitoring device 85 (i.e. by the datalogger 80) as input data for conducting an operation analysis of the passenger transport system. In detail, the datalogger file is configured to be received and processed for conducting an operation analysis of the passenger transport device as shown, for example, in Fig. 1.

[0056] In S210, the operation analysis processing is conducted by using at least a part of the datalogger file obtained in S200 as input data. It is to be noted that according to the respective type of operation analysis, only specific parts of the datalogger file or the totality of the datalogger file data may be used. Furthermore, other data and parameters being obtained from other sources, such as pre-stored data or data received from other sensors or the like, can be used as input data for the operation analysis.

[0057] According to some examples of embodiments, the operation analysis concerns, for example, a behavior prediction processing of the passenger transport device as a condition monitoring processing, in order to predict how the passenger transport system reacts in the future. Alternatively or additionally, the operation analysis concerns a fault detection processing in the passenger transport device, in order to determine, for example, a root cause in case a fault condition such as an unexpected car stop or the like happens.

[0058] In S220, an output operation related to the datalogger file data is conducted. For example, the server 90 outputs, e.g. upon request or in reaction to a trigger event such as a timer based instruction or a detection of a fault event, a result of the operation analysis. Furthermore, in addition to an output or the result of the operation analysis, a part or the totality of data contained in the obtained datalogger file can be output. A recipient for the output operation is, for example, an external terminal device, such as the terminal 100 communicating with the server 90.

[0059] According to some examples of embodiments, for the operation analysis, a diagnostic model of physical components of the passenger transport device based on electrical and mechanical parameters is used. A corresponding configuration of an operation analysis is described in the following with reference to Fig. 5.

[0060] Fig. 5 shows a diagram illustrating an analysis model processing according to some examples of embodiments, which is usable as a basis for an operation analysis as described above.

[0061] Specifically, as indicated in Fig. 5, in parallel to

the "real" passenger transport system (indicated by reference sign 200), which consists of the physical elements and parts of the passenger transport system such as the elevator system shown, for example, in Fig. 2, a virtual model 300 of specific parts of the passenger transport system and the interaction therebetween is developed and operated in a suitable computation environment, such as the server 90. For example, the model 300 concerns the driving unit parts, such as the motor, the hoistway and the like, of the elevator system shown in Fig. 1.

[0062] For example, parameters of the elevator system, such as masses, frictions, balancing, compensation and efficiencies of the elevator system are calculated when the electrical input power etc. of the hoisting motor is measured. The model of the physical parts of the elevator system includes a plurality of parameters and equations how these parameters relate to measured parameters, such as power and car acceleration signals. In this connection, specific drive conditions such as a round-trip test (discussed later) are preferred in order to obtain results being better processable.

[0063] One goal is, for example, to minimize modeling error (such as a power system modeling error) from the equation used in the model 300. By conducting an iterative optimization for the respective terms and parameters of the model during a model development phase, in order to minimize the modeling error, a matching between the model and the actual elevator system is tried to be obtained.

[0064] Fig. 6 shows a flow chart of a processing conducted in an analysis model development processing according to some examples of embodiments. For example, the processing described in connection with Fig. 6 is used for developing the model 300 of the passenger transport system according to Fig. 5. In other words, the model developed in the processing shown in Fig. 6 is usable for conducting a creating the diagnostic model of the physical components of the passenger transport device and/or for modifying an already developed model.

[0065] In S300, the datalogger file from the monitoring device 85 is obtained which contains data, control signals and the like related to an operation and control of the passenger transport system. In this connection, also an actual behavior of the passenger transport device is derived from specific parts of the datalogger file, for example the actual acceleration of the elevator car under known driving conditions (e.g. input power), and the like.

[0066] According to some examples of embodiments, the datalogger file used in this connection is one being obtained from output data and control signals in a specific sample phase. In other words, the output data and control signals on which the datalogger file used for the model generation is based represent specific sample data obtained in a drive scheme of the passenger transport device. For example, the predetermined drive scheme comprises a round-trip course of the passenger transport system in an empty state during a preset day time (e.g. night time), wherein the sample datalogger file reflecting

these (known) conditions provides suitable data for generating or checking the virtual model.

[0067] In S310, an operation analysis model of the passenger transport system is determined. For example, in an initial phase of the processing according to Fig. 6, a basic model of physical components of the passenger transport system and the interaction therebetween is generated by using known electrical and/or mechanical parameters of the passenger transport system, and suitable calculation programs or the like, in order to establish a first version of the virtual model thereof. This model is usable for calculating a simulation result of the operational behavior of the passenger transport system under conditions derived from the datalogger file. For example, the virtual model is configured in such a manner that data concerning the load, the input electrical power and the like, which are contained in the datalogger file, may be used as input data for the virtual model. In a later phase, e.g. after a first completion of the processing of Fig. 6, the operation analysis model determined to be used in S310 is a modified second version of the first version (described later).

[0068] In S320, a simulation based on the determined model is executed. Specifically, a simulated behavior of the passenger transport system is calculated by using the (current) version of the diagnostic model of the physical components of the passenger transport device and specified data from the datalogger file. The result of the simulation is compared with data indicating the actual behavior of the passenger transport system included in the same datalogger file. For example, when the load and the electric power input in the actual elevator system shown in Fig. 1 are used as input data for the simulation, a calculated acceleration and/or speed of the elevator car can be seen as simulation result. This simulation result is then comparable with an actually measured acceleration and/or speed of the elevator car, which is also indicated in the datalogger file.

[0069] Based on the comparison in S320, in S330, it is decided whether the model being determined in S310 is suitable or not. That is, it is decided in S330 whether a sufficient match between the model and the actual passenger transport device is achieved. For example, the decision may be based on a difference between a parameter reflecting the actual behavior of the passenger transport system and the simulated parameter indicated in the simulation result thereof. A corresponding parameter is e.g. the speed or acceleration of the elevator car.

[0070] When the difference is equal to or below a preset threshold, the model may be decided to be appropriate (YES in S330). In this case, in S340, it is decided that the presently determined model is usable for an operation analysis, so that it is used in the processing of S210 of Fig. 4, for example.

[0071] On the other hand, e.g. in case the difference is above the threshold, the model is determined to be inappropriate (NO in S330). In this case, in S350, a modification processing for modifying the current version of

the diagnostic model determined in S310 is executed so as to achieve a better result in the next run. Then the processing returns, wherein in case the processing of S350 was part of the processing, the model determined in S310 of the next run is the modified model.

[0072] It is to be noted that even though in the above description a parameter regarding acceleration and/or speed is used as a basis for the determination of whether or not the model is appropriate, it is of course possible to use other parameters or additional parameters defining the operation condition of the passenger transport system, as long as the corresponding parameters can be derived from the datalogger file reflecting the actual operation of the passenger transport system.

[0073] In the following, application examples of embodiments of the invention are described in further detail, wherein the passenger transport system in these examples is assumed to be an elevator system as described in connection with Fig. 1, for convenience sake.

[0074] In a first application example, the datalogger file is used for developing the operation model of the elevator system in order to provide a basis usable, for example, to obtain valuable data that can be used in maintenance and fault prevention operations. For this purpose, the datalogger 80 in the elevator system is configured to collect and provide suitable data and to generate the datalogger file under specific conditions, such as during a nightly test run with an empty car. Then this sample datalogger file is provided e.g. to the server 90 for model development. When sufficient data are available, e.g. when the datalogger 80 (the monitoring device 85) has provided a sufficient number of datalogger files including the required signals and data, the system model is constructed by using corresponding modeling tools (such as "R" or "MatLab" or "Octave" or "Python"). Then, the model is checked or tested by using data from datalogger files, as discussed in connection with Fig. 6. If the result of the model test is not satisfactory (e.g. when the simulation results does not fit to the actual data so that it has to be concluded that the model cannot predict the elevator behavior), new data might be required to be obtained and/or the model is to be changed. Then, as a next iteration step, the processing of Fig. 6 is repeated, for example. As an end result, an operation diagnosis model is found that fits to the actual data to a sufficient degree.

[0075] When the model is finally found, a condition monitoring of the elevator can be executed in a suitable manner, for example in such a way that the elevator's behavior is checked every night. For example, when an elevator has been idle long enough (which is typically the case during nighttime, a test run (sample drive scheme) is executed. This sample drive scheme include, for example, that the elevator is driven to the lowest floor and then a round-trip (lowest-highest-lowest floor) is executed. For example, the sample drive scheme may be conducted with the normal operation speed or with a reduced operation speed. By means of the sample drive scheme, a repeatable set of output data (signals etc.) in controlled

conditions (empty car etc.) is obtainable. During the sample drive scheme (i.e. the round-trip) the datalogger 80 records predetermined parameters, such as the electrical power and speed, and store this as the datalogger file.

5 The datalogger file is then sent to the server 90, e.g. via diagnostics framework. In the server 90, mechanical system parameters of the elevator system may be fetched from a corresponding database (e.g. SAP/iBase) and combined with the data in the datalogger file. This combined data is then used as an input data package for determining the elevator behaviour. For example, friction charts and other results can be determined. The results can then be analyzed, wherein as a result thereof, for example, a maintenance service or the like is triggered when seen necessary. Furthermore, the result may be made available to research and development personal and/or field technician upon request.

[0076] It is to be noted that the results of the monitoring can be used for various purposes. While the above examples are related to the current operation condition of the passenger transport system, it is also possible to use the results for long-term monitoring. For example, models related to frequency converter's powerstage lifetime calculation etc. can be developed.

20 **[0077]** As one example for using the results, a service technician or troubleshooter can request the results in case of a fault. For example, the results based on the datalogger file can be used for finding out why the elevator is not working and how to fix it. For example, the server 90 can provide to the service technician (i.e. to the terminal 100, for example) data regarding the fault history of the elevator, parameters related to analysis results and even data from the datalogger file itself which are related to the fault being examined. For example, 35 when a technician goes to the site of the elevator system due to a corresponding call for help, and the reason for the fault is not found, the technician asks for detailed fault report from the server with his terminal device 100 (e.g. a smartphone running a suitable application, a laptop and the like). The server provides corresponding data, wherein also fault information and related datalogger signals obtained during the fault are contained. This report can then be studied by the technician and used for locating the root cause and the exact location of the fault. Hence, 40 the technician is able to fix the elevator without additional measurement devices (e.g. oscilloscope etc.).

[0078] Fig. 7 shows a diagram of a configuration of a monitoring device according to some examples of embodiments, which is configured to implement a monitoring procedure for a passenger transport system such as an elevator system as described in connection with some of the examples of embodiments. It is to be noted that the monitoring device 85, which comprises function of the controller 60 and the datalogger 80 of Fig. 2, may include further elements or functions besides those described herein below. Furthermore, even though reference is made to a device like a controller, the device or function may be also another device or function having

a similar task, such as a chipset, a chip, a module, an application etc., which can also be part of a controller or attached as a separate device to a controller, or the like. It should be understood that each block and any combination thereof may be implemented by various means or their combinations, such as hardware, software, firmware, one or more processors and/or circuitry.

[0079] The monitoring device 85 shown in Fig. 7 may include a processing circuitry, a processing function, a control unit or a processor 8501, such as a CPU or the like, which is suitable for executing instructions given by programs or the like related to the control procedure. The processor 8501 may include one or more processing portions or functions dedicated to specific processing as described below, or the processing may be run in a single processor or processing function. Portions for executing such specific processing may be also provided as discrete elements or within one or more further processors, processing functions or processing portions, such as in one physical processor like a CPU or in one or more physical or virtual entities, for example. Reference signs 8502 and 8503 denotes input/output (I/O) units or functions (interfaces) connected to the processor or processing function 8501. The I/O units 8502 and 8503 may be used for communicating with the other elements or function as described in connection with Fig. 2, for example, the sensor 70, the frequency converter 50, the drive unit 30 and/or the server 90. The I/O units 8502 and 8503 may be a combined unit including interface or communication equipment towards several elements, or may include a distributed structure with a plurality of different interfaces for different elements. Reference sign 8504 denotes a memory usable, for example, for storing data and programs to be executed by the processor or processing function 8501 and/or as a working storage of the processor or processing function 8501. It is to be noted that the memory 8504 may be implemented by using one or more memory portions of the same or different type of memory.

[0080] The processor or processing function 8501 is configured to execute processing related to the above described monitoring procedures. In particular, the processor or processing circuitry or function 8501 includes one or more of the following sub-portions. Sub-portion 8505 is a processing portion which is usable as a portion for obtaining output data and control signals. The portion 8505 may be configured to perform processing according to S100 and S110 of Fig. 3. Furthermore, the processor or processing circuitry or function 8501 may include a sub-portion 8506 usable as a portion for generating a datalogger file. The portion 8506 may be configured to perform a processing according to S120 of Fig. 3. In addition, the processor or processing circuitry or function 8501 may include a sub-portion 8507 usable as a portion for providing the datalogger file. The portion 8507 may be configured to perform a processing according to S130 of Fig. 3.

[0081] In addition, according to another example of

embodiments, there is provided an apparatus comprising at least one processing circuitry, and at least one memory for storing instructions to be executed by the processing circuitry, wherein the at least one memory and the instructions are configured to, with the at least one processing circuitry, cause the apparatus at least:

Furthermore, according to some other examples of embodiments, in the above defined apparatus, the at least one memory and the instructions may be further configured to, with the at least one processing circuitry, cause the apparatus to conduct at least one of the processing defined in the above described methods, for example a method according that described in connection with Fig 3 or Fig. 4.

[0082] As described above, according to some examples of embodiments, procedures allowing to improve monitoring of the operation and drive condition of a passenger transport system such as an elevator or an escalator, and controlling such a passenger transport system are provided. Continuous signals that reveal what happened during operation of the passenger transport system and in particular during a fault are made available for analysis by a service technician or trouble shooter. Hence, it is possible to enable a fast fault finding and development of advanced algorithm for condition based maintenance of elevators and escalators. A fast issue fixing allows to save time, money and customer nerves.

[0083] The datalogger file can be used to get samples during a specific test drive for advanced analytics algorithms running in a server. Hence, advanced diagnostics for predictive maintenance can be provided, e.g. by using the already present elevator/escalator control software as source for the datalogger file contents.

[0084] The monitoring operation using the generated datalogger file is highly scalable and can be adjusted to various requirements. Hence, a flexible condition monitoring and fault finding processing is possible. Furthermore, condition monitoring and fault finding processing can be conducted locally and remotely.

[0085] It should be appreciated that

- embodiments suitable to be implemented as software code or portions of it and being run using a processor or processing function are software code independent and can be specified using any known or future developed programming language, such as a high-level programming language, such as objective-C, C, C++, C#, Java, Python, Javascript, other scripting languages etc., or a low-level programming language, such as a machine language, or an assembler.
- implementation of embodiments is hardware independent and may be implemented using any known or future developed hardware technology or any hybrids of these, such as a microprocessor or CPU (Central Processing Unit), MOS (Metal Oxide Sem-

iconductor), CMOS (Complementary MOS), BiMOS (Bipolar MOS), BiCMOS (Bipolar CMOS), ECL (Emitter Coupled Logic), and/or TTL (Transistor-Transistor Logic).

- embodiments may be implemented as individual devices, apparatuses, units, means or functions, or in a distributed fashion, for example, one or more processors or processing functions may be used or shared in the processing, or one or more processing sections or processing portions may be used and shared in the processing, wherein one physical processor or more than one physical processor may be used for implementing one or more processing portions dedicated to specific processing as described, 5
- a device may be implemented by a semiconductor chip, a chipset, or a (hardware) module including such chip or chipset; 10
- embodiments may also be implemented as any combination of hardware and software, such as ASIC (Application Specific IC (Integrated Circuit)) components, FPGA (Field-programmable Gate Arrays) or CPLD (Complex Programmable Logic Device) components or DSP (Digital Signal Processor) components. 15
- embodiments may also be implemented as computer program products, including a computer usable medium having a computer readable program code embodied therein, the computer readable program code adapted to execute a process as described in embodiments, wherein the computer usable medium may be a non-transitory medium. 20

[0086] Although the present invention has been described herein before with reference to particular embodiments thereof, the present invention is not limited thereto and various modifications can be made thereto. 25

Claims 30

1. An operation monitoring device (85) for monitoring operation and drive conditions of a passenger transport device, including 35

a drive control portion (60) configured to control a drive source (30) for driving the passenger transport device, and 40
 a datalogger portion (80) connected to the drive control portion, wherein the datalogger portion (80) is configured to 45
 generate and store a datalogger file based on output data and control signals of the passenger transport device, wherein at least a part of the output data and control signals is obtained from the drive control portion (60), and 50
 provide the datalogger file to an external server (90) for at least one of condition monitoring and 55

fault search processing.

2. The operation monitoring device (85) according to claim 1, further including

a sample data obtaining portion (8505) configured

to instruct the drive control portion (60) to execute a predetermined drive scheme of the passenger transport device, and to instruct the datalogger portion (80) to generate and store a sample datalogger file during the execution of the predetermined drive scheme and to provide the sample datalogger file to the server.

3. The operation monitoring device (85) according to claim 2, wherein the predetermined drive scheme comprises a round-trip course of the passenger transport device in an empty state during a preset day time.

4. The operation monitoring device (85) according to any of claims 1 to 3, wherein 25

the drive control portion (60) comprises a motion and torque controller configured to calculate and control at least one of a position reference, a speed reference and a torque reference of a frequency converter controlling a drive motor of the passenger transport device, and the passenger transport device is one of an elevator and an escalator.

5. The operation monitoring device (85) according to any of claims 1 to 4, wherein the output data and control signals of the passenger transport device comprises at least one of 35

electrical signals indicating at least one of an intermediate circuit voltage, a drive motor current, and an electrical power at motor terminals, mechanical signals indicating at least one of a position of the passenger transport device, a load weight of the passenger transport device, a speed of the passenger transport device, and an acceleration of the passenger transport device, and 40
 function signals indicating at least one of a destination selection and a safety switch activation, wherein the datalogger file further includes time indications related to the output data and control signals used. 45

6. Method for monitoring operation and drive conditions of a passenger transport device, including 50

- controlling (S100) a drive source (30) for driving the passenger transport device,
generating (S120) a datalogger file based on output data and control signals of the passenger transport device, wherein at least a part of the output data and control signals is obtained from a drive control portion (60) used for controlling the drive source (30) for the passenger transport device,
storing (S120) the datalogger file, and
providing (S130) the datalogger file to an external server (90) for at least one of condition monitoring and fault search processing.
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7. A control system of a passenger transport device, including
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- an operation monitoring device (85) according to any of claims 1 to 6, and
a server (90) configured to conduct an operation analysis of the passenger transport device, wherein the operation analysis comprises at least one of a behavior prediction processing of the passenger transport device and a fault detection processing in the passenger transport device,
wherein the datalogger file provided by the datalogger portion (80) is used as input data for the operation analysis.
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8. The control system according to claim 7, wherein the server (90) is further configured to output at least one of
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- a result of the operation analysis and at least a part the datalogger file
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- to an external terminal device (100) communicating with the server (90).
9. The control system according to claim 7 or 8, wherein the server (90) is further configured to
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- use a diagnostic model of physical components of the passenger transport device based on electrical and mechanical parameters for conducting the operation analysis.
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10. The control system according to claim 9, wherein the server (90) is further configured to
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- conduct a diagnostic model developing processing for creating or modifying the diagnostic model (300) of the physical components of the passenger transport device, the developing processing comprising deriving an actual behavior of the passenger transport device from the datalogger file,
- calculating a simulated behavior by using a current version of a diagnostic model of the physical components of the passenger transport device, comparing the derived actual behavior and the simulated behavior, and
deciding whether a sufficient match between the model and the passenger transport device is achieved, on the basis of the comparison, wherein in case the decision is that a sufficient match is not achieved, the current version of the diagnostic model is modified.
11. A method of controlling of a passenger transport device, including
- controlling a drive source for driving the passenger transport device,
generating (S200) a datalogger file based on output data and control signals of the passenger transport device, wherein at least a part of the output data and control signals is obtained from a drive control portion used for controlling the drive source for the passenger transport device,
storing the datalogger file,
providing the datalogger file to an external server, and
conducting (S210) an operation analysis of the passenger transport device, wherein the operation analysis comprises at least one of a behavior prediction processing of the passenger transport device and a fault detection processing in the passenger transport device, wherein the datalogger file provided by the datalogger portion is used as input data for the operation analysis.
12. A computer program product for a computer, including software code portions for performing the steps of any of claims 6 or 11 when said product is run on the computer.
13. The computer program product according to claim 12, wherein
- the computer program product includes a computer-readable medium on which said software code portions are stored, and/or
the computer program product is directly loadable into the internal memory of the computer or transmittable via a network by means of at least one of upload, download and push procedures.

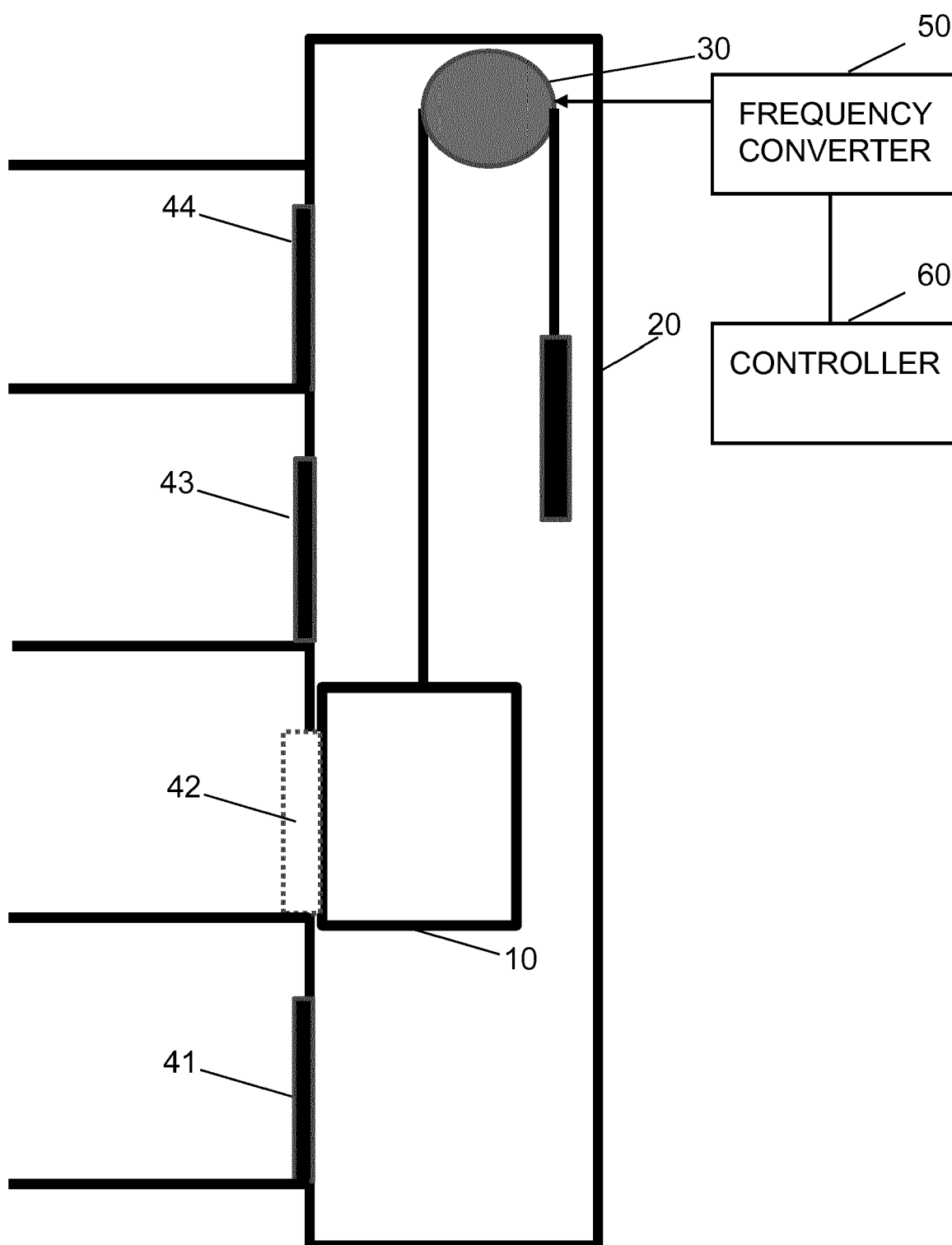


Fig. 1

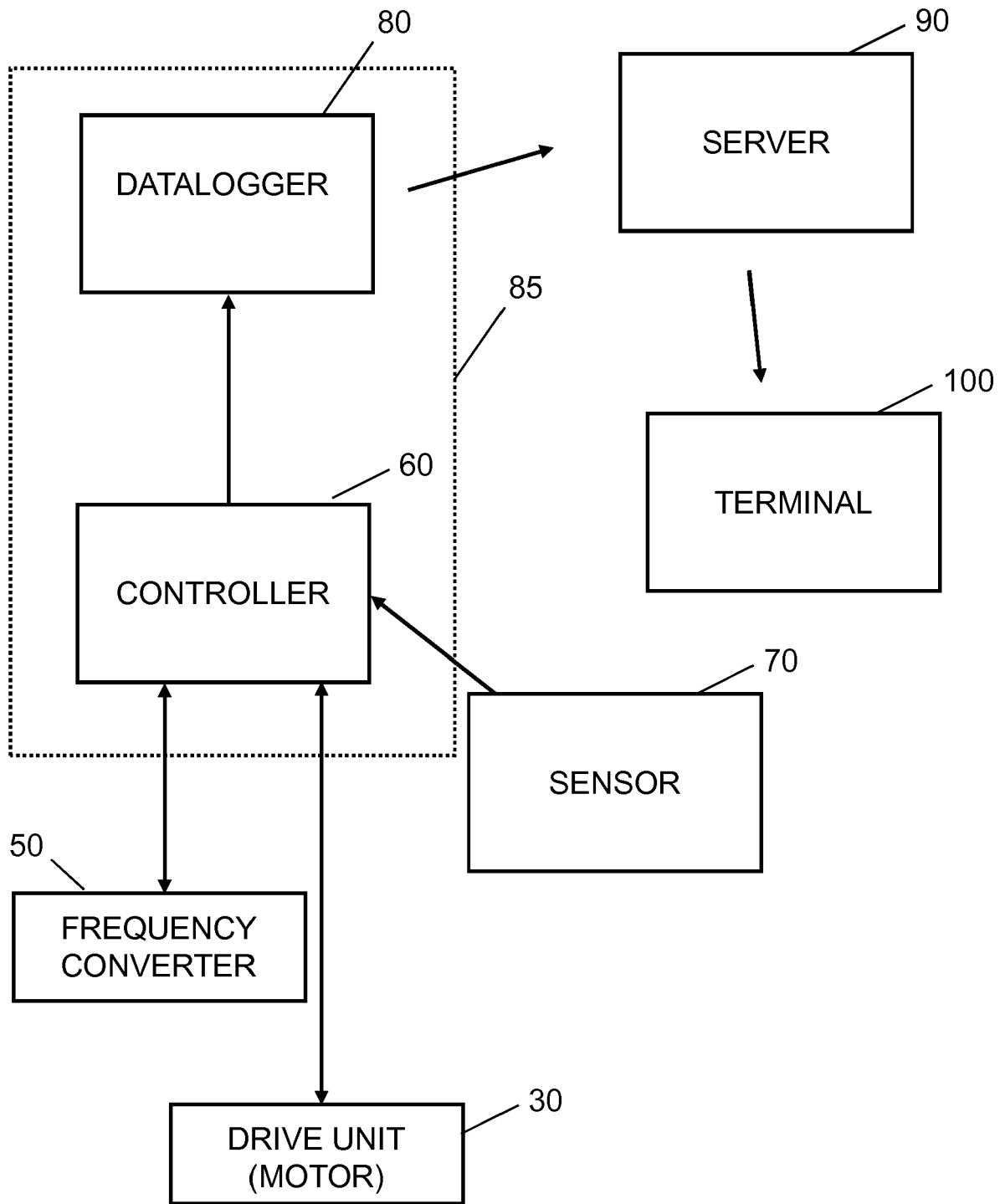


Fig. 2

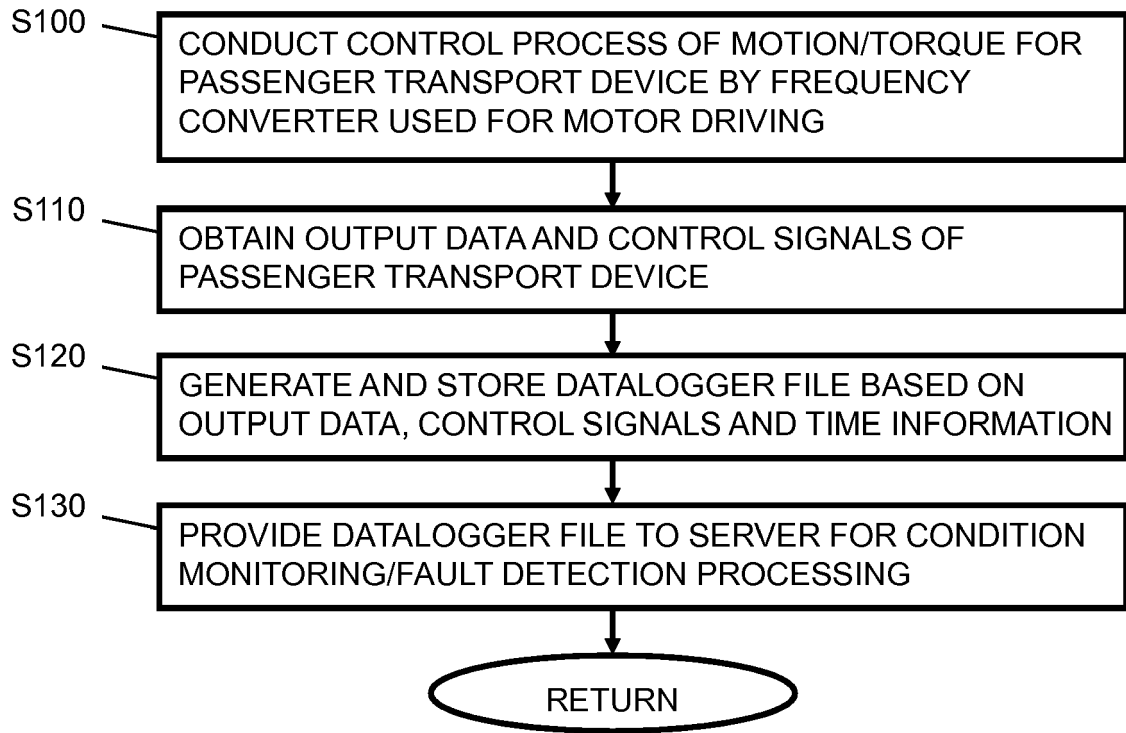


Fig. 3

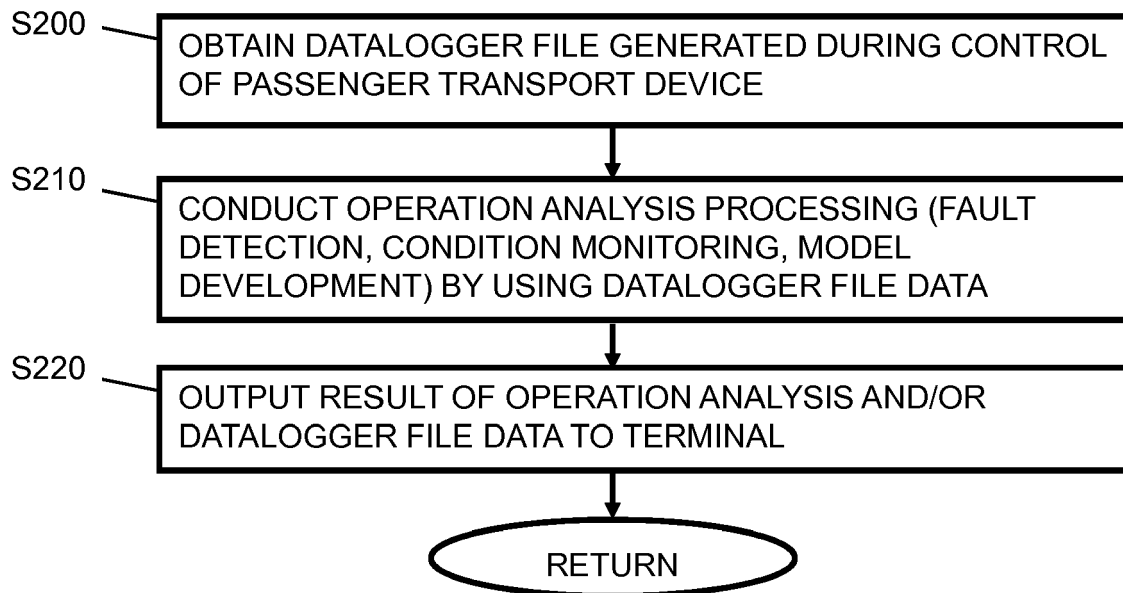


Fig. 4

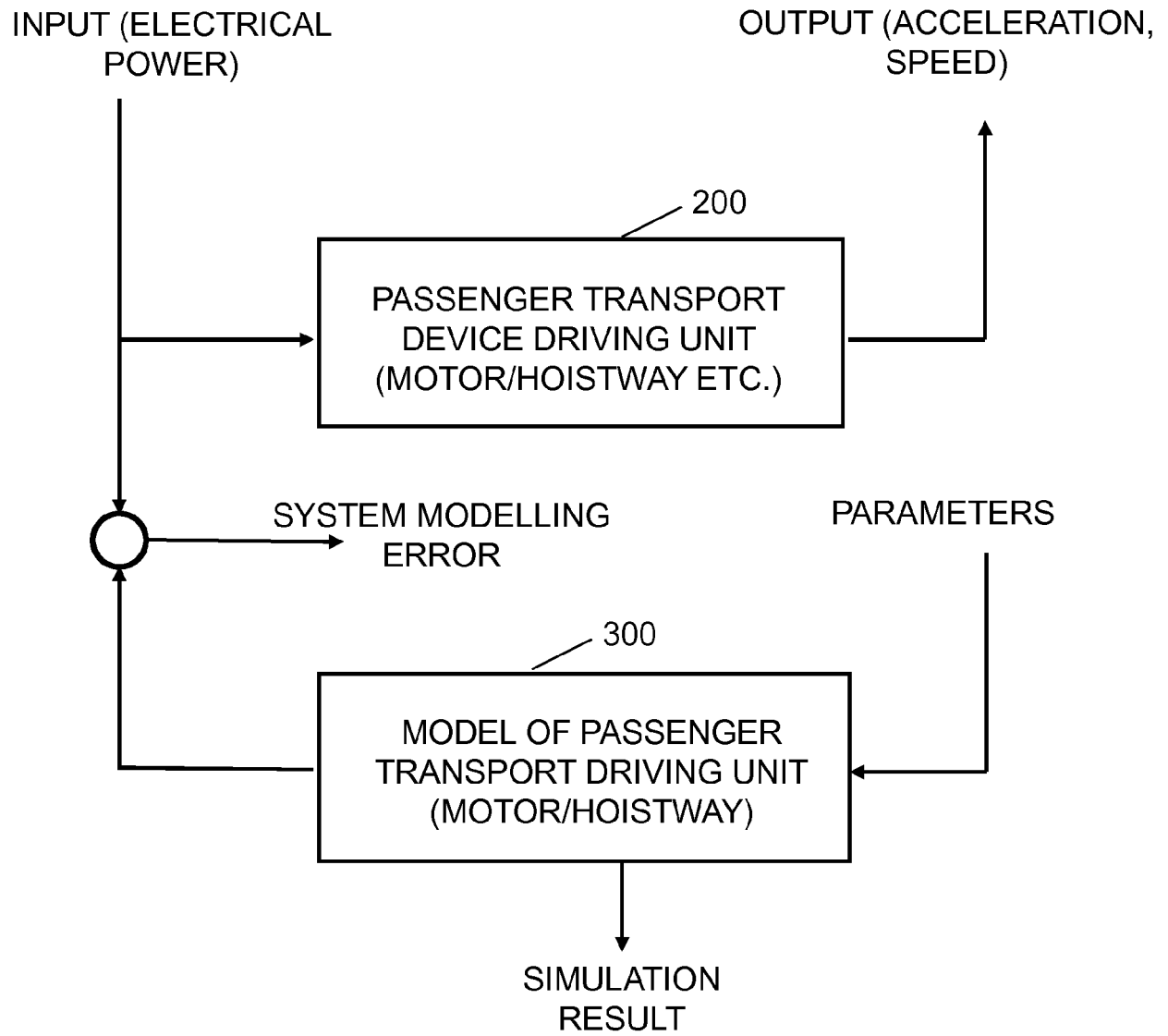


Fig. 5

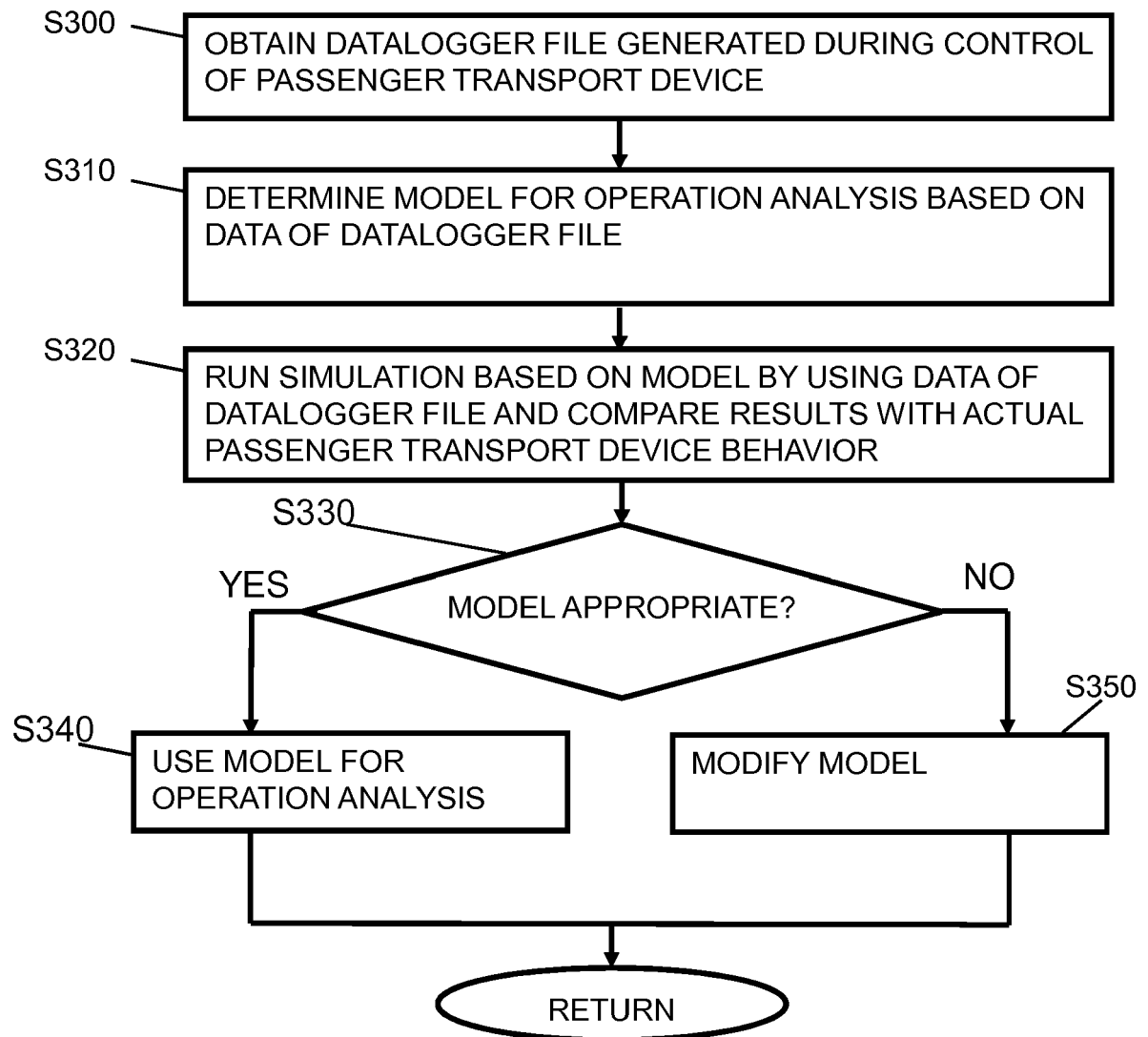


Fig. 6

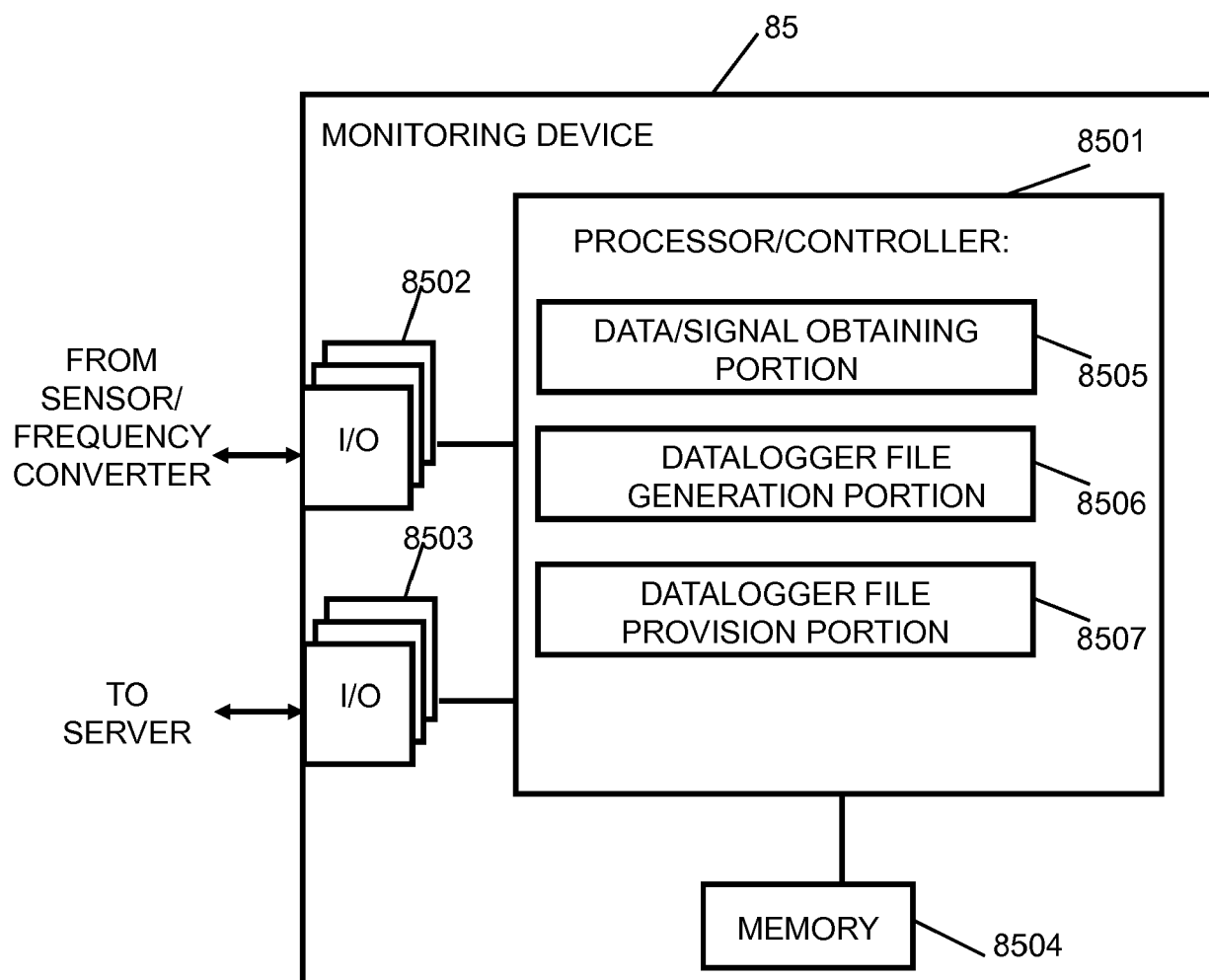


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
EP 17 15 6188

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