

DESCRIPTION

ELEVATOR GROUP MANAGEMENT CONTROL APPARATUS AND ELEVATOR GROUP MANAGEMENT CONTROL METHOD

Field

Embodiments of the present invention relate to an elevator group management control apparatus and an elevator group management control method.

Background

An elevator is usually provided as an elevator group which includes a plurality of elevators, so that a plurality of cars thereof is integrally managed as a group by an elevator group management control apparatus in some cases.

Summary

Embodiments of the present invention provide an elevator group management control apparatus that is capable of providing energy saving while maintaining the proper service performance, thereby allowing the balance between the service performance and the energy-saving performance to be optimized.

According to a first aspect of the present invention, there is provided an elevator group management control apparatus for managing an elevator group including a plurality of cars, the apparatus comprising: an actual value aggregation unit configured to aggregate an actual response time value that is an actual value of a response time corresponding to a time from when a hall call is registered to when the car responds to the hall call; a target setting unit configured to set a target response time value that is a target value of the response time; an operating time adjustment unit configured to adjust an energy-saving level so that the actual response time value aggregated by the actual value aggregation unit converges to the target response time value set by the target setting unit, the energy-saving level representing the degree of energy saving that affects the actual response time value of the elevator group; and an operating time management unit configured to create on the basis of the energy-saving level a car mask for limiting a car able to respond to a call, wherein the energy-saving level is set according to the number of cars in operation per unit time, the number of cars in operation being a parameter that can take a decimal value, when the number of cars in operation is an integer value, the number of cars in operation representing that the integer number of the cars can be assigned, and when the number of cars in operation is a decimal value, the number of cars in operation representing a proportion of time that can be assigned in a unit time interval.

According to a second aspect of the present invention,

there is provided an elevator group management control method for managing an elevator group including a plurality of cars, the method comprising: aggregating an actual response time value that is an actual value of a response time corresponding to a time from when a hall call is registered to when the car responds to the hall call; setting a target response time value that is a target value of the response time; adjusting an energy-saving level so that the actual response time value aggregated converges to the target response time value set, the energy-saving level representing the degree of energy saving that affects the actual response time value of the elevator group; and creating, on the basis of the energy-saving level, a car mask for limiting a car able to respond to a call, wherein the energy-saving level is set according to the number of cars in operation per unit time, the number of cars in operation being a parameter that can take a decimal value, when the number of cars in operation is an integer value, the number of cars in operation representing that the integer number of the cars can be assigned, and when the number of cars in operation is a decimal value, the number of cars in operation representing a proportion of time that can be assigned in a unit time interval.

According to the elevator group management control apparatus described above, it is possible to provide energy saving while maintaining the proper service performance, thereby allowing the balance between the service performance and the energy-saving performance to be optimized.

Brief Description of Drawings

FIG. 1 is a block diagram illustrating the outline of a group management control apparatus according to an embodiment.

FIG. 2 is a diagram illustrating an example of a record of operation of a car created by the group management control apparatus according to the embodiment.

FIG. 3 is a diagram illustrating an example of a target setting input screen used by the group management control apparatus according to the embodiment.

FIG. 4 is a diagram illustrating an example of an energy-saving level setting table created by the group management control apparatus according to the embodiment.

FIG. 5 is a time chart illustrating an example of an operating time schedule set by the group management control apparatus according to the embodiment.

FIG. 6 is a time chart illustrating an example of the operating time schedule set by the group management control apparatus according to the embodiment.

FIG. 7 is a flowchart illustrating an example of control performed by the group management control apparatus according to the embodiment.

FIG. 8 is a diagram illustrating an example of a car mask created by the group management control apparatus

according to the embodiment.

FIG. 9 is a diagram illustrating an example of the car mask created by the group management control apparatus according to the embodiment.

FIG. 10 is a diagram illustrating an example of recorded data managed by an operating time management unit of the group management control apparatus according to the embodiment.

FIG. 11 is a diagram illustrating an example of an actual value displayed by the group management control apparatus according to the embodiment.

FIG. 12 is a block diagram illustrating the outline of a group management control apparatus according to a variation.

FIG. 13 is a block diagram illustrating the outline of a group management control apparatus according to a variation.

Description of Embodiments

A group management control apparatus 1 illustrated in FIG. 1 as an elevator group management control apparatus is applied to an elevator group management control system 100 including an elevator group 2. The group management control apparatus 1 provides efficient operation service by managing the elevator group 2 as a group and the operation of a plurality of cars 120, thereby improving service performance.

Here, the service performance refers to the performance pertaining to the convenience of a user who uses the elevator group 2. The service performance can be expressed as, for example, a waiting time from when a user registers a hall call by operating a hall input device 160 provided in an elevator hall 124 to when he/she gets in the car 120, a riding time from when the user gets in the car 120 to when he/she gets off the car, or a service time corresponding to the waiting time and the riding time added together. This service performance tends to be improved by shortening what is called a response time, for example. Here, the response

time corresponds to the time from when a hall call is registered to when a car responds to the hall call, or typically the time from when the user registers the hall call to when a door of the car 120 opens up. Accordingly, the group management control apparatus 1 can improve the service performance by basically determining the car 120 to which the hall call is assigned such that the response time takes the shortest time possible. Here, the hall call is an operation performed by the user to call the car 120 through the hall input device 160. Moreover, the timing at which the door of the car 120 opens may correspond to a timing at which the door starts to open or a timing at which the door is completely open.

On the other hand, it is desired that such elevator group management control system 100 achieve energy saving to be environmentally friendly. The group management control apparatus 1 of the present embodiment achieves energy saving with a good prospect by setting an energy-saving target value while maintaining the service performance.

First, there will be described the elevator group management control system 100 to which the group management control apparatus 1 is applied. The elevator group management control system 100 includes the group management control apparatus 1 and the elevator group 2, where the group management control apparatus 1 manages the elevator group 2 as a group. The elevator group 2 includes a plurality of elevators 3 such as elevators No. 1 to No. 4. Each of the plurality of cars 120 of the elevators moves up and down a hoistway to provide operation service to a plurality of floors such as first to 10th floors. The group management control apparatus 1 integrally controls the elevator group 2. The group management control apparatus 1 creates an operation schedule for each of the plurality of cars 120 and transmits the schedule to each car control device 122 provided to each car 120.

Note that while four of the elevators 3, namely the elevators No. 1 to No. 4, are included in the elevator group 2 in the following description, the elevator group may instead include three of the elevators 3 or five or more of the elevators 3. The floor receiving the operation service is not limited to the first to 10th floors either. Moreover, four of the elevators 3 including the elevators No. 1 to No. 4 are simply referred to as the elevator 3 in the following description unless otherwise noted.

Specifically, each elevator 3 includes the car 120 which carries a passenger, the car control device 122, and the like. Each elevator 3 is what is called a traction type elevator in which the car 120 and a counter weight are connected by a main rope. Each elevator 3 is provided with a common elevator hall 124.

Each car 120 includes a car input device (a car call registration device) 120a, a car guide device 120b, a weight detector 120c, and the like. The car input device 120a registers a car call for a destination floor in accordance with an operation input by a user. The car guide device 120b includes a buzzer that can output a notification sound, a speaker that can announce a variety of voice information, and a display (a display unit) that can display a variety of display information, for example. The weight detector 120c detects the carrying weight in the car 120. The carrying weight detected by the weight detector 120c mainly represents the weight of a user on board the car 120. The carrying weight is also influenced by the weight of baggage carried by the user but typically tends to fluctuate in accordance with the number of users (the number of passengers). The weight detector 120c can measure a loaded weight and an unloaded weight by detecting the fluctuation of the carrying weight while the door of the car 120 is open, for example. Here, the loaded weight refers to the weight of a user who gets in the car 120 on a certain floor. The unloaded weight refers

to the weight of a user who gets off the car 120 on a certain floor.

A user who gets in the car 120 from the elevator hall 124 on a certain floor inputs a destination floor by operating the car input device 120a, for example. The car input device 120a detects the input of the destination floor by the user as a car call and performs car call registration by transmitting car call information on the detected car call to the group management control apparatus 1 through the car control device 122. The car call information includes information such as the destination floor input by the user, an identification number (hereinafter referred to as a "car number" or a "Car ID" depending on the occasion) of the car 120, and a time of occurrence of the car call.

In addition to the car input device 120a, the car guide device 120b, the weight detector 120c and the like, a hoisting machine or the like that moves the car 120 up and down is electrically connected to each car control device 122. Each car control device 122 performs various controls including moving the car 120 up/down and opening/closing the door. Each car control device 122 is electrically connected to the group management control apparatus 1 as well. Each car control device 122 controls each unit of each car 120 according to the operation schedule of each car 120 received from the group management control apparatus 1. Each car control device 122 includes a microcomputer and a drive circuit, the microcomputer having a CPU (Central Processing Unit), a ROM, a RAM, a backup RAM and an input/output port unit that are mutually connected via a normal bidirectional common bus, for example. The ROM (Read Only Memory) stores in advance a predetermined control program or the like. The RAM (Random Access Memory) temporarily stores a computation result of the CPU. The backup RAM stores information such as map data prepared in advance and specifications of the corresponding elevator 3. Each elevator 3 can move to an

arbitrary destination floor when the corresponding car control device 122 controls each unit to move the car 120 up and down the hoistway.

The elevator hall 124 is provided on each elevator stopping floor (the first to 10th floors in this case) at which the car 120 can land. Each elevator hall 124 is provided with a hall input device (a hall call registration device) 160, a hall guide device 170, and the like. The hall input device 160 registers a hall call for a destination direction (up or down) in accordance with an operation input by a user. The hall guide device 170 includes a buzzer that can output a notification sound, a speaker that can announce a variety of voice information, and a display (a display unit) that can display a variety of display information, for example.

A user on a certain floor inputs a desired destination direction by operating the hall input device 160 in the elevator hall 124 on that floor, for example. Specifically, the hall input device 160 is provided with an up button and a down button so that the user presses a button (the up button or the down button) according to the desired destination direction. The hall input device 160 detects the input of the destination direction by the user as a hall call and performs hall call registration by transmitting hall call information on the detected hall call to the group management control apparatus 1. The hall call information includes information such as a time of occurrence of the hall call, a floor on which the hall call is made, and a direction (up or down) of the hall call.

Note that a call input from the car input device 120a is hereinafter sometimes referred to as the "car call" and a call input from the hall input device 160 as the "hall call" in order to distinguish the two.

The group management control apparatus 1 is electrically connected to each car control device 122, the hall input

device 160, and the hall guide device 170 to perform various controls. The group management control apparatus 1 manages the elevator group 2 as a group by mutually communicating and transferring information such as a detection signal, a drive signal, and a control command with each car control device 122. Upon receiving the hall call information from the hall input device 160, the group management control apparatus 1 selects and determines the car 120 to be responding to the hall call from among the plurality of cars 120. The group management control apparatus 1 creates and updates an operation schedule of an assigned car, and transmits the schedule to the corresponding car control device 122. The group management control apparatus 1 includes a microcomputer and a drive circuit, the microcomputer having a CPU (Central Processing Unit), a ROM, a RAM, a backup RAM and an input/output port unit that are mutually connected via a normal bidirectional common bus, for example. The ROM (Read Only Memory) stores in advance a predetermined control program or the like. The RAM (Random Access Memory) temporarily stores a computation result of the CPU. The backup RAM stores information such as map data prepared in advance and specifications of the elevator 3.

Note that the operation of selecting the car 120 to respond to the hall call is hereinafter sometimes referred to as "assignment" and the selected car 120 as the "assigned car".

The group management control apparatus 1 includes a group management controller 130, an operating time controller 140, and a display controller 150 in terms of a functional concept. The group management controller 130 typically performs an assignment process of assigning the hall call to any of the cars 120. The operating time controller 140 typically sets various control parameters that are used when the group management controller 130 performs assignment. The group management controller 130 of the present embodiment

manages the operation of the plurality of cars 120 on the basis of a car mask created by an operating time management unit 144 of the operating time controller 140, as is described below. The display controller 150 controls the display or the like of the car guide device 120b and the hall guide device 170.

The group management controller 130 includes, in terms of a functional concept, a car status recording unit 131, an assigning car selector 132, a car operation controller 133, a mask management unit 134, and the like.

The car status recording unit 131 continuously collects car information on each car 120 from each car control device 122. The car information includes information on the car 120 in operation such as a position, a direction of movement, an open/closed state of the door, and weight data. The weight data includes the loaded weight and the unloaded weight on each floor as described above. The car information further includes operating power consumption pertaining to the operation of the car 120, for example. Here, the car status recording unit 131 integrates these pieces of car information to create the record of operation. An example of the record of operation created by the car status recording unit 131 is illustrated in FIG. 2 to be described below.

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The assigning car selector 132 receives the hall call information from the hall input device 160 and assigns the car 120 which is to respond to the hall call. A variety of approaches can be employed as a method of assignment. The assigning car selector 132 can use the method of assignment in which, for example, a predetermined evaluation function is used to calculate a predicted value of the response time for each car 120 on the basis of the status of the car at the time of assignment so that the car 120 with the smallest predicted value is assigned as the assigned car. Here, the response time typically corresponds to a time interval from

when the hall call is generated to when the car 120 responds to the hall call, namely, to when the car 120 arrives at a floor where the hall call is generated and opens the door.

The car operation controller 133 creates the operation schedule of each car 120 on the basis of the assignment result by the assigning car selector 132, an unresponded hall call, an unresponded car call, and the like. Here, the unresponded hall call and the unresponded car call refer to the hall call and the car call that are not yet responded, respectively. The car operation controller 133 transmits the operation schedule of each car 120 to the corresponding car control device 122.

The mask management unit 134 designates the car 120 to be a candidate for the assigned car when the assigning car selector 132 performs the assignment. Not all the cars 120 can be the candidate for the assigned car. In other words, the mask management unit 134 designates the car 120 which has a restriction to respond to the hall call (the car 120 that cannot be assigned) when the assigning car selector 132 performs the assignment. In a case where a control is performed to limit the candidate for the assigned car on the upper floors and the lower floors, for example, the mask management unit 134 manages information on whether or not the hall call and the car call on each floor can be assigned to each car 120. The mask management unit 134 then considers the car 120, to which the hall call on that floor can be assigned, as the candidate and selects the assigned car from the candidate when assigning the hall call, for example. The mask management unit 134 of the present embodiment designates the car 120 to be the candidate for the assigned car on the basis of the control parameter such as mask information that is transmitted from the operating time controller 140 to be described below.

Subsequently, the operating time controller 140 calculates, as an actual value pertaining to the elevator

group 2 managed as a group, the number of persons on board, an average response time, and the operating power consumption in a predetermined fixed time interval preset from the record of operation. The operating time controller 140 compares the calculated actual value with a preset energy-saving target value and changes an operating time control parameter (a parameter to control the operating time) on the basis of the comparison result. The operating time controller 140 thereafter creates an operating time schedule of each car 120 from the changed operating time control parameter, converts the schedule into the mask information, and transmits the information to the mask management unit 134. Here, the predetermined fixed time interval corresponds to an energy-saving unit time interval and may be simply referred to as a "unit time interval" in the following description. The unit time interval is a unit time interval used in adjusting the level of energy saving and may be set at will. While a 30-minute interval is adopted in the description, for example, the unit time interval may be a five-minute interval, a 10-minute interval, or a 60-minute interval as well.

Specifically, the operating time controller 140 includes, in terms of the functional concept, an actual value aggregation unit 141, a target setting unit 142, an operating time adjustment unit 143, the operating time management unit 144, and the like.

The actual value aggregation unit 141 aggregates an actual group management performance value in each unit time interval from the car status recording unit 131. The actual value aggregation unit 141 aggregates an actual response time value that is an actual value of the response time from when the hall call is registered to when the car 120 responds to the hall call. In the present embodiment, the actual value aggregation unit 141 aggregates at least an average actual response time value as the actual value (actual group management performance value) pertaining to the elevator

group 2 managed as a group, the average actual response time value being an average value of the actual response time value of the car 120 in each preset unit time interval. Here, the actual value aggregation unit 141 may further aggregate, as the actual value pertaining to the elevator group 2, an actual value of the number of users in each unit time interval and an actual operating power consumption value in each unit time interval. The actual value of the number of users refers to the actual value of the number of persons who uses the elevator group 2. The actual operating power consumption value refers to the actual value of the power consumed when the elevator group 2 is operated. The actual value aggregation unit 141 reads the record of operation from the car status recording unit 131 to create and store actual aggregation data as the actual value pertaining to the elevator group 2 on the basis of the record of operation.

FIG. 2 is a diagram illustrating an example of the record of operation created by the car status recording unit 131. The car status recording unit 131 records data as illustrated in FIG. 2 once a predetermined action (Action) occurs in each car 120. The predetermined action here includes adding a hall call (Add Hall Call), deleting a hall call (Delete Hall Call), starting the up/down run (Start Run), stopping the up/down run (Stop Run), opening the door (Door Open), and closing the door (Door Closed), for example. Here, the addition of the hall call is an action of registering a new hall call in response to the operation of the hall input device 160 by the user. The deletion of the hall call is an action of deleting the hall call that is already responded when any of the cars 120 responds to the hall call registered by the operation of the hall input device 160 and arrives at the floor on which the hall call is made. Moreover, the data to be recorded includes a time (time [sec]) at which the predetermined action occurs, a hall call ID number (Hall Call), the direction of movement of the car 120/the direction

of the hall call (Direction), a floor at which the car 120 starts/stops the up/down run and a floor at which the hall call is added (At Floor), a car call ID number (Car Call), a destination floor (To Floor), the loaded weight (Load Weight), the unloaded weight (Unload Weight), and the operating power consumption (Energy [kWh]). Note that the operating power consumption is the power consumed when operating the car 120 and is recorded every predetermined period of time (such as every 30 seconds in this case), for example.

FIG. 2 illustrates that the car 120 (the car 120 of the elevator No. 1) with a Car ID = 1 is empty on the first floor and then moves to floors in the order of the first floor, the seventh floor, the ninth floor, the fifth floor, the first floor, and the 10th floor. The stop at each of the seventh, fifth, and 10th floors is made in response to the hall call, while the stop at each of the ninth and first floors is made in response to the car call. Here, the Car ID is the identification number that is set to each car 120 as described above. The Car ID is given to each car 120 such as the Car ID = 1 to the car 120 of the elevator No. 1 and a Car ID = 2 to the car 120 of the elevator No. 2 in order to be able to distinguish the car 120 of each elevator. The car status recording unit 131 records the loaded weight (Load Weight) and the unloaded weight (Unload Weight) at the start of each up/down run (Start Run), on the basis of the change in the carrying weight of the car immediately before the car stops and immediately after the car starts moving on each floor. FIG. 2 illustrates that the weight of 135 kg is loaded on the seventh floor at time (time) = 18, and the weight of 135 kg is unloaded on the ninth floor at time (time) = 31, for example.

From the record of operation recorded by the car status recording unit 131 as illustrated in FIG. 2, the actual value aggregation unit 141 aggregates the average actual response time value of the car 120 in every unit time interval, the

actual value of the number of users in every unit time interval, and the actual operating power consumption value in every unit time interval.

Here, the actual response time value can be defined as the time from the addition of the hall call (Add Hall Call) until the deletion of the hall call (Delete Hall Call) for each hall call ID number (Hall Call), for example. The actual value aggregation unit 141 can calculate the average actual response time value in every unit time interval by calculating the average value of the actual response time value (such as an arithmetic mean) in every unit time interval. Note that it is preferred for the actual value aggregation unit 141 to not include, in the calculation of the average value in the unit time interval, a hall call ID number with no hall call being generated in the unit time interval for which the average actual response time value is calculated. Contrarily, it is preferred for the actual value aggregation unit 141 to calculate the average value in the unit time interval from the preceding time interval with regards to a hall call ID number with no hall call being added in the unit time interval for which the average actual response time value is calculated.

The actual value aggregation unit 141 can further calculate the actual value of the number of users in every unit time interval as follows. That is, the actual value aggregation unit 141 finds the sum of the loaded weight (Load Weight) as the number of users getting in the car in the unit time interval, divides the sum by a preset estimated weight per person (such as about 65 kg), and rounds off the outcome. The actual value aggregation unit 141 can thus calculate the actual value of the number of users in every unit time interval by finding the sum of the number of users estimated in the aforementioned manner in each unit time interval.

Moreover, the actual value aggregation unit 141 can calculate the actual operating power consumption value in

every unit time interval by finding the sum of the operating power consumption (Energy [kWh]) that is recorded every predetermined time in each unit time interval. Here, the operating power consumption that is recorded in the record of operation can take the value measured by a watt-hour meter installed in each car 120, for example. When such watt-hour meter is not provided, the actual value aggregation unit 141 may calculate the actual operating power consumption value in every unit time interval as follows. That is, the actual value aggregation unit 141 calculates an estimated operating power consumption value with a predetermined electric energy calculation formula by using the distance travelled, the direction, and the carrying weight of the car in a single run from the start of the up/down run (Start Run) to the stop of the up/down run (Stop Run) from the record of operation or the like illustrated in FIG. 2. The actual value aggregation unit 141 then calculates the actual operating power consumption value in every unit time interval on the basis of the calculated estimated operating power consumption value.

The actual value aggregation unit 141 aggregates for all the cars 120 the average actual response time value in every unit time interval, the actual value of the number of users in every unit time interval, and the actual operating power consumption value in every unit time interval. The actual value aggregation unit 141 thereafter transmits the aggregated average actual response time value in every unit time interval, the aggregated actual value of the number of users in every unit time interval, and the aggregated actual operating power consumption value in every unit time interval to the operating time management unit 144, which then registers the values.

The target setting unit 142 sets the energy-saving target value for the elevator group 2. The energy-saving target value is set in advance by a building manager of a building in which the elevator group management control

system 100 is provided or a system administrator thereof in accordance with the level of energy saving required. The target setting unit 142 sets as the energy-saving target value a target response time value that is a target value of the response time. In the present embodiment, the target setting unit 142 sets as the energy-saving target value an average target response time value that is the target value of the average actual response time value in every unit time interval. The average target response time value typically corresponds to the response time during which it is allowed to make the user wait for the sake of prioritizing energy saving until the time reaches the target value. Roughly speaking, the group management control apparatus 1 of the present embodiment increases an energy-saving level to be described and aims for further energy saving when the average actual response time value in every unit time interval has a leeway to reach the average target response time value. On the other hand, the group management control apparatus 1 decreases the energy-saving level and attempts to ensure the service performance when the average actual response time value in every unit time interval has no leeway to the average target response time value. The target setting unit 142 can set the energy-saving target value by a variety of methods.

As a first setting method, the target setting unit 142 may directly set the average target response time value, which is set arbitrarily by the administrator or the like through an input device, as the energy-saving target value. In this case, a different value may be set as the average target response time value in accordance with a time period of the unit time interval. That is, the average target response time value may take a different value in each time period such as 20 seconds in early morning and late at night and 30 seconds during the day.

As a second setting method, the target setting unit 142

may calculate an allowable average target response time value and set this value as the energy-saving target value, the allowable average target response time value being calculated on the basis of a target operating power consumption reduction rate (%) per day that is set arbitrarily by the administrator or the like through an input device, for example. Here, the target operating power consumption reduction rate per day can be represented as $[(\text{the actual operating power consumption value per day} - \text{a target operating power consumption value per day}) / \text{the actual operating power consumption value per day}] \times 100$, for example. In this case, the target setting unit 142 calculates a target operating power consumption value on the basis of the actual operating power consumption value per day on a reference day with no energy saving implemented and the preset target operating power consumption reduction rate per day, for example. The target setting unit 142 then sets the allowable average target response time value such that the actual operating power consumption value in every unit time interval aggregated by the actual value aggregation unit 141 converges to the target operating power consumption value. The group management control apparatus 1 in this case makes adjustment of the energy-saving level in every unit time interval by increasing or decreasing the average target response time value. Note that the aforementioned reference day may be determined by a variety of methods such as the administrator or the like specifying an arbitrary day as the reference day, or the first day of each month being set as the reference day. Moreover, the value aggregated by the actual value aggregation unit 141 or, for example, an average value in one week may be used as the actual operating power consumption value per day on the reference day with no energy saving implemented. Furthermore, it is determined that the actual operating power consumption value is convergent to the target

operating power consumption value not just when the actual operating power consumption value = the target operating power consumption value. The target setting unit 142 may determine that the actual operating power consumption value is convergent to the target operating power consumption value when conditional Expression (1) below is satisfied, for example. In conditional Expression (1), β represents a preset allowable error.

$$|\text{Actual operating power consumption value} - \text{target operating power consumption value}| \leq \beta \quad (1)$$

Broadly speaking, the first setting method is a method of specifying the allowable limit of the service performance and aiming for energy saving within that limit. On the other hand, the second setting method is a method of directly specifying the achievement rate of energy saving and not providing a limit to the service performance.

Note that the operating time controller 140 of the present embodiment changes the energy-saving level in every unit time interval, dynamically changes the operating time of the car, and performs control such that the average actual response time value equals the average target response time value, as described below. At that time, the operating time controller 140 can set in advance a time period during which energy saving is not implemented, thereby avoiding the risk of degrading the service performance during that time period. The time period during which energy saving is not implemented is registered at will of the administrator or the like through an input device, for example. The administrator or the like may register a plurality of time periods. In order to prevent degradation of the service performance during the expected busy time period when people come to work (such as 8:00 to 9:00) and leave work (such as 17:00 to 18:00), for example, the time period may be registered as a time period during which energy saving is not implemented.

Here, FIG. 3 is a diagram illustrating an example of a target setting input screen used by the target setting unit 142. The input screen illustrated in FIG. 3 is displayed on a display unit of the input device, for example. FIG. 3 illustrates that the energy-saving target value is set by the aforementioned second setting method where the operating power consumption reduction rate per day is set to 10%, and a reference power consumption date used for comparison is set to the first day of each month. Note that FIG. 3 illustrates the case where each of the time periods from 8:00 to 9:00 in the morning and 17:00 to 18:00 in the evening is registered as a non energy-saving time period (a time period during which energy saving is not implemented).

The operating time adjustment unit 143 makes an adjustment of the average actual response time value by adjusting the operating time of each car 120 from the actual group management performance value and the energy-saving target value. The operating time adjustment unit 143 makes an adjustment of the operating time of each car 120 by adjusting the energy-saving level in every unit time interval. The operating time adjustment unit 143 makes an adjustment of the energy-saving level such that the actual response time value aggregated by the actual value aggregation unit 141 converges to the target response time value set by the target setting unit 142. More specifically, the operating time adjustment unit 143 makes the adjustment of the energy-saving level in every unit time interval such that the average actual response time value in every unit time interval aggregated by the actual value aggregation unit 141 converges to the average target response time value set by the target setting unit 142. As a result, the operating time adjustment unit 143 makes adjustments of the operating time of each car 120 as well as the average actual response time value in every unit time interval.

First, there will be described a case where the energy-saving target value is set by the first setting method, that is, where the average target response time value is set directly.

In this case, the operating time adjustment unit 143 relatively decreases the energy-saving level in the unit time interval when the average actual response time value in every unit time interval aggregated by the actual value aggregation unit 141 is larger than the average target response time value set by the target setting unit 142. On the other hand, the operating time adjustment unit 143 relatively increases the energy-saving level in the unit time interval when the average actual response time value in every unit time interval aggregated by the actual value aggregation unit 141 is smaller than the average target response time value set by the target setting unit 142. Accordingly, the operating time adjustment unit 143 makes the adjustment of the energy-saving level in every unit time interval such that the average actual response time value in every unit time interval converges to the average target response time value.

Here, the definition of the energy-saving level will be described. The energy-saving level is an index representing the degree of energy saving implemented by the elevator group 2. The degree of energy saving affects the actual response time value described above in the way that the relatively higher the degree of energy saving, the relatively longer the aforementioned actual response time value tends to be. Here, the energy-saving level represents the degree of energy saving in every unit time interval. The energy-saving level is then set such that the relatively higher the level, the relatively higher the degree of energy saving. In other words, the energy-saving level is set such that the relatively higher the level, the relatively smaller the actual operating power consumption value.

The energy-saving level in the present embodiment is

determined according to at least the number of cars 120 in operation. As illustrated in FIG. 4, for example, the energy-saving level is defined such that the number of cars in operation are decreased as the level gets higher in order from an energy-saving level zero (Level 0) at which all the cars are in operation, an energy-saving level one (Level 1), an energy-saving two (Level 2), and so forth. The level table illustrated in FIG. 4 is created in advance by reflecting the intention of the administrator, for example. As a result, the energy-saving level is set such that the relatively higher the level, the relatively smaller the number of cars in operation and the actual operating power consumption value as well as the relatively higher the degree of energy saving.

FIG. 4 illustrates the level table where four of the cars 120 are provided in total. In the level table illustrated in FIG. 4, four of the cars are in operation at the energy-saving level zero (Level 0) which, in other words, corresponds to a state where no energy saving is implemented. Seven levels, including the energy-saving level zero (Level 0) up to a level at which one car is in operation, are defined in the level table illustrated in FIG. 4.

Here, the energy-saving level is determined in accordance with the number of cars 120 in operation and a pitch, in order to be able to divide the levels into smaller levels. The number of cars 120 in operation that defines the energy-saving level is an average number of cars in operation per unit time and can be represented as a parameter which can take a decimal value. The number of cars in operation takes a value (four cars in this case) according to the total number of cars 120 in the elevator group 2 at the lowest energy-saving level, namely, the energy-saving level zero (Level 0), and the value gets smaller each time the energy-saving level is raised from the lowest level. Here, the number of cars in operation decreases by 0.5 car each time

the energy-saving level is raised by one level. When the number of cars in operation takes an integer value, that number of cars is to be assigned, meaning that the integer number of cars can be assigned. On the other hand, the number of cars taking a decimal value indicates the proportion of time that can be assigned in the unit time interval. Moreover, the pitch is a numerical value specified when the number of cars in operation takes the decimal value. The pitch is a parameter pertaining to a switch interval between a state where a predetermined car 120 responds to a call and a state where the predetermined car does not respond to the call. That is, the pitch represents the number of repetitions of switching between the assignable and unassignable states of the predetermined car 120 during the unit time interval.

Now, there will be described more specifically the relationship between the number of cars 120 in operation and the pitch that define the energy-saving level, with reference to FIGS. 5 and 6. Each of FIGS. 5 and 6 has a horizontal axis representing a time axis t and a vertical axis representing ON/OFF. Here, the unit time interval is set to 60 minutes as an example. In FIGS. 5 and 6, an "ON" indicates that a hall call may be assigned (assignable), while an "OFF" indicates that a hall call may not be assigned (unassignable).

FIG. 5 illustrates a case where the number of cars in operation equals 3.5 cars and the pitch equals 1. In this case, three of the cars 120 are constantly in the assignable (ON) state, whereas the remaining one car 120 is unassignable (OFF) during the latter 30 minutes. In such case, the number of cars in operation that can be assigned in the unit time interval equals four cars in the first 30 minutes and three cars in the latter 30 minutes, meaning that 3.5 cars are in operation on average.

On the other hand, FIG. 6 illustrates a case where the

number of cars in operation equals 3.5 cars and the pitch equals 6. In this case, three of the cars 120 are constantly in the assignable (ON) state, whereas the remaining one car 120 repeatedly switches between the assignable state (ON) and the unassignable state (OFF) every five minutes for six times during the unit time interval. In this case as well, the number of cars in operation during the unit time interval equals 3.5 cars on average. This does not necessarily mean that the predetermined car 120 stops right at the point when the car 120 switches from the assignable state to the unassignable state. The car 120 operates until any user in the car gets off the car and stops after there is no user in the car 120. In this case, the car 120 responds to all hall calls and car calls and stops upon detecting that the carrying weight of the car is zero.

In each energy-saving level, the pitch number as described above is not required when the number of cars in operation equals an integer (such as three cars) because the elevator always operates with that number of cars during that time period. On the other hand, in each energy-saving level, the ON/OFF schedule is determined as described above by specifying the number of ON/OFF switches during that time period according to the pitch number when the number of cars in operation takes the decimal value. That is, the group management control apparatus 1 can set the pattern of the ON/OFF operating time schedule of the car 120 in various ways in each unit time interval by appropriately setting the two parameters, the number of cars in operation and the pitch, in each energy-saving level. The group management control apparatus 1 can set the pattern of the ON/OFF operating time schedule of the car 120 by setting in advance the level table of the energy-saving level as illustrated in FIG. 4. The group management control apparatus 1 sets the operating time schedule such that the car 120 stops for a longer period of time little by little as the energy-saving level is raised

from the energy-saving level zero with no energy saving implemented, thereby increasing the degree of energy saving. Furthermore, the group management control apparatus 1 can make a minor adjustment of energy saving by setting the energy-saving level to the smaller levels as described above. At this time, as illustrated in FIG. 6, the group management control apparatus 1 can restrain the service performance from changing greatly during the unit time interval by relatively increasing the pitch number and frequently switching the number of cars in operation between the four cars and the three cars during the unit time interval.

Note that the predetermined car 120 switching between the assignable (ON) and unassignable (OFF) states as described above may be set by the administrator or the like in advance or selected according to the status of each car 120.

Next, a method of adjusting the energy-saving level by the operating time adjustment unit 143 will be described.

The operating time adjustment unit 143 performs group management control at the unit time interval and then reads the average actual response time value during the unit time interval in the time period aggregated by the actual value aggregation unit 141 and the average target response time value set by the target setting unit 142, for example. Then, the operating time adjustment unit 143 compares the average actual response time value during the unit time interval in the time period with the average target response time value. The operating time adjustment unit 143 relatively decreases the energy-saving level in the unit time interval when the average actual response time value is larger than the average target response time value. The operating time adjustment unit 143 relatively increases the energy-saving level in the unit time interval when the average actual response time value is smaller than the average target response time value.

Here, the operating time adjustment unit 143 changes the

energy-saving level in every unit time interval by one level a day, for example. That is, when the average actual response time value in the unit time interval during a certain time period is larger than the average target response time value, the operating time adjustment unit 143 decreases the energy-saving level in the unit time interval of the corresponding time period on a next day by one level. When the average actual response time value in the unit time interval during a certain time period is smaller than the average target response time value, on the other hand, the operating time adjustment unit 143 increases the energy-saving level in the unit time interval of the corresponding time period on a next day by one level. Note that, taking any changes and the like into account, the operating time adjustment unit 143 may be configured to not change the energy-saving level when the difference between the average actual response time value and the average target response time value falls within a preset allowable difference δ (such as three seconds). The operating time adjustment unit 143 transmits the energy-saving level to the operating time management unit 144 when the energy-saving level is changed so that the energy-saving level of the time period registered in the operating time management unit 144 is updated.

Note that the operating time adjustment unit 143 can set a time period during which energy saving is not implemented, as described above. The operating time adjustment unit 143 can set in advance a time period during which the energy-saving level in every unit time interval is not adjusted. As set in FIG. 3, for example, the operating time adjustment unit 143 can set the expected busy time period such as when people come to work and leave work as the time period during which the energy-saving level is not adjusted. As a result, the group management control apparatus 1 can keep the service performance from being exceedingly degraded during the busy

time period or the like.

Moreover, the operating time adjustment unit 143 can individually set in advance a default energy-saving level for every unit time interval. The operating time adjustment unit 143 can set in advance a relatively high default energy-saving level to a time period which is clearly expected to be an off-hour, for example. Contrarily, for example, the operating time adjustment unit 143 can set in advance a relatively low default energy-saving level to a time period which is expected to be busy. As a result, the group management control apparatus 1 can make early adjustment of the energy-saving level in every unit time interval to a proper level.

The operating time management unit 144 changes the operating time control parameter of the elevator group 2 in accordance with the energy-saving level in every unit time interval adjusted by the operating time adjustment unit 143, and manages the operating time and the like. The operating time management unit 144 creates, as the operating time control parameter, a car mask on the basis of the energy-saving level in every unit time interval adjusted by the operating time adjustment unit 143 to perform update and management. Here, the car mask is the operating time control parameter used to limit the car 120 that is able to respond to the hall call. In other words, the car mask is the operating time control parameter used to narrow down the candidate for the car 120 to which the generated hall call is assigned. The operating time management unit 144 creates mask information according to the operating time schedule of each car 120 from the changed operating time control parameter and transmits the mask information to the mask management unit 134. Accordingly, the operating time management unit 144 dynamically updates and manages the operating time of the car in every unit time interval, the average actual response time value, and the like.

Here, an example of control performed by the group management control apparatus 1 will be described with reference to a flowchart in FIG. 7 while describing the operating time management unit 144 and the like in more detail. FIG. 7 illustrates a processing flow of a certain day. An elevator group management control method of the present embodiment is basically executed by the group management control apparatus 1. The elevator group management control method includes an actual value aggregating step, a target setting step, an operating time adjustment step, and an operating time management step.

First as the target setting step, the target setting unit 142 sets the energy-saving target value, or the allowable average target response time value in this case, according to the input from the administrator or the like, and the operating time management unit 144 reads the average target response time value and writes the value for every unit time interval (step S1).

The operating time management unit 144 then determines whether or not the day is the first day of operation managing the elevator group (step S2). When the day is determined to be the first day of operation by the operating time management unit 144 (step S2: Yes), the operating time adjustment unit 143 sets all the energy-saving levels in every unit time interval for the day to the preset default value (step S3) and proceeds to step S5. When the day is determined to be not the first day of operation by the operating time management unit 144 (step S2: No), the operating time adjustment unit 143 sets each energy-saving level in every unit time interval of the day to a value adjusted on the previous day (step S4) and proceeds to step S5.

Next in step S5, the operating time management unit 144 determines whether or not the elevator operation is finished for the day (step S5). The operating time management unit

144 ends the control for the day upon determining that the elevator operation is finished for the day (step S5: Yes).

When determining that the elevator operation is not finished for the day (step S5: No), the operating time management unit 144 creates the car mask on the basis of the energy-saving level in every unit time interval, as the operating time management step (step S6). Here, the operating time management unit 144 reads from the level table illustrated in FIG. 4, for example, the number of cars in operation and the pitch of the energy-saving level in the unit time interval of a next time period. The operating time management unit 144 then creates the car mask from the number of cars in operation and the pitch of the energy-saving level being read, and transmits the mask information corresponding to the created car mask to the mask management unit 134.

Here, the car mask defines the assignable/unassignable states of each car 120 at an arbitrary time in relation to every UP hall call and DOWN hall call on each floor. Each of FIGS. 8 and 9 illustrates an example of the car mask created by the operating time management unit 144 and includes the first to 10th floors as the target floors. Basically, the car mask illustrated in either FIG. 8 or FIG. 9 is set to all the cars 120 along with a target time (a target time period). FIG. 8 is the car mask indicating the assignable state. The car mask indicating the assignable state is always "0 (unassignable)" for a hall call (UP) going up from the 10th floor which is the top floor and a hall call (DOWN) going down from the first floor which is the bottom floor because such calls do not exist. The car mask indicating the assignable state is set to "1 (assignable)" for all other hall calls. Meanwhile, FIG. 9 is the car mask indicating the unassignable state. The car mask indicating the unassignable state is set to "0 (unassignable)" for all hall calls. As a result, the car 120 to which the car mask indicating the unassignable state is assigned has a restriction on

responding to all the hall calls.

It is assumed for example that the unit time interval is 30 minutes and the target time period is from 10:00 to 10:30. In this case, the operating time management unit 144 creates a mask as follows and transmits the mask to the mask management unit 134 when the energy-saving level is at the energy-saving level one (Level 1) with 3.5 cars in operation and one pitch as illustrated in FIG. 4. That is, the operating time management unit 144 creates the car mask indicating the assignable state (FIG. 8) as the car mask of four cars, namely, all the cars 120, for the first 15 minutes from 10:00 to 10:15 and transmits the mask information based on the mask to the mask management unit 134 along with the time information. On the other hand, the operating time management unit 144 creates the car mask indicating the assignable state (FIG. 8) as the car mask of three of the cars 120 and the car mask indicating the unassignable state (FIG. 9) as the car mask of the one remaining car, for the latter 15 minutes from 10:15 to 10:30. The operating time management unit 144 then transmits the mask information based on each car mask created to the mask management unit 134 along with the time information. After receiving the mask information, the mask management unit 134 updates the car mask by executing an AND operation for each element between the car mask transmitted by the operating time management unit 144 and a car mask, if any, that is held for the purpose of a factor different from energy saving such as split operation. Likewise, the operating time management unit 144 creates the car mask from the energy-saving level in the next unit time interval. There is no need to change the car mask as described above in the middle of the unit time interval when the number of cars in operation takes the integer value. Accordingly, the assigning car selector 132 employs a predetermined evaluation function to assign the optimal car 120 from among the cars 120 having the value of the car mask

updated to "1 (assignable)".

Note that the operating time management unit 144 may allow the administrator or the like to preset the car 120 that is determined to be unassignable according to the energy-saving level, or may select such car according to the status of each car 120 as appropriate or at random. The operating time management unit 144 may specify in advance the car 120 that is unassignable such that the elevator No. 1 is specified where there is one unassignable car and the elevators No. 2 and No. 3 where there are two unassignable cars, for example. When the unassignable car 120 is selected according to the status or the like of each car 120, the operating time management unit 144 may select the unassignable car 120 according to the number of hall calls assigned at that point and/or the number of persons on board at that point, for example. In this case, the operating time management unit 144 may be configured to not select, as the unassignable car 120, the car 120 to which a relatively large number of hall calls are assigned or the car 120 which has a relatively large number of persons on board. Moreover, the operating time management unit 144 may rotate the unassignable car 120 as appropriate within the unit time interval. In this case, the operating time management unit 144 may operate each of the all four cars 120 as 0.875 car to realize the total number of cars in operation equivalent to 3.5 cars, for example. Furthermore, the operating time management unit 144 may select from preset candidates the car 120 which has a restriction on responding to a call, namely, the car 120 that is unassignable, when creating the car mask. In this case, for example, a list of candidates for the unassignable car 120 may be created beforehand according to the status in response to a request from the administrator or the like so that the operating time management unit 144 selects the unassignable car from the list of candidates. Accordingly, the group management control apparatus 1 can

plan the unassignable car 120 in advance when the plurality of cars 120 is subjected to zoning to serve the upper floors and the lower floors, and can thus restrain the degradation of service performance. The group management control apparatus 1 can further level out the rate of operation of each car 120 in order to prevent deterioration of any specific car 120.

Referring back to FIG. 7, the actual value aggregation unit 141 executes the actual value aggregating step after the process performed in step S6 and the operation performed for the unit time interval during the next time period. That is, the actual value aggregation unit 141 aggregates the actual value pertaining to the elevator group 2 managed as a group or, in this case, the average actual response time value in every unit time interval, the actual value of the number of users, and the actual operating power consumption value and transmits the values to the operating time management unit 144 to be recorded (step S7). The operating time management unit 144 then transmits to the operating time adjustment unit 143 the average target response time value in the unit time interval being read in step S1 as well as the average actual response time value in every unit time interval being recorded in step S7 (step S8).

Subsequently, the operating time adjustment unit 143 executes the process in each of step S9 to step S13 on the basis of the average target response time value and the average actual response time value, and makes the adjustment of the energy-saving level in the unit time interval on the next day. That is, as the operating time adjustment step, the operating time adjustment unit 143 adjusts the energy-saving level in every unit time interval of the elevator group 2 such that the average actual response time value in every unit time interval converges to the average target response time value (step S9 to step S13).

Here, the operating time adjustment unit 143 determines

whether or not the value obtained by subtracting the average target response time value from the average actual response time value is greater than the preset allowable difference δ (step S9).

When determining that the value obtained by subtracting the average target response time value from the average actual response time value is less than or equal to the allowable difference δ (step S9: No), the operating time adjustment unit 143 determines whether or not the subtracted value is less than the allowable difference $-\delta$ (step S10).

When determining that the value obtained by subtracting the average target response time value from the average actual response time value is greater than or equal to the allowable difference $-\delta$ (step S10: No), the operating time adjustment unit 143 moves to the process in step S5 and repeats each of the processes that follows.

When determining in step S9 that the value obtained by subtracting the average target response time value from the average actual response time value is greater than the allowable difference δ (step S9: Yes), the operating time adjustment unit 143 decreases the energy-saving level in the unit time interval on the next day by one level (step S11). The operating time adjustment unit 143 thereafter transmits the energy-saving level in the unit time interval to the operating time management unit 144, which records the level (step S13), and moves to the process in step S5 to repeat each of the processes that follows.

When determining that the value obtained by subtracting the average target response time value from the average actual response time value is less than the allowable difference $-\delta$ (step S10: Yes), the operating time adjustment unit 143 increases the energy-saving level in the unit time interval on the next day by one level (step S12). The operating time adjustment unit 143 thereafter transmits the

energy-saving level in the unit time interval to the operating time management unit 144, which records the level (step S13), and moves to the process in step S5 to repeat each of the processes that follows.

FIG. 10 is a diagram illustrating an example of recorded data managed by the operating time management unit 144. FIG. 10 illustrates that the unit time interval is set to 30 minutes while the average target response time value is set to 20 seconds across the board. However, no energy saving is implemented (the energy-saving level zero is set) from 8:00 to 9:00. FIG. 10 illustrates a case where each of the average actual response time value, the actual value of the number of users, and the actual operating power consumption value is recorded for the past two days and the current time is 8:00. At this point, the data corresponding to 30 minutes from 7:30 to 8:00 is aggregated. The average actual response time value on that day is 25.4 seconds which exceeds the target value (20 seconds), whereby the energy-saving level on the next day can be decreased from the energy-saving level three (Level 3) to the energy-saving level two (Level 2). As for the time period from 8:00 to 9:00 when no energy saving is implemented, the operating time management unit 144 transmits the car mask illustrated in FIG. 8 to the mask management unit 134, for example. Accordingly, the actual value is recorded from 8:00 to 9:00 with no change in the energy-saving level. At 9:00, the energy-saving level two (Level 2) is set so that the operating time management unit 144 sets the car mask illustrated in FIG. 9 to one car and the car mask illustrated in FIG. 8 to the rest of the cars and transmits the mask information to the mask management unit 134 along with the time information. At 9:30, the operating time adjustment unit 143 makes the adjustment of the energy-saving level from 9:00 to 9:30 on the next day on the basis of the actual value recorded on that day from 9:00 to 9:30. The operating time controller 140 makes adjustments

while performing these operations until 24:00 when the elevator operation is finished for the day. On the next day, the operation is started with the energy-saving level adjusted on the previous day as a pre-execution energy-saving level.

There has been described the case where the energy-saving target value is set by the first setting method, namely, where the average target response time value is set directly. Next, there will be described the case where the energy-saving target value is set by the second setting method, namely, where the average target response time value is set on the basis of the target operating power consumption reduction rate per day. Note that the description that is the repetition of the first setting method will be omitted as much as possible in the following description.

In this case, the target setting unit 142 calculates the average target response time value with which the target operating power consumption reduction rate per day can be achieved, for example. When the target operating power consumption reduction rate cannot be achieved with the calculated average target response time value, the target setting unit 142 recalculates the average target response time value to adjust the target value.

For example, the target setting unit 142 reads the actual operating power consumption value per day on a reference day with no energy saving implemented. The actual operating power consumption value per day on the reference day with no energy saving implemented may be obtained by operating the elevator for one day or a fixed period of time with no energy saving (at the energy-saving level zero) and aggregating the value by the actual value aggregation unit 141, for example. Subsequently, the target setting unit 142 sets the default average target response time value according to the target operating power consumption reduction rate per day that is set at will by the administrator or the like.

In this case, the target setting unit 142 may set the default average target response time value = the average actual response time value per day $\times$ (1 + the target operating power consumption reduction rate per day), for example. The average actual response time value on the reference day that is aggregated by the actual value aggregation unit 141 may be used as the average actual response time value per day, for example. Where the average actual response time value is 30 seconds and the target operating power consumption reduction rate per day is 10%, for example, one can calculate the default average target response time value = $30 \times (1 + 0.1) = 33$ seconds. Once the default average target response time value is determined, the group management control apparatus 1 implements energy saving as implemented by the first setting method.

The target setting unit 142 then calculates a total actual operating power consumption value at the end of each day, determines that the actual value is convergent once there is less change within a fixed range (such as a change within 10%), and calculates an actual operating power consumption reduction rate value. The target setting unit 142 compares the calculated actual operating power consumption reduction rate value with the preset target operating power consumption reduction rate per day to decrease the average target response time value by a predetermined amount when the actual value exceeds the target value and increase the average target response time value by a predetermined amount when the actual value falls below the target value. Here, the predetermined amount may be set to a preset fixed amount or to an amount in accordance with a difference between the actual operating power consumption reduction rate value and the target operating power consumption reduction rate per day.

Let us assume that $X(t)$, Y , and $Y(t)$ indicate the

average target response time value, the target operating power consumption value, and the actual operating power consumption value on a t-th day, respectively. Assuming that the total actual operating power consumption value per day converges on the t-th day, for example, the target setting unit 142 sets the average target response time value on a t + 1st day to be equal to $X(t + 1) = K \times (Y - Y(t)) + X(t)$ and $K = -X(0)/Y(0)$. Each of $X(0)$ and $Y(0)$ is a value when the elevator is operated without energy saving, while the target operating power consumption value equals $Y = Y(0) \times (1 + \alpha)$. Here, α denotes the target operating power consumption reduction rate per day. Accordingly, the target setting unit 142 can calculate the target operating power consumption value Y on the basis of an actual operating power consumption value $Y(0)$ per day with no energy saving implemented and the target operating power consumption reduction rate α per day that is preset. The target setting unit 142 can then increase/decrease the allowable average target response time value $X(t + 1)$ such that the actual operating power consumption value $Y(t)$ at every unit time interval aggregated by the actual value aggregation unit 141 converges to the target operating power consumption value Y . The group management control apparatus 1 can then continuously execute the operation at the energy-saving level on the basis of the average target response time value increased/decreased as described above without bringing the level back to the energy-saving level zero (Level 0), repeat such operation, and achieve the target operating power consumption reduction rate.

Next, the display controller 150 illustrated in FIG. 1 executes control to display, on a display unit, a piece of information related to the energy-saving target value of the elevator group 2 set by the target setting unit 142 and a piece of information related to the actual value pertaining

to the elevator group 2 aggregated by the actual value aggregation unit 141. Here, a display device such as the car guide device 120b and the hall guide device 170 can be used as the display unit. The display controller 150 controls the car guide device 120b through each car control device 122 to guide and display the information related to the energy-saving target value and the information related to the actual value. The display controller 150 further controls the hall guide device 170 to guide and display the information related to the energy-saving target value and the information related to the actual value. FIG. 11 illustrates an example of the display of the actual value displayed by the display controller 150. The display controller 150 may also extract as needed the information related to the energy-saving target value and the information related to the actual value from the recorded data illustrated in FIG. 10 to allow the car guide device 120b and the hall guide device 170 to guide and display the information. As a result, the group management control apparatus 1 can display the energy-saving target value and the actual value to make the actual result widely known to the user or appeal the result to the user.

The group management control apparatus 1 can set the target energy-saving value at will by the administrator or the like setting the average target response time value and the target operating power consumption reduction rate per day. The group management control apparatus 1 converges the actual value to the energy-saving target value set at will by adjusting the energy-saving level as appropriate, to be able to achieve energy saving. As a result, the group management control apparatus 1 can achieve energy saving while maintaining the proper service performance.

The energy-saving level being set by the pitch and the number of cars in operation that possibly takes a decimal value, the group management control apparatus 1 can set the energy-saving level to smaller levels and make minor

adjustments of the degree of energy saving in more detail. As a result, the group management control apparatus 1 can dynamically change the operating time schedule or the like indicating the assignable/unassignable states of each car 120 in more detail, for example, and can thus achieve energy saving with a better prospect.

Moreover, the group management control apparatus 1 changes the energy-saving level in every unit time interval one level at a time per day to be able to gradually optimize the energy-saving performance such that the service performance does not change to a degree perceivable by the user while keeping the service performance from changing abruptly.

The aforementioned group management control apparatus 1 includes the actual value aggregation unit 141, the target setting unit 142, the operating time adjustment unit 143, and the operating time management unit 144. The actual value aggregation unit 141 aggregates the average actual response time value. The target setting unit 142 sets the average target response time value. The operating time adjustment unit 143 adjusts the energy-saving level such that the average actual response time value converges to the average target response time value. The operating time management unit 144 creates the car mask on the basis of the energy-saving level.

The aforementioned elevator group management control method includes the actual value aggregating step, the target setting step, the operating time adjustment step, and the operating time management step. The average actual response time value is aggregated in the actual value aggregating step. The average target response time value is set in the target setting step. The energy-saving level is adjusted in the operating time adjustment step such that the average actual response time value converges to the average target response time value. The car mask restricting the car 120 that can

respond to a call is created on the basis of the energy-saving level in the operating time management step.

Therefore, the group management control apparatus 1 and the elevator group management control method can achieve energy saving while maintaining the proper service performance, thereby allowing the balance between the service performance and the energy-saving performance to be optimized.

Note that the elevator group management control apparatus and the elevator group management control method according to the aforementioned embodiment are not limited to what is described in the aforementioned embodiment but can be modified in various ways within the scope of the claims.

While there has been described that the energy-saving level is set on the basis of the number of cars in operation and the pitch, the energy-saving level may be set such that the degree of energy saving is increased and the actual operating power consumption value is relatively decreased as the energy-saving level is increased. The energy-saving level may have an up-down distance (stopping floors) and/or an up-down speed as a parameter, for example. Moreover, the number of cars 120 in operation that defines the energy-saving level changes in 0.5 car increments according to the energy-saving level in the aforementioned description, but may instead change in increments of an integer number of cars (such as one car). Contrarily, the number of cars 120 that defines the energy-saving level may change in the smaller scale of 0.1 car increments, for example. Furthermore, the aforementioned energy-saving level can be changed not only to the seven different levels from the energy-saving level zero (Level 0) to the energy-saving level six (Level 6) as described above, but to a plurality of levels such as two to six levels or eight levels or greater.

The operating time adjustment unit 143 in the aforementioned description changes the energy-saving level in every unit time interval one level at a time per day.

However, the operating time adjustment unit 143 may also change the energy-saving level by a predetermined period of time such as several days, one week, or one month.

It has also been described that the operating time adjustment unit 143 sets the energy-saving level for every unit time interval of the day. The traffic demand of the elevator group 2 differing greatly between a weekday and a holiday, however, the operating time adjustment unit 143 may separately adjust an energy-saving level for weekday and an energy-saving level for holiday, for example. Likewise, the operating time adjustment unit 143 may separately adjust the energy-saving level for each day of the week that is separated in advance as the day having a different daily traffic demand pattern, for example.

Furthermore, the operating time adjustment unit 143 changes the energy-saving level one level at a time in the aforementioned description but may change the level by a plurality of levels. The operating time adjustment unit 143 may change the energy-saving level in every unit time interval per day according to the deviation between the average actual response time value and the average target response time value in every unit time interval, for example. In this case, when the average actual response time value in the unit time interval is greater than the average target response time value, the operating time adjustment unit 143 decreases the energy-saving level in the unit time interval during the time period on a next day according to the deviation between the average actual response time value and the average target response time value. When the average actual response time value in the unit time interval is smaller than the average target response time value, on the other hand, the operating time adjustment unit 143 increases the energy-saving level in the unit time interval during the time period on the next day according to the deviation between the average actual response time value and the

average target response time value.

In this case, the group management control apparatus 1 performs an experiment or the like to grasp in advance the relationship between the range of change of the energy-saving level (the number of cars in operation in this case) and the amount of change of the average actual response time value. On the basis of the relationship, the group management control apparatus 1 sets in advance the correspondence between the deviation between the average actual response time value and the average target response time value, and the range of change of the energy-saving level, and then represents the correspondence in the form of a map (or a mathematical model). The operating time adjustment unit 143 then calculates, on the basis of the map, the range of change of the energy-saving level according to the deviation between the average actual response time value and the average target response time value and changes the energy-saving level one level at a time or by a plurality of levels according to the range of change.

The group management control apparatus 1 can optimize the energy-saving performance more quickly in this case. Note that, in this case, the operating time adjustment unit 143 may further set an upper limit (an upper-limit guard value) to the range of change of the energy-saving level. As a result, the group management control apparatus 1 can promptly optimize the energy-saving performance such that the service performance does not change to the degree perceivable by the user while keeping the service performance from changing abruptly. Moreover, while the map specifying the correspondence between the deviation and the range of change of the energy-saving level is used, there may be used a map specifying a different correspondence according to the traffic demand, the time period (a rush-hour time period or an off-hour time period), and the actual value of the number of users, for example. The group management control

apparatus 1 can thus change the energy-saving level appropriately according to the traffic demand, the time period, the actual value of the number of users, and the like. The operating time adjustment unit 143 may further set the range of change of the energy-saving level according to the traffic demand, the time period, and the actual value of the number of users, for example.

Moreover, a group management control apparatus 1 may include a sudden traffic demand detector 145 as illustrated in a variation in FIG. 12. An operating time controller 140 in this case includes the sudden traffic demand detector 145 in addition to an actual value aggregation unit 141, a target setting unit 142, an operating time adjustment unit 143, and an operating time management unit 144.

The sudden traffic demand detector 145 detects the occurrence of a sudden traffic demand on the basis of the change in an average actual response time value or an actual value of the number of users in every unit time interval aggregated by the actual value aggregation unit 141. The sudden traffic demand detector 145 reads the average actual response time value and the actual value of the number of users in every unit time interval that are aggregated by the actual value aggregation unit 141. Then, the sudden traffic demand detector 145 detects that the sudden traffic demand is generated when at least either the average actual response time value or the actual value of the number of users in a current unit time interval is changed substantially from the value in an immediately preceding unit time interval. The sudden traffic demand detector 145 may detect the substantial change in the average actual response time value or the actual value of the number of users on the basis of a preset determination value, for example. Moreover, the sudden traffic demand detector 145 may detect that the sudden traffic demand is generated when the average actual response time value or the actual value of the number of users

aggregated in the unit time interval is increased two-fold or more compared to an average value of the past three times, or when the car 120 becomes full for a moment, for example. One can detect that the car 120 is full when a loaded weight (Load Weight) in a record of operation illustrated in FIG. 2 exceeds 90% of a rated load capacity of the car, for example. Upon detecting the occurrence of the sudden traffic demand, the sudden traffic demand detector 145 transmits the detection result to the operating time adjustment unit 143.

Subsequently, the operating time adjustment unit 143 sets an energy-saving level to the lowest level which is in this case an energy-saving level zero (Level 0) equivalent to no energy saving implemented, when the occurrence of the sudden traffic demand is detected by the sudden traffic demand detector 145. The operating time adjustment unit 143 then brings the energy-saving level back to a level on a day before the occurrence of the sudden traffic demand, when the sudden traffic demand detector 145 detects the end of the sudden traffic demand. The sudden traffic demand detector 145 may detect the end of the sudden traffic demand when a condition for the detection of the occurrence of the sudden traffic demand is no longer satisfied, or detect the end of the sudden traffic demand on the basis of a different criterion, for example. The end criterion may be set more strictly than an occurrence criterion so that the operating time adjustment unit 143 brings the energy-saving level back to the level on the preceding day after the demand gets back to normal sufficiently. The operating time adjustment unit 143 may also restore the energy-saving level a fixed period of time after the sudden traffic demand is ended. As a result, the group management control apparatus 1 can ensure the sufficient service performance by bringing the energy-saving level down to the lowest level when the sudden traffic demand is generated and, at the same time, can return to the

energy-saving performance before the occurrence of the sudden traffic demand when the sudden traffic demand is ended.

Note that in this case, the energy-saving level in the unit time interval that is temporarily brought down to the lowest energy-saving level zero (Level 0) is re-adjusted from the lowest energy-saving level zero (Level 0) the next day. Granting that the sudden traffic demand occurs again during the same time period the next day, the group management control apparatus 1 can ensure the proper service performance since the energy-saving level is set to the lowest energy-saving level zero (Level 0) this time. On the other hand, the group management control apparatus 1 gradually increases the energy-saving level when the sudden traffic demand does not recur, whereby the energy-saving level is re-adjusted to the proper energy-saving level in the end.

The default energy-saving level set by the aforementioned group management control apparatus 1 is not limited to the energy-saving level zero (Level 0). The group management control apparatus 1 may set the default energy-saving level in early morning (such as 6:00 to 7:00) and late at night (such as 22:00 to 24:00) to an energy-saving level six (Level 6), for example, when one finds in advance that "one car is sufficient in early morning and late at night". In this case, the group management control apparatus 1 can ensure sufficient energy-saving performance at an early stage. The group management control apparatus 1 can achieve the above by setting a time period during which the default is set to a level other than the energy-saving level zero (Level 0) and a default during that time period. Note that the group management control apparatus 1 may set the default energy-saving level for all time periods to the energy-saving level zero (Level 0) when setting nothing as the default. When an energy-saving target value is given on the basis of a target operating power consumption reduction rate per day (that is, when the second setting method is employed), the

group management control apparatus 1 may set the energy-saving level for all time periods of a corresponding day to the energy-saving level zero (Level 0) as the operating power consumption per day to be a reference day is required.

Furthermore, the aforementioned group management control apparatus 1 may be applied to a system which is referred to as a so-called DCS (Destination Control System) in which the elevator group 2 employs an in-hall destination registration system as illustrated in a variation in FIG. 13. In this case, an elevator group management control system 100 includes an in-hall destination registration device 180 which can register a destination floor in an elevator hall 124. The elevator group management control system 100 guides a user to an assigned car when the user designates a destination floor via the in-hall destination registration device 180 in the elevator hall 124 and the assigned car is guided to the user by an hall guide device 170 or the like. The elevator group management control system 100 in FIG. 13 illustrates a hybrid DCS which is provided with the in-hall destination registration device 180 in the elevator hall 124 on a predetermined floor (such as a first floor to be a reference floor) and a hall input device 160 in the elevator hall 124 on another floor. The elevator group management control system 100 may be a full DCS which is provided with the in-hall destination registration device 180 in the elevator hall 124 on all floors.

When applied to such DCS, the group management control apparatus 1 can measure the waiting time for each user in the elevator hall 124 which is provided with the in-hall destination registration device 180. Accordingly, the group management control apparatus 1 replaces an average actual response time value in every unit time interval by an average actual waiting time value in every unit time interval or a pseudo average actual response time value corresponding to the average waiting time. Here, the pseudo average actual

response time value corresponds to the time obtained by converting the average waiting time to the equivalent of the average response time. Moreover, the pseudo average actual response time value is obtained by setting the waiting time of a user, to whom a specific car 120 is assigned for the first time among users present on a certain floor, as the response time. Let us assume a case where the car 120 of an elevator No. 1 does not respond to a call on the first floor. In this case, the waiting time of a user P1 on the first floor is the pseudo response time when the car 120 of the elevator No. 1 is assigned to the user P1. After the assignment, the waiting time of a user P2 to whom the car 120 of the elevator No. 1 is reassigned does not correspond to the pseudo response time and is not to be aggregated. The pseudo average actual response time value is equivalent to the average value of the pseudo response time.

Therefore, in this case, an actual value aggregation unit 141 aggregates as the average actual response time value in every unit time interval either the average actual waiting time value in every unit time interval on the floor where the in-hall destination registration device 180 is installed or the pseudo average actual response time value corresponding to the average waiting time. The actual value aggregation unit 141 uses the response time as described above to aggregate the average actual response time value on a floor where the in-hall destination registration device 180 is not installed. Accordingly, the group management control apparatus 1 can achieve energy saving while maintaining proper service performance even when the elevator group 2 employs the in-hall destination registration system, thereby allowing the balance between the service performance and the energy-saving performance to be optimized.

It has been described that the group management control apparatus 1 adjusts the energy-saving level in every fixed time interval and creates the car mask on the basis of the

average actual response time value in every fixed time interval and the average target response time value in every fixed time interval. However, the group management control apparatus 1 may be configured where the operating time adjustment unit 143 adjusts the instantaneous energy-saving level such that simply the actual response time value aggregated by the actual value aggregation unit 141 converges to the target response time value set by the target setting unit 142, not on the basis of the average value in every fixed time interval or the like. The operating time management unit 144 may then create the car mask on the basis of the instantaneous energy-saving level. Likewise, the aforementioned elevator group management control method may be configured to include the actual value aggregating step of simply aggregating the actual response time value, not the average value in every fixed time interval or the like, and the target setting step of setting the target response time value. The elevator group management control method may then include the operating time adjustment step of adjusting the energy-saving level such that the actual response time value converges to the target response time value, and the operating time management step of creating the car mask on the basis of the energy-saving level.

The balance between the service performance and the energy-saving performance can be optimized according to the elevator group management control apparatus and the elevator group management control method of the aforementioned embodiment and variations.

According to the elevator group management control apparatus of at least one embodiment described above, the elevator group management control apparatus for managing an elevator group including a plurality of cars includes an actual value aggregation unit, a target setting unit, an operating time adjustment unit, and an operating time management unit. The actual value aggregation unit is

configured to aggregate an actual response time value that is an actual value of a response time corresponding to a time from when a hall call is registered to when the car responds to the hall call. The target setting unit is configured to set a target response time value that is a target value of the response time. The operating time adjustment unit is configured to adjust an energy-saving level so that the actual response time value aggregated by the actual value aggregation unit converges to the target response time value set by the target setting unit, the energy-saving level representing the degree of energy saving that affects the actual response time value of the elevator group. The operating time management unit is configured to create on the basis of the energy-saving level a car mask for limiting a car able to respond to a call. Limiting a car is realized by modification of assigning evaluation function instead of a car mask.

That is to add a large value to the evaluation function of the limiting car. As a result, this car is never assigned. Therefore, it is possible to provide energy saving while maintaining the proper service performance, thereby allowing the balance between the service performance and the energy-saving performance to be optimized.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. The embodiments may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirits of the inventions.

CLAIMS:

[Claim 1]

An elevator group management control apparatus for managing an elevator group including a plurality of cars, the apparatus comprising:

an actual value aggregation unit configured to aggregate an actual response time value that is an actual value of a response time corresponding to a time from when a hall call is registered to when the car responds to the hall call;

a target setting unit configured to set a target response time value that is a target value of the response time;

an operating time adjustment unit configured to adjust an energy-saving level so that the actual response time value aggregated by the actual value aggregation unit converges to the target response time value set by the target setting unit, the energy-saving level representing the degree of energy saving that affects the actual response time value of the elevator group; and

an operating time management unit configured to create on the basis of the energy-saving level a car mask for limiting a car able to respond to a call, wherein

the energy-saving level is set according to the number of cars in operation per unit time, the number of cars in operation being a parameter that can take a decimal value, when the number of cars in operation is an integer value, the number of cars in operation representing that the integer number of the cars can be assigned, and when the number of cars in operation is a decimal value, the number of cars in operation representing a proportion of time that can be assigned in a unit time interval.

[Claim 2]

The apparatus according to claim 1, wherein

the energy-saving level is set further according to a pitch that is a switch pitch between a state where the cars respond to a call and a state where the cars do not respond to the call, and

the number of cars in operation is an average number of cars in operation per unit time, takes a value corresponding to a total number of the cars of the elevator group when the energy-saving level is at a lowest level, and decreases as the energy-saving level is increased from the lowest level.

[Claim 3]

The apparatus according to claim 1, wherein the operating time adjustment unit is configured to set in advance a time period during which the energy-saving level is not adjusted.

[Claim 4]

The apparatus according to claim 1, wherein the operating time adjustment unit is configured to individually set in advance a default value of the energy-saving level.

[Claim 5]

The apparatus according to claim 1, wherein the operating time management unit is configured to, when creating the car mask, select from among preset candidates the car that has a restriction on responding to a call.

[Claim 6]

The apparatus according to claim 1, further comprising a display controller configured to cause a display unit to display information related to the target value set by the target setting unit and information related to the actual value aggregated by the actual value aggregation unit.

[Claim 7]

The apparatus according to claim 1, further comprising a group management controller configured to manage an operation of the plurality of cars on the basis of the car mask created by the operating time management unit.

[Claim 8]

The apparatus according to claim 1, wherein

the actual value aggregation unit is configured to aggregate an average actual response time value that is an average value of the actual response time value in every fixed time interval that is preset,

the target setting unit is configured to set an average target response time value that is a target value of the average actual response time value in the every fixed time interval,

the operating time adjustment unit is configured to adjust the energy-saving level in the every fixed time interval so that the average actual response time value in the every fixed time interval aggregated by the actual value aggregation unit converges to the average target response time value set by the target setting unit, and

the operating time management unit is configured to create the car mask on the basis of the energy-saving level in the every fixed time interval.

[Claim 9]

The apparatus according to claim 8, wherein the operating time adjustment unit is configured to change by the day the energy-saving level in the every fixed time interval one level at a time.

[Claim 10]

The apparatus according to claim 8, wherein the operating time adjustment unit is configured to changes by the day the energy-saving level in the every fixed time interval according to a deviation between the average actual response time value in the every fixed time interval and the average target response time value.

[Claim 11]

The apparatus according to claim 8, wherein

the elevator group includes an in-hall destination registration device configured to register a destination floor in an elevator hall, and

the actual value aggregation unit is configured to aggregate as an average actual response time value in the every fixed time interval either an average actual waiting time value in the every fixed time interval or a pseudo average actual response time value corresponding to an average waiting time on a floor where the in-hall destination registration device is installed.

[Claim 12]

The apparatus according to claim 8, wherein the operating time adjustment unit is configured to relatively decrease the energy-saving level in the fixed time interval when the average actual response time value in the every fixed time interval is greater than the average

target response time value, and relatively increase the energy-saving level in the fixed time interval when the average actual response time value in the every fixed time interval is smaller than the average target response time value, to adjust the energy-saving level in the every fixed time interval so that the average actual response time value in the every fixed time interval converges to the average target response time value.

[Claim 13]

The apparatus according to claim 8, wherein

the actual value aggregation unit is configured to further aggregate an actual operating power consumption value that is an actual value of power consumed when the elevator group is operated, and

the target setting unit is configured to calculate a target operating power consumption value on the basis of the actual operating power consumption value per day with no energy saving implemented and a preset target operating power consumption reduction rate per day, and set the average target response time value that is allowable so that the actual operating power consumption value in the every fixed time interval aggregated by the actual value aggregation unit converges to the target operating power consumption value.

[Claim 14]

The apparatus according to claim 8, wherein

the actual value aggregation unit is configured to further aggregate the actual value of the number of users that is an actual value of the number of persons who use the elevator group,

the apparatus further comprises a sudden traffic demand detector configured to detect an occurrence of a sudden traffic demand on the basis of a change in the average actual response time value in the every fixed time interval aggregated by the actual value aggregation unit or an actual value of the number of users, and

the operating time adjustment unit is configured to set the energy-saving level to a lowest level when the occurrence of the sudden traffic demand is detected by the sudden traffic demand detector, and bring the energy-saving level back to a level before the occurrence of the sudden traffic demand when the sudden traffic demand detector detects an end of the sudden traffic demand.

[Claim 15]

An elevator group management control method for managing an elevator group including a plurality of cars, the method comprising:

aggregating an actual response time value that is an actual value of a response time corresponding to a time from when a hall call is registered to when the car responds to the hall call;

setting a target response time value that is a target value of the response time;

adjusting an energy-saving level so that the actual response time value aggregated converges to the target response time value set, the energy-saving level representing the degree of energy saving that affects the actual response time value of the elevator group; and

creating, on the basis of the energy-saving level, a car mask for limiting a car able to respond to a call, wherein

the energy-saving level is set according to the number of cars in operation per unit time, the number of cars in operation being a parameter that can take a decimal value, when the number of cars in operation is an integer value, the number of cars in operation representing that the integer number of the cars can be assigned, and when the number of cars in operation is a decimal value, the number of cars in operation representing a proportion of time that can be assigned in a unit time interval.