TITLE OF THE INVENTION:

ELEVATOR SYSTEM AND CONTROL METHOD OF ELEVATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an elevator system and control method of elevator.

2. Description of the Related Art

Japanese Unexamined Patent Application Publication No. 2011-102158 discloses a first related-art technique for elevator group control of controlling a plurality of elevators. The elevator group control includes the steps of: determining the number of elevator passengers; storing individual inter-floor traffic amounts; deciding, based on totals of passengers of the individual inter-floor travels, which floor one elevator car can service in response to a hall call. This first related-art technique achieves power saving operation (energy saving operation) by assigning the elevator car to any one of the floors based on the decision on the floor to be serviced by the elevator car answering the hall call. The first related-art technique seeks to decrease the number of starting elevators and the energy consumption (power consumption) of starting elevators by assigning the elevator car based

on the decision on the floor to be serviced by the elevator car answering the hall call.

Japanese Unexamined Patent Application Publication No. 1992-217570 discloses a second related-art technique which includes the steps of: detecting an allowable amount of electric power for a plurality of elevators; and deciding, based on the allowable amount of electric power, the number of elevators that can be started simultaneously in a building.

Further, Japanese Unexamined Patent Application Publication No. 2010-208770 discloses a third related-art technique in which an average un-response time after the lapse of a predetermined period of time is estimated from fluctuations in average un-response time between a hall call and an elevator car's arrival at a floor where the hall call is made. According to this third related-art technique, the estimated average un-response time is compared with a threshold value and if it is determined that an excessive number of elevator cars are running, some elevator cars are placed in standby mode.

SUMMARY OF THE INVENTION

The first related-art technique is adapted to control call assignment to the elevator car based on the decision on the floor to be serviced by the elevator car

answering the hall call. In this manner, the first related-art technique seeks to decrease the number of starting elevators. However, the call occurs at random in actual traffic stream at off time or in usual condition. It is therefore difficult to make a proper decision on the floor to be serviced by the elevator car in such a manner to decrease the number of starting elevators.

The second related-art technique does not consider usage status of the elevators, involving a fear that the number of elevator cars to be started simultaneously is unduly decreased to impair passenger convenience.

The third related-art technique does not make a clear definition of the relation between the average un-response time and the number of elevator cars. The third related-art technique is deemed to implement simple control in which whether to stop the elevator car or not is determined by comparing the average un-response time with the threshold value. What is more, the threshold value fluctuates significantly depending upon the number of approaching, waiting or riding passengers in the building, the number of elevator cars installed in the building, the handling capacity of the elevator cars and the like. Therefore, the third related-art technique fails to set the number of running elevator cars that is suited to the actual traffic stream.

Further, there is another problem common to these related-art techniques that the elevator car in stand-by mode is changed from one to another depending upon the conditions so that the passengers are confused. The passengers do not know which elevator car is in stand-by mode and hence, they may wait for the arrival of the elevator car in the stand-by mode in vain or may wander from one elevator car to another.

In view of the above problems, the invention has an object of providing an elevator system and control method of elevator in which the operation of a plurality of elevator cars can be controlled in response to the usage status of the elevator. The invention has another object of providing an elevator system and control method of elevator that can achieve both good handling capacity of elevator cars and low energy consumption by controlling the operation of the elevator cars according to the number of waiting passengers for an elevator car.

While the invention can be viewed in a plurality of aspects, the following description is made on some of the aspects of the invention.

According to the invention for achieving the above objects, an elevator system for controlling a plurality of elevator cars travelling through a plurality of floors, includes: a detector of number of waiting passengers that

detects the number of waiting passengers for an elevator car at least at any one of the plural floors; a calculation part for sum of numbers of waiting passengers that calculates, as the sum of the numbers of waiting passengers, the sum of the numbers of waiting passengers detected by the detector of number of waiting passengers; and a control part for running of elevator cars that calculates the number of running elevator cars out of the plural elevator cars based on the sum of the numbers of waiting passengers and controls the running of the plural elevator cars based on the calculated number of running elevator cars.

The control part for running of elevator cars may set the number of running elevator cars in response to the increase or decrease in the sum of the numbers of waiting passengers.

The control part for running of elevator cars may increase or decrease the number of running elevator cars in response to the increase or decrease in the sum of the numbers of waiting passengers and according to a predetermined sequence of elevator cars on/off.

The calculation part for sum of numbers of waiting passengers may calculate the sum of the numbers of waiting passengers by multiplying the number(s) of waiting passengers detected at predetermined floor(s) out of the

plural floors by a factor of 1 or more.

According to the invention, the operation of the plural elevator cars can be controlled in response to the usage status of elevator. Further, according to the invention, the operation of the elevator cars can be controlled in response to the number of waiting passengers for the elevator car. Thus, the invention can serve both to ensure good handling capacity of elevator cars and to achieve energy saving (power saving).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an explanatory diagram of general concept of an embodiment of the invention;

FIG. 2 is a diagram showing an overall structure of an elevator system;

FIGS. 3A to 3C are diagrams showing how to control the number of running elevator cars:

FIG. 4 is a diagram showing exemplary sensors for detecting the number of passengers waiting for elevator:

FIG. 5 is an explanatory diagram showing an example of method of calculating the number of waiting passengers;

FIG. 6 is a flow chart showing the steps of processing of setting an upper limit of the number of running elevator cars;

FIGS. 7A and 7B are diagrams showing contents of a

table for managing the upper limit of the number of running elevator cars;

FIGS. 8A and 8B are diagrams showing contents of schedule data for managing the upper limit of the number of running elevator cars;

FIG. 9 is a flow chart showing the steps of processing of setting the number of running elevator cars according to the number of waiting passengers;

FIG. 10 is a diagram showing contents of a table for managing relation between the number of running elevator cars and the handling capacity thereof;

FIG. 11 is a flow chart showing the steps of processing of selecting an elevator car to run or to go stand-by mode;

FIGS. 12A to 12C are diagrams explaining that the sequence of elevator cars on/off is controllable according to a layout of an elevator hall;

FIG. 13 is a flow chart showing the steps of processing of determining whether stand-by mode condition is established or not; and

FIGS. 14A and 14B are a group of diagrams showing exemplary structures for indicating to the passengers that the elevator is running or in stand-by mode.

DETAILED DESCRIPTION OF THE INVENTION

The embodiments of the invention will be described in detail as below with reference to the accompanying drawings.

It is to be noted, however, that the invention is not limited to the embodiments described herein. It goes without saying that the invention includes any modifications or changes that a person ordinarily skilled in the art to which the invention pertains can make without departing from the spirit and scope of the invention.

Further, the embodiments described herein do not limit the scope of the invention defined by the appended claims or the interpretation of the invention set forth in the appended claims is not limited by the following embodiments.

Further, all the combinations of the features described in the embodiments are not always essential.

In the description of the drawings, elements having common features will be referred to by like reference numerals and will be explained only once to avoid repetition.

As shown in a general schematic diagram of FIG. 1, an elevator system 1 controls a plurality of elevator cars that travel through a plurality of floors from the first floor to the Nth floor, for example. The floors are each

provided with a sensor part 101a to 101c for detecting the number of passengers waiting for the arrival of the elevator car. Detectors 102a to 102c of the number of approaching, waiting or riding passengers that receive an output from the sensor parts 101a to 101c, respectively, correspond to a "detector of number of waiting passengers".

A calculator 103 of sum of the numbers of approaching, waiting or riding passengers as a "calculation part for sum of numbers of waiting passengers" is an accumulator that calculates the sum of the numbers of waiting passengers on a predetermined floor out of the waiting passengers on the individual floors as detected by the sensor parts 101a to 101c. The resultant sum corresponds to a "sum of waiting passengers".

A term "the number of passengers" means the number of passengers who ride in the elevator. A term "the number of waiting passengers" means the number of passengers who, out of the passengers, wait for the elevator. The embodiment focuses attention on the numbers of waiting passengers on the respective floors. However, the embodiment may also be configured to control the elevator based on the number of passengers.

A calculator/setter 501 of the number of running elevator cars corresponding to a "control part for running of elevator cars" is a calculator/setter of the number of

running elevator cars in response to the number of passengers, which calculates the number of elevator cars to run, out of the plural elevator cars. The calculation is made based on the sum calculated by the above calculator 103.

The running elevator car selected as a run object is placed in a waiting mode, for example, in which the elevator car can be assigned with a hall call. An elevator car not selected as the run object goes stand-by mode in which the elevator car is supplied with less power than the running elevator car.

Adopting the above configuration, this embodiment is adapted to set the number of running elevator cars in response to the usage status of the elevator and to decrease wasteful operation of the elevator. Thus, the embodiment can provide a handling capacity of elevator cars that meets the actual situation, thus enhancing passenger convenience. Further, the embodiment does not run more elevator cars than necessary and hence, can achieve decreases in the energy consumption and the on-peak energy (on-peak electric power).

First Embodiment

The structure and the like of the energy-saving elevator system 1 are described as below with reference to the accompanying drawings. This embodiment focuses

attention on the number of elevator passengers in a building, or particularly on the number of waiting passengers and changes the number of running elevator cars as needed in response to the change in the number of passengers.

Thus, this embodiment can provide both the passenger convenience and the energy (power)saving effect. In the case of changing the number of running elevator cars, this embodiment is designed to run or stop the elevator cars according to a predetermined sequence. Hence, the embodiment permits the passengers to ride in any of the plural elevator cars as needed without being confused.

Further, this embodiment is adapted to control the number of running elevator cars based on an power usage status in a building equipped with the plurality of elevator cars or in an area where the building is located. This permits the building to respond adequately to a request for cooperation in rolling blackouts or adjustment of power supply-demand balance.

FIG. 2 shows the whole structure of the power-saving elevator system 1. First, a brief description is made on a major flow of control. This system 1 first detects the overall number of passengers riding in the elevator cars in the building by means of the sensor parts, and calculates the time-averaged component and the fluctuation

component thereof. Based on the time-averaged component and fluctuation component, this system 1 calculates such a number of running elevator cars as to satisfy a demand. Lastly, this system 1 operatively runs or stops each of the elevator cars according to a sequence of elevator cars on/off previously defined based on a layout of the elevator cars.

Control structures of this system 1 includes: a passenger number detection processor 100 for detecting the number of approaching, waiting or riding passengers, a passenger number data processor 200, an upper running-car number limit processor 300, a time schedule processor 400 and a running-car number processor 500.

These control structures control power supply to motors 703a, 703b for moving up and down elevator cars 704a, 704b. As will be described hereinafter, the control structures of this system 1 controls the power supply to the elevators by providing on/off control of switches 701a, 701b disposed between a voltage source of the building and inverters 702a, 702b. Whether the elevator car is running or in standby mode is displayed on a status indicator 600 disposed at an elevator hall (hereinafter, also referred to as "hall").

In the following description, unless otherwise individuated, the elevator cars 704a, 704b may be

collectively referred to as elevator car 704, the motors 703a, 703b may be collectively referred to as motor 703, the inverters 702a, 702b may be collectively referred to as inverter 702, and switches 701a, 701b may be collectively referred to as switch 701.

Although a controlled object of this system 1 is an elevator group including a plurality of elevators, the elevators of the elevator group need not be controlled as the group. The control structures will be described in detail as below.

The sensor parts 101a to 101c at the respective floors each detect the number of riding passengers in the elevator car or waiting passengers at the hall on the respective floors. Subsequently, the sensor parts output detection signals or detection data. In the figure, the sensor part is expressed as "sensor". The sensor part 101a disposed on the first floor is abbreviated as "sensor (1)". The sensor part 101b disposed on the second floor is abbreviated as "sensor (2)". The sensor part 101c disposed on the Nth floor is abbreviated as "sensor (N)". Unless otherwise individuated, the sensor parts may be collectively referred to as "sensor part 101".

Examples of the sensor for detecting the waiting passengers (waiting passengers for elevator car) include: camera, infrared temperature sensor, security gate,

security door, ID (identification) tug, destination floor register, in-car load sensor and the like. It is also possible to use any ones of these sensors in combination.

The presence or absence of a passenger or the outline thereof can be detected by analyzing image data acquired by means of the camera such as a CCD (Charge Coupled Device) camera. The body temperature of the riding passenger can be detected by using the infrared temperature sensor, infrared image sensor or the like. Further, the number of riding passengers can be determined from distribution of body temperatures. The security gate and security door are entrance/exit management systems that permit the passage of only authenticated passengers. Fingerprint, vocal print, iris, vein configuration, password, ID tug and the like, for example, are used to make authentication. When the passenger passes the security gate or the like, passenger entrance/exit information indicating who at what post passed the security gate or door at what time can be acquired. This information may be used to estimate the number of waiting passengers at the elevator hall disposed ahead of the security gate or door.

The destination floor register is a machine allowing the elevator passenger to register his/her destination floor beforehand and is disposed in the vicinity of the

security gate, for example. All the passengers need to manipulate the destination floor register to register his/her destination floor beforehand because the elevator car is assigned to the floors based on the previously registered floor. Therefore, the number of waiting passengers at the elevator hall can be estimated based on the information inputted to the destination floor register.

The in-car load sensor detects the gross weight of passengers riding in the elevator car. The number of passengers riding in the elevator car can be estimated by dividing the detected gross weight by average passenger weight.

The number of passengers currently waiting at the elevator hall can be determined as the number of waiting passengers by subtracting the number of passengers entering the elevator car to start moving from the number of passengers having arrived at the elevator hall.

Based on passenger authentication information acquired by each of the sensor parts 101a to 10ac on the respective floors, each of the detectors of the number of passengers 102a to 102c detects the number of approaching, waiting or riding passengers. Hereinafter, "the number of approaching, waiting or riding passengers" will be referred to as "the number of waiting passengers, etc." for convenience. The detector of the number of passengers

102a on the first floor detects the number of waiting passengers, etc. on the first floor based on the detection signal from the sensor part 101a on the first floor. The detector of the number of passengers 102b on the second floor detects the number of waiting passengers, etc. on the second floor based on the detection signal from the sensor part 101b on the second floor. Similarly, the detector of the number of waiting passengers 102c on the Nth floor detects the number of waiting passengers, etc. on the Nth floor based on the detection signal from the sensor part 101c on the Nth floor. Unless otherwise individuated, the detectors of the number of passengers may be collectively referred to as "passenger number detector 102".

It is noted here that the number of passengers means the number of approaching, waiting or riding passengers per given time period (e.g., 5-minute period) at some clock time. The number of waiting passengers means the number of passengers, out of the elevator passengers, who are waiting at the elevator hall. The concept of the number of passengers and the number of waiting passengers is applicable to the whole building on a per-elevator basis or on a per-floor basis.

The calculator 103 of sum of the numbers of approaching, waiting or riding passengers (abbreviated as

the "summing part" in the figure) calculates the sum of the numbers of waiting passengers, etc. by summing up the numbers of waiting passengers, etc. detected by the passenger number detectors on the respective floors (abbreviated as "detect number of passengers" in the figure). The sum of the numbers of waiting passengers, etc. (in some cases, abbreviated as "sum of passenger numbers") means the number of waiting passengers, etc. in the whole building where a group of elevators as the controlled object of this system is installed.

This embodiment illustrates a case where the respective numbers of waiting passengers, etc. on the individual floors in the building are detected. Alternatively, the elevator system may also be constructed such that the number of waiting passengers, etc. on a particular floor or some particular floors is detected. In an office building or the like, for example, the number of waiting passengers, etc. on a lobby floor or dining hall floor often accounts for the majority of the number of waiting passengers, etc. in the whole building. In this case, therefore, it suffices to detect the number of waiting passengers, etc. on the lobby floor and/or the dining hall floor. If the elevator system adopts the structure where the number of waiting passengers, etc. only on one particular floor or some particular floors is

detected, the elevator system is decreased in the number of sensor parts. The elevator system as a whole can achieve cost reduction.

In a case where the numbers of waiting passengers, etc. on all the floors in the building are detected, the passenger numbers on the respective floors may be weighted and added up. For example, weighting factors for the floors such as a lobby floor and a cafeteria floor accessed by a large number of passengers are increased and the sum of the passenger numbers is calculated. Thus, the elevator system can control the elevators with priority placed on the floors accessed by many passengers.

Alternatively, the elevator system may also be so constructed as to control the elevators based on the number of waiting passengers, etc. not only on the lobby floor and dining hall floors but also on a floor accessed by more passengers than the other floors of the all floors as the controlled object.

The passenger number data processor 200 processes data on the sum of passenger numbers calculated by the calculator 103 of sum of passenger numbers. First, a time average calculator 201 (abbreviated as "time average" in the figure) calculates the time-averaged value of the data on the sum of passenger numbers. The time-averaged value herein means the average value per predetermine time

period or the value obtained through a low-pass filter. Minor fluctuation components are removed from the data on the sum of passenger numbers by calculating the time-averaged value of the data on the sum of passenger numbers. Thus, bias component data can be extracted.

A deviation calculator 202 (abbreviated as "deviation" in the figure) calculates a difference between the current data on the sum of passenger numbers and the time-averaged value. A selection decision part 203 (abbreviated as "selection" in the figure) changes passenger number data to use based on the difference between the time-averaged value and the data on the sum of passenger numbers.

Specifically, the selection decision part 203 uses the time-averaged value in a case where the difference between the time-averaged value and the data on the sum of passenger numbers is small. In a case where the difference between the time-averaged value and the data on the sum of passenger numbers is large, the selection decision part 203 uses the current data on the sum of passenger numbers as it is.

By using the time-averaged value as the data on the number of waiting passengers, etc., stable decision can be made on the number of running elevator cars without being affected by the minor fluctuation components. In the case

of an abrupt increase in the number of waiting passengers, etc., the current data on the sum of passenger numbers is used in place of the time-averaged value. In this manner, the elevator system can respond quickly to the abrupt fluctuation of the number of waiting passengers, etc.

According to this embodiment as described above, one of the time-averaged value of the data on the sum of passenger numbers and the data on the sum of passenger numbers is used as data for elevator control depending upon the magnitude of the difference between the data on the sum of passenger numbers and the time-averaged value. Thus, this embodiment is adapted to set the number of running elevator cars in response to the usage status of the elevators. In a case where the number of waiting passengers, etc. is relatively stable, the elevator system can set the number of running elevator cars to a stable value. In the case of an abrupt change in the number of waiting passengers, etc., the elevator system can quickly follow the change to increase the number of running elevator cars.

The upper running-car number limit processor 300 sets an upper limit of the number of elevator cars based on the amount of power used or the like in a power system of the building provided with the elevators or in a power system in the whole area where the building is located.

A power system information database 301 (abbreviated as "DB" in the figure) manages data on the amount of power used in or power use rate of the power system in the area where the building of interest is located. The power use rate means the ratio of amount of power used to amount of power generated. Hereinafter, the term "the amount of power used or power use rate" may sometimes be abbreviated as "the amount of power used or the like".

A CEMS (Community Energy Management System) 302 is a system that manages the energy in a managed object area. The CEMS 320 can input the data on the amount of energy used or the like in the power system to the power system information database 301 via communication network or the like.

A BEMS (Building Energy Management System) 303 is a system that manages the energy in the building where the elevators are installed. The BEMS 303 can receive the data on the amount of energy used or the like in the power system from a management system of an electric power provider or the like and input the received data to the database 301.

A data acquisition part 304 for the amount power used or the power use rate (hereinafter abbreviated as "data acquisition part") acquires via communications the data on the amount of power used or the like in the area

of interest or the building of interest from at least any one of the power system information database 301, the CEMS 302 and the BEMS 303.

An upper limit setting part 306 for setting an upper limit of the number of running elevator cars (abbreviated as "set upper limit" in the figure) sets the upper limit of the number of running elevator cars by referring to an upper running-car number limit table 305 based on the acquired data on the amount of power used or the like. The table 305 abbreviated as the "upper limit" in the figure previously defines relation between the data on the amount of power used or the like and the upper limit of the number of running elevator cars.

In a case where a section that acquires the data on the amount of power used or the like is not provided, the time schedule processor 400 may be used to set the upper limit of the number of running elevator cars. The upper limit setting part 306 refers to a schedule table 401 (abbreviated as "schedule" in the figure) for managing the upper limit of the number of running elevator cars according to the current clock time acquired from a clock 402. Thus, the upper limit setting part 306 can acquire, from the table 401, the data on the upper limit of the number of running elevator cars at the current clock time and set the acquired data as the upper limit of the number

of running elevator cars.

The upper limit setting part 306 can also set the upper limit of the number of running elevator cars by combining the data on the amount of power used or the like and the data on the number of running elevator cars stored in the time-based schedule table 401. For example, the upper limit setting part 306 normally sets the upper limit of the number of running elevator cars according to the data in the time-based schedule table 401. However, when the amount of power used or the like is increased to above a predetermined value, the upper limit setting part 306 sets the upper limit of the number of running elevator cars based on the data on the amount of power used or the like.

The running-car number processor 500 calculates the number of running elevator cars according to the upper limit of the number of running elevator cars and the sum of elevator passengers. According to the determined number of running elevator cars, the running-car number processor 500 runs or stops the elevator cars in a predetermined sequence.

The calculator/setter 501 of the number of running elevator cars functions to calculate the number of running elevator cars in response to the number of waiting passengers, etc. and to set the number of running elevator

cars to the calculated value. The calculator/setter 501 of the number of running elevator cars determines as the number of running elevator cars a value equal to or less than the upper limit of the number of running elevator cars (hereinafter, sometimes abbreviated as "upper limit") set by the upper limit setting part 306. Namely, the calculator/setter 501 of the number of running elevator cars calculates the number of running elevator cars at a value that is equal to or less than the upper limit and that provides a handling capacity of elevator cars best suited to (closest in value to) the sum of the numbers of waiting passengers, etc., and sets the calculated value as the number of running elevator cars.

In order to determine such a number of running elevator cars as to provide the handling capacity of elevator cars that is the closest to the sum of the numbers of waiting passengers, etc., the calculator/setter 501 of the number of running elevator cars uses specification data stored in an elevator specification database (abbreviated as "DB" in the figure) 502. The specification data on each elevator includes: speed, car's capacity, door open time/door close time, number of floors to stop at, acceleration/deceleration and the like, for example. The term "handling capacity of elevator cars" used herein means the number of passengers to be carried

by a plurality of elevator cars per given time.

In a case where the sum of the numbers of waiting passengers, etc. is calculated for one or more particular floors, the calculator/setter 501 of the number of running elevator cars calculates the handling capacity of elevator cars for the particular floor(s) and determines such a number of running elevator cars as to provide a handling capacity closest to that for the particular floor(s).

In a case where the number of waiting passengers, etc. on a floor that has the largest number of waiting passengers, etc. is used, the calculator/setter 501 of the number of running elevator cars calculates the handling capacity of elevator car to serve the largest number of waiting passengers, etc. and determines such a number of running elevator cars as commensurate with the calculated handling capacity.

Instead of calculating the handling capacity, the calculator/setter 501 of the number of running elevator cars may also determine the number of running elevator cars commensurate with the number of waiting passengers, etc., by dividing the number of waiting passengers, etc. by the elevator car's capacity. This calculation method is more effective in a case where the number of waiting passengers rather than the number of passengers is handled because the number of running elevator cars corresponding

to the number of waiting passengers can be determined directly.

An elevator car selector 503 selects anew an elevator car to run or go stand-by mode according to the number of running elevator cars set by the calculator/setter 501 of the number of running elevator cars. According to this embodiment, a plurality of elevators is referred to as "elevator car 1", "elevator car 2", "elevator car 3" and so on and hence, the term "elevator car" is used instead of the term "elevator".

In a case where, for example, three elevator cars are currently running and the set value for the number of running elevator cars is decreased to two, the elevator car selector 503 selects one elevator car from the running elevator cars according to a predetermined sequence and then, places the selected elevator car in the stand-by mode. Conversely in a case where the set value for the number of running elevator cars is increased to four, the elevator car selector 503 selects one elevator car from the elevator cars in stand-by mode according to a predetermined sequence and then, runs the selected elevator car.

The elevator car selector 503 needs current elevator-car on/off information on the individual elevator cars in order to select anew an elevator car to run or go

stand-by mode. Hence, the elevator car selector 503 retrieves from an elevator status data acquisition part 504 (abbreviated as "status acquisition" in the figure) data indicative of the latest statuses of the individual elevator cars. The latest status data may include: current location of elevator car, moving speed of elevator car, open/close of door of elevator car, floor at which elevator car is to stop, hall call assigned to elevator car and the like, for example.

The elevator car selector 503 selects an elevator car to run or go stand-by mode in the given sequence previously defined. The predetermined sequence is generated based on the layout of the elevators at the elevator hall and from the view point of preventing, as much as possible, the passengers from being confused. Data on the predetermined sequence corresponding to the layout of the elevator hall is stored in an on/off sequence table 505 (abbreviated as "sequence" in the figure).

When the elevator car selector 503 decides one elevator car to go stand-by mode, a stand-by mode decision part 506 (abbreviated as "determine stand-by or not" in the figure) determines whether the elevator car as a stand-by mode object can go stand-by mode or not. In this embodiment, power supply to the elevator car as the stand-

by mode object is shut down by opening the switch 701 interconnecting the inverter 702 and the voltage source of the building whereby the elevator car of interest is placed in the stand-by mode.

The stand-by mode decision part 506 retrieves status data on the elevator car as the stand-by mode object from the elevator status data acquisition part 504 and determines whether the elevator car as the stand-by mode object can go stand-by mode or not. Lest the riding passenger(s) should be confined in the elevator car, the stand-by mode decision part 506 determines the elevator car of interest to be capable of going stand-by mode if, for example, the elevator car of interest has the door closed and remains stopped in a floor for more than a predetermined period of time and is not assigned with a call.

In this embodiment, the power supply to the elevator car in stand-by mode is shut down in order to decrease the energy consumption by the elevator car in stand-by mode as much as possible. Therefore, the embodiment makes a strict stand-by mode decision in order not to encounter a problem that the riding passenger(s) is inadvertently confined in the elevator car. In a case where the elevator car can be installed with a camera or infrared temperature sensor for detecting the riding passenger(s)

in the elevator car, for example, it is also possible to utilize a signal from such a sensor for determining whether the elevator car of interest can go stand-by mode or not.

A command output part 507 (abbreviated as "output command" in the figure) outputs a power-on command signal or power-off command signal to the elevator car decided to run or go stand-by mode. The power-on command signal and power-off command signal are inputted to the switch 701 for opening or closing a circuit between the voltage source of the building and the elevator car.

When the power-on command signal is inputted to the switch 701, the switch 701 is closed to electrically connect the voltage source of the building with the inverter 702 for the elevator car. Thus, the motor 703 is activated so that the elevator car is shifted from the stand-by mode to a run mode.

When the power-off command signal is inputted to the switch 701, on the other hand, the switch 701 is opened to electrically disconnect the voltage source of the building from the inverter 702 for the elevator car. Thus, the elevator car is shifted from the run mode to the stand-by mode.

While illustration is omitted, the elevator cars are each equipped with a controller and is adapted to operate

in response to a command from the controller. The power-on command signal and power-off command signal from the command output part 507 are also inputted to the controller of a target elevator car. In response to the command signals, the controller returns the elevator car from the stand-by mode to the run mode or shifts the elevator car from the run mode to the stand-by mode.

As described above, each of the elevator cars is equipped with the remotely-operable switch 701. In order to place the "elevator car 1" in stand-by mode, for example, the command output part 507 applies the power-off command signal so as to open the switch 701a for the "elevator car 1" and to shut down the power supply to the inverter 702a and motor 703a. Thus is eliminated standby energy consumption by the inverter 702a and motor 703a and the energy consumption by the elevator car in stand-by mode can be decreased.

The status indicator 600 is a function to inform the passenger as to whether the elevator car is in the run mode or the stand-by mode. As will be described hereinafter, one indicator is provided at the elevator hall or otherwise, each elevator car is provided with one indicator on a front side of the door thereof. The status indicator 600 (expressed as "indicator in elevator hall" in the figure) indicates the status of the elevator car(s).

The status indicator 600 is also adapted to display only elevator car(s) in the stand-by mode but not to display the elevator car(s) in the run mode.

The passenger arriving at the elevator hall can readily know which elevator car is in the stand-by mode by looking at signs on the status indicator. Therefore, the passenger can move to the running elevator car without being confused.

A sequence of control operations shown in FIG. 2 is implemented by an arithmetic processing unit (not shown) such as a microprocessor executing a predetermined computer program. The arithmetic processing unit periodically executes the control operations at 1 to 5-minute intervals corresponding to the minimum fluctuation time in which the number of waiting passengers, etc. fluctuates.

By controlling the elevator cars on/off at several-minute intervals, the elevator system can deal with the abrupt increase in the number of waiting passengers, etc. as well as with the abrupt increase in the amount of power used. It is noted that a control period can be set longer if the elevator system does not deal with the abrupt increase in the number of waiting passengers, etc. or the amount of power used.

It suffices that the elevator system changes the

number of running elevator cars in control cycles of at least 5 to 10 minutes. Thus, the running status of the elevator cars is changed so frequently that the elevator system can prevent the passengers from being confused. What is more, various components are less susceptible to deterioration and the like due to fluctuated voltage or current because the number of changes in the mode of the elevator is decreased.

FIG. 3A, FIG. 3B and FIG. 3C illustrate an example of operations by the control structures of this system. Three graphs shown in FIG. 3A, FIG. 3B and FIG. 3C plot the same chronological sequence on the abscissa, respectively. FIG. 3A shows the time varying amount of power used in the building or area. FIG. 3B shows the time varying number of waiting passengers, etc. FIG. 3C shows the time varying number of running elevator cars that is set in response to the amount of power used or the number of waiting passengers, etc. The following description, which is divided into three time domain A (A01), time domain B (A02) and time domain C (A03), is made on how the number of running elevator cars is adjusted according to the amount of power used or the number of waiting passengers, etc.

Looking at the time domain A (A01), a characteristic line A04 of FIG. 3A representing the amount of power used

maintains a constant value. A characteristic line A05 of FIG. 3B representing the number of waiting passengers, etc. is increased. In the time domain A (A01) of FIG. 3C, the number of running elevator cars A07 is progressively increased within a range of an upper limit A06 represented by a dotted line so that elevator cars may have a handling capacity commensurate with the number of waiting passengers, etc. As indicated by a symbol "A08" for example, the upper limit of the number of running elevator cars is increased from two to three. As indicated by a symbol "A09", the upper limit is further increased from three to four.

Looking at the time domain B (A02), the characteristic line A04 of FIG. 3A representing the amount of power used is increased, while the characteristic line A05 of FIG. 3B representing the number of waiting passengers, etc. maintains a constant value. In the time domain B (A02) of FIG. 3C, the amount of power used is increased and hence, the upper limit is decreased according to the upper running-car number limit table 305 defining the relation between the number of power used and the upper limit of the number of running cars. As indicated by a symbol "A10", for example, the upper limit of the number of running elevator cars is decreased from four to three.

As a result of the upper limit decreasing from four to three, the number of running elevator cars is also decreased from four to three. In this manner, this embodiment decides the upper limit of the number of running elevator cars placing priority on the amount of power used rather than on the number of waiting passengers, etc.

This embodiment places a top priority on setting the number of running elevator cars based on the amount of power used (or power use rate) and decides the upper limit of the number of running elevator cars that is within the upper limit dependent upon the amount of power used or the like and that provides the greatest possible handling capacity commensurate with the number of waiting passengers, etc.

Even in a case where the handling capacity of elevator cars is insufficient for the number of waiting passengers, etc., therefore, this system prioritizes the control of the number of running elevator cars based on the amount of power used when a large amount of power is used (for example, the power use rate of the power system is 80% or more). Thus, the system can contribute to sustaining the power supply-demand balance of the power system although the elevator passengers may experience temporary inconvenience.

Looking at the time domain C (A03), the characteristic line A04 of FIG. 3A representing the amount of power used stops increasing and maintains a constant value. The characteristic line A05 of FIG. 3B representing the number of waiting passengers, etc. starts to decrease in value. In FIG. 3C, the characteristic line A05 is decreased in value in the time domain C (A03) and hence, the handling capacity becomes excessive. As indicated by a symbol A11, therefore, the number of running elevator cars is decreased further by one.

This embodiment controls the number of running elevator cars to the minimum necessary in response to the elevator usage status (quantity demanded). Thus, this embodiment can prevent more elevator cars than necessary from running, thus achieving an enhanced energy saving effect.

Namely, this embodiment responds to the latest sum of the numbers of waiting passengers, etc. for plural elevator cars and decides such a number of running elevator cars as to provide a greater handling capacity than the sum of the numbers of waiting passengers, etc. (or a handling capacity as close as possible to the sum of the numbers of waiting passengers, etc.). Therefore, this embodiment is adapted to operate the elevator system with the minimum number of running elevator cars that satisfy

the demand for elevator ride.

As a result, this embodiment can meet the opposite demands for the passengers' convenience (ensuring good handling capacity) and the decrease in energy consumption. Further, the embodiment can even eliminate the standby energy consumption by the elevator cars because the power supply to the elevator cars to go stand-by mode is shut down.

When the predetermined elevator car is placed in the run mode or the stand-by mode, the embodiment places the predetermined elevator car in the run mode or stand-by mode according to the sequence previously defined based on the layout of the elevator cars at the elevator hall. Therefore, the passengers can smoothly ride in any one of the elevator cars controlled by this system or wait at the elevator hall with ease.

Alternatively, it is also contemplated to place the elevator car in the stand-by mode in order of increasing time to go stand-by mode. In this case, however, it is difficult for the passenger to predict which of the elevator cars will go stand-by. Hence, the passengers wait for the arrival of the elevator car with anxiety. This results in lowered passenger convenience.

As shown in FIG. 3C, for example, the passengers may be confused if the elevator car in the stand-by mode is

changed each time the number of running elevator cars is changed. Further, if the running elevator cars get centered on a less accessible location for the passengers (e.g., in the innermost recess of the elevator hall) in the layout of the elevator hall, the passengers rush to the running elevator cars so that the passenger convenience is lowered.

However, the embodiment is provided with the status indicator 600 for informing the passengers as to which elevator car is in the stand-by mode. Therefore, even in the structure where the elevator car to go stand-by mode changes each time, the status indicator 600 can previously supply the information to the waiting passengers at the elevator hall so that the passenger convenience is not impaired.

The details of the control structures shown in FIG. 2 are described with reference to FIG. 4 to FIG. 14B.

FIG. 4 shows an example of the sensor parts 101a to 101c for detecting the passengers waiting for the elevator car (and the riding passengers in the elevator car).

The lobby floor (first floor), for example, is provided with an infrared motion sensor 101a1 at an entrance 710 and a security gate 101a2 permitting the passage of only authenticated passengers. The number of passengers entering the lobby floor can be detected by

means of these sensors 101a1, 101a2. Otherwise, an ID authentication device or the like other than the security gate 101a2 is also usable. Further, a camera 101a3 may be installed on a ceiling of a hall way from the entrance 710 to the elevator hall so as to detect the passengers moving to the elevator hall. Further, a hall camera 101a4 may be installed on a ceiling of the elevator hall so as to detect the passengers waiting for the arrival of the elevator car.

The hall camera 101a4 is a sensor for detecting the number of waiting passengers for elevator car at the elevator hall. The other sensors 101a1 to 101a3 are sensors for detecting the passengers approaching the elevator hall to ride in the elevator car.

Description is made on sensors on the floors other than the lobby floor. On the Nth floor, for example, a security door 101c2 is installed at a hall way to the elevator hall. A person wanting to use the elevator must be authenticated by an ID authentication device 101c1 provided at the security door 101c2. Thus, the passengers moving to the elevator hall can be detected by the ID authentication device 101c1. Further, it is also possible to detect the number of waiting passengers at the elevator hall on the Nth floor by means of a hall camera 101c3 installed on a ceiling of the elevator hall on the Nth

floor.

In addition to the groups of sensors 101a1 to 101a4, 101c1 to 101c3 disposed on the building floors, other sensors 704a1, 704a2 may also be installed in the elevator car.

A load sensor 704a1 detects the gross weight of passengers riding in an elevator car 704a. Hence, the number of passengers riding in the elevator car can be estimated by dividing the gross weight by a predetermined average body weight. Further, an in-car camera 704a2 may also be used to detect the riding passengers in the car.

In a case where the sensors 101a1 to 101a4, 101c1 to 101c3 are not provided on the building floors, it is also possible to estimate the number of waiting passengers, etc. by utilizing the in-car load sensor 704a1 and/or the in-car camera 704a2.

FIG. 5 shows a structure of the passenger number data processor 200. First, the time average calculator 201 calculates, per predetermined time period, the time-averaged value of the sum of the passenger numbers 'PTn' (sum of the numbers of waiting passengers, etc.) at clock time 'n' calculated by the calculator 103 of sum of passenger numbers. A method of moving average, for example, is used to calculate the average value at each clock time 'n'. The calculation process is shown below.

Time-averaged value of number of waiting passengers, etc. = $(1/T)(\Sigma PTn)$ … (1),

where Σ denotes an integration value of 'PTn' within time period 'T'. The time period 'T' is set for a range of 1 to 10 minutes. The reason for setting the time period for average calculation is to take a broad view of the fluctuations in the number of waiting passengers, etc. and to disregard the small fluctuations thereof.

In a case where the number of running elevator cars is changed based on the fluctuations in the passenger number at an interval of less than 1 minute, the number of running elevator cars is changed more frequently than necessary and hence, the energy saving effect is decreased.

On the other hand, in a case where the time period 'T' is set to an unduly long period, obtained data is lowered in followability to the fluctuations in the number of waiting passengers, etc. This may lead to a fear that the handling capacity falls short to increase wait time, resulting in the decrease of passenger convenience. Aiming at balancing the energy saving effect with the passenger convenience, the embodiment is designed to calculate the average value of the number of waiting passengers, etc. at a time interval 'T' of 1 to 10 minutes, for example.

The processing of calculating the time average may

be replaced by a computation using the low-pass filter (LPF) which regards the sum of passenger numbers 'PTn' as time-series signal.

The deviation calculator 202 shown in FIG. 5 calculates a difference (PTn- $\overline{PTn}$) between data 'PTn' at clock time 'n' and time average '$\overline{PTn}$'.

Based on the magnitude of (PTn - $\overline{PTn}$), the selection decision part 203 selects one of the time average '$\overline{PTn}$' and the data 'PTn' at clock time 'n', as the data on the number of waiting passengers, etc.

Specifically, the selection decision part 203 compares (PTn- $\overline{PTn}$) with a predetermined threshold by way of processing of comparison with threshold 203a. The selection decision part 203 performs a switching operation 203b for selectively using the time average '$\overline{PTn}$' in the case of (PTn - $\overline{PTn}$) < threshold or the data 'PTn' at clock time 'n' in the case of (PTn - $\overline{PTn}$) > threshold.

This embodiment normally uses the time average '$\overline{PTn}$'. In the case of an abrupt increase in the number of waiting passengers, etc., however, the data 'PTn' at clock time 'n' is used. Even in the case of an abrupt increase in the number of waiting passengers, etc. like immediately after the close of a big conference, the embodiment can quickly deal with the change. Thus, the embodiment can increase the number of running elevator cars in quick

response to the abrupt increase in the number of waiting passengers, etc., preventing the increase in the wait time for the passengers to wait at the hall.

FIG. 6 is a flow chart showing the steps of processing of setting an upper limit of the number of running elevator cars. Description is made on the processing of setting the upper limit of the number of running elevator cars based on the data on the amount of power used and the time schedule table. While the processing is mainly performed by the upper limit setting part 306, the description of the flow chart is made on assumption for convenience that the elevator system 1 is principally responsible for the processing. The same applies to the description made hereinafter on the other flow charts.

The elevator system 1 determines whether one of the data on the amount of power used and the data on the power use rate is acquirable or not (FA01). The data acquisition part 304 retrieves the data on the amount of power used or the like from the power system information database 301, CEMS 302 and BEMS 303 described with reference to FIG. 2.

If the data on the amount of power used or the like is acquirable (FA01: YES), the elevator system 1 acquires the data on the amount of power used or the like (FA02).

The elevator system 1 refers to the upper running-car number limit table 305 based on the data on the amount of power used or the like, and sets the upper limit of the number of running elevator cars to a value 'A' (FA03).

On the other hand, in a case where the elevator system 1 does not have a function to communicate with the BEMS 303, CEMS 302 or the like, or where the network communications function of the elevator system is temporarily broken down, the system cannot acquire the data on the amount of power used or the like (FA01: NO). Hence, the elevator system 1 skips the steps FA02 and FA03, proceeding to step FA04.

Now, exemplary contents of the upper running-car number limit table 305 are described with reference to FIG. 7A and FIG. 7B. FIG. 7A shows the example of the upper running-car number limit table 305, where ranges of the power use amount or the like and the corresponding upper limits of running elevator cars are set forth in a table format.

In the example of FIG. 7A, the data on the amount of power used or the like is represented by the power use rate (ratio of amount of power used to amount of power generated by power system of interest). In the case of an power use rate of 82%, for example, the upper limit of the number of running elevator cars is set to '2'. In the

example shown in FIG. 7A and FIG. 7B, four elevator cars in total are installed. That the upper running elevator-car limit is set to '2' means that only a half of the all elevator cars can run.

FIG. 7B graphically shows the characteristic of the upper running-car number limit table 305. The graph plots the power use rate on the abscissa and the upper running elevator-car limit on the ordinate. As shown in the graph, the table is characterized by decreasing the upper limit of the number of running elevator cars with the increase in the power use rate (or the amount of power used). Particularly in a region where the power use rate is 80% or more, a "caution level" is set indicating a small margin of power supply-demand balance. In a case where the power use rate is in the region of "caution level", the upper limit of the number of running elevator cars is set to less than a half of all the elevator cars (the total number of controlled elevator cars in the case of an elevator group control).

A region where the power use rate is 90% or more means a "warning level" indicating little margin of power supply-demand balance. In the region of "warning level", the upper limit of the number of running elevator cars is set to '1' in order to prevent the power supply-demand from becoming imbalanced. Further, in a region where the

power use rate is 95% or more, the upper limit of the number of running elevator cars is set to '0' so as to place all the elevator cars in stand-by mode. In this manner, the energy consumption is decreased.

According to the embodiment as described above, the upper limit of the number of running elevator cars is set in response to the amount of power used (or power use rate) in the building where the elevators are installed or the area where the building is located, as shown in FIG. 7B. Thus, the elevator system can properly control the energy consumption by the elevators according to the power supply-demand status. As a result, the elevator system 1 of the embodiment can contribute to the stable power supply-demand balance.

Returning to FIG. 6, the elevator system 1 acquires clock time information from the clock 402 (FA04). The elevator system 1 refers to the schedule table 401 of upper running-car number limit based on the clock time information and sets the upper limit of the number of running elevator cars to a value 'B' (FA05).

FIGS. 8A and 8B show an example of the schedule table 401 of upper running-car number limit. As shown in FIG. 8A, the schedule table 401 defines the upper running-car limit per clock hour. While FIGS. 8A and 8B show only a time range from 8 o'clock to 20 o'clock as an example,

the schedule table may also be configured to set the upper running-car number limit per hour in a time range from 0 o'clock to 24 o'clock. Further, the upper running-car number limit may also be defined on the basis of another time unit such as 30 minute, or 90 minute rather than hour.

FIG. 8B graphically shows the characteristic of the schedule table 401. As shown in the graph of FIG. 8B, the number of running elevator cars is limited during midday hours (e.g., from 11 o'clock to 16 o'clock) when the margin of power supply-demand balance is small. Particularly in a time slot from 13 o'clock to 15 o'clock when the margin of power supply-demand balance is further decreased, the upper limit of the number of running elevator cars is set to '2', a half of all the elevator cars.

Returning to FIG. 6, the elevator system 1 determines whether the data on the amount of power used or the like could be acquired or not (FA06). If the data on the amount of power used or the like is acquired (FA06: YES), the elevator system 1 determines whether or not the value 'A' of upper running-car number limit decided based on the power usage status is less than the value 'B' of upper running-car number limit decided based on the schedule (FA07).

If the upper limit value 'A' based on the power

usage status is less than the upper limit value 'B' based on the current clock time (A < B), the elevator system 1 sets the upper running-car number limit to the upper limit value 'A' (FA08). Conversely, if the upper limit value 'A' is equal to or more than the upper limit value 'B' (A≥B), the elevator system 1 determines whether or not to prioritize the upper limit value based on the power usage status (FA09).

In a case where the upper limit value 'A' based on the power usage status is prioritized (FA09: YES), the elevator system 1 sets the upper limit of the number of running elevator cars to the upper limit value 'A' (FA08). In a case where the upper limit value 'A' based on the power usage status is not prioritized (FA09: NO), the elevator system 1 sets the upper limit of the number of running elevator cars to the upper limit value 'B' (FA10).

In Step FA10, the smaller one 'B' of the upper limit value 'A' and the upper limit value 'B' is set as the upper limit of the number of running elevator cars, after all. In a case where the data on the amount of power used is not acquired (FA06: NO), the elevator system 1 sets the upper limit of the number of running elevator cars to the upper limit value 'B'.

As described above, the embodiment has a total number of three methods ready beforehand, which include:

(1) method where the upper limit value is decided based on the power usage status; (2) method where the upper limit value is decided based on the time schedule; and (3) method where the methods (1) and (2) are used in combination to decide the upper limit value.

The elevator system 1 sets the upper limit of the number of running elevator cars by using any one of these three methods. When the data indicative of the power usage status is acquirable, therefore, the elevator system can set the upper limit value based on the data. When such data is not acquirable, the elevator system can set the upper limit value according to the time schedule or the like.

As a result, the elevator system 1 of the embodiment can contribute to the stable power supply-demand balance.

Further, according to the third setting method, the elevator system 1 sets the upper limit of the number of running elevator cars to the smaller one of the upper limit value 'A' based on the power usage status and the upper limit value 'B' based on the time schedule. As compared with the case where the upper limit value is set simply based on the time schedule, therefore, the third method has the potential of providing higher power saving effect or power saving effect.

FIG. 9 is a flow chart showing the steps of

processing of calculating and setting the number of running elevator cars according to the number of waiting passengers, etc. While the processing is mainly performed by the calculator/setter of number of running elevator cars 501, the description is made on assumption for convenience that the elevator system 1 is principally responsible for the processing.

According to the flow chart of FIG. 9, the upper limit of the number of running elevator cars and the number of waiting passengers, etc. are used for calculating and setting the number of running elevator cars according to the power usage status and elevator usage status. The steps of the processing are described in sequence as below.

First, the elevator system 1 retrieves data 'J1' on upper running-car number limit from the upper limit setting part 306 (FB01). Next, the elevator system 1 retrieves data on number of waiting passenger etc. from the selection decision part 203 (FB02) and converts the data on number of waiting passenger etc. to a value 'UN' of the number of waiting passengers etc. per given time period (e.g., per 5 minute period) (FB03). In Step FB03, the elevator system converts the number of waiting passengers etc. to the value 'UN' of the number of waiting passengers etc. per given time period in order to

compare the value of the handling capacity of the elevator cars with the number of waiting passengers etc. under the same conditions.

The elevator system 1 selects, from a data table of handling capacity of elevator cars, the minimum number 'J2' of elevator cars that provides a larger value of the handling capacity (the sum of handling capacities of all the elevator cars controlled) than the value 'UN' of the number of waiting passengers etc. per given time period (FB04).

Now referring to FIG. 10, an example of the handling capacity table is described. The handling capacity table stores the values of handling capacity of elevator for the respective numbers of elevator cars. The handling capacity of elevator is defined as the number of transportable passengers per given time period.

The elevator system 1 compares the value 'UN' of the number of waiting passengers etc. per given time period that is calculated in Step FB03 with the value of handling capacity listed in the handling capacity table in ascending order of the number of cars starting from one. The elevator system 1 selects, from the table of FIG. 10, the minimum number of running elevator cars that provides the larger value of handling capacity per given time period than the value 'UN' of the number of waiting

passengers etc. per given time period.

The elevator system 1 can determine the value of the handling capacity by calculating the volume of passengers carried per round trip of each elevator car based on, for example, speed, capacity, door open time/door close time, number of stops at floors, acceleration/deceleration or the like of each elevator car; summing up the volumes of passengers carried per round trip of the elevator cars; and converting the resultant sum to a volume of passengers carried per given time period.

The data on elevator speed and the like that is used for the calculation of handling capacity is retrievable from specification data stored in the elevator specification database 502. For calculation of the handling capacity for each number of running elevator cars, the elevator system uses an on/off sequence contained in data stored in the on/off sequence table 505 that specifies the order in which the elevator cars go run mode or stand-by mode.

Returning to FIG. 9, the elevator system 1 determines whether or not the minimum number 'J2' of running elevator cars is equal to or more than the upper running-car number limit 'J1' (FB05). If the upper limit 'J1' is not more than the minimum running-car number 'J2' (J2≥J1), the elevator system 1 sets the number 'J' of

running elevator cars to 'J1' (FB06). In a case where the minimum running-car number 'J2' is less than the upper limit 'J1' (J2 < J1), on the other hand, the elevator system 1 sets the number 'J' of running elevator cars to 'J2' (FB07).

As described above with reference to FIG. 9, the embodiment prioritizes the upper limit based on either the power usage status or the time schedule and selects, as the running-car number, the minimum number of elevator cars that is equal to or less than the upper limit and provides the handling capacity to carry not less than the number of waiting passengers, etc.

As a result, the embodiment operates the minimum number of elevator cars that can carry the number of waiting passengers, etc. under the condition prioritizing the power usage status (the status of power supply-demand balance). Thus, the embodiment can further improve the energy saving effect or power saving effect because the minimum number of elevator cars that is commensurate with the number of waiting passengers, etc. is operated. What is more, the embodiment improves not only the energy saving effect but also the passenger convenience. This is because the number of elevator cars that is commensurate with the number of waiting passengers, etc. is operated.

FIG. 11 is a flow chart showing the steps of

processing of selecting an elevator car to go run mode or stand-by mode. While the processing is mainly performed by the elevator car selector 503, the description of the flow chart is made on assumption for convenience that the elevator system 1 is principally responsible for the processing. In this processing, the elevator car to go run mode or stand-by mode is selected according to the selected number of running elevator cars. The processing is described in sequence as below.

First, the elevator system 1 retrieves parameter data 'J3' on number of running elevator cars from the calculator/setter of number of running elevator cars 501 (FC01). Next, the elevator system 1 retrieves data 'J4' on current number of running elevator cars from the elevator status data acquisition part 504 (FC02).

The elevator system 1 determines whether or not the parameter 'J3' of the number of running elevator cars is equal to or more than the current number of running elevator cars (J3≥J4). If the parameter 'J3' of the number of running elevator cars is equal to or more than the current number of running elevator cars (J3≥J4), the elevator system 1 determines that the current number 'J4' of running elevator cars is insufficient and selects elevator car(s) to run anew (FC04). In Step (FC04), the elevator system 1 selects (J3-J4) elevator cars to run

anew with reference to the on/off sequence table 505.

On the other hand, if the parameter 'J3' of the number of running elevator cars is less than the current number 'J4' of running elevator cars (J3 < J4), the elevator system 1 determines that the current number 'J4' of running elevator cars is more than necessary and selects elevator car(s) to go stand-by mode (FC05). In Step (FC05), the elevator system 1 refers to the on/off sequence table 505 and selects (J4-J3) elevator car(s) as the stand-by mode object from the currently running elevator cars.

Lastly, the elevator system 1 outputs, to the next step, data (elevator car designation, etc.) for identifying the elevator car(s) selected as the run mode object or stand-by mode object, the illustration of which is omitted. In this manner, the embodiment decides the elevator car(s) to go run mode or stand-by mode according the predetermined sequence of elevator cars on/off (sequence set forth in the table 505).

According to the embodiment, a plurality of elevator cars run or go stand-by mode according to the given sequence. Even if a special indicator or display is not provided in a building, passengers who relatively frequently visit the building can make a good guess as to which elevator car is running or which elevator car is in

the stand-by mode.

As will be described hereinafter, the embodiment specifies the sequence of elevator cars on/off, considering the convenience for boarding and alighting passengers from a viewpoint of the elevator hall layout and a flow line of passengers. Thus, the embodiment can even further improve the passenger convenience.

FIG. 12A, FIG. 12B and FIG. 12C each show an example of the contents of the on/off sequence table 505 for managing the order in which the elevator cars go run mode or stand-by mode. The sequence of elevator cars on/off is defined based on the layout of the individual elevator cars at the elevator hall.

FIG. 12A, FIG. 12B and FIG. 12C each show an example of defining the sequence of elevator cars on or off according to the layout of the plural elevator cars. In the case of elevator cars to go stand-by mode in contrast to the case of elevator cars to go run mode anew, the hall is apt to be overcrowded. It is therefore necessary to define the sequence in such a manner to permit the passengers to board the elevator cars smoothly.

FIG. 12A shows an example where four elevator cars in total are arranged on one side of the hall. Entrance/exit of the elevator hall is disposed on both the right and left sides of FIG. 12A. A flow line B02 of

passengers entering through the left-hand hall entrance B01 as seen in the figure is a flow line of the largest number of waiting passengers, etc., namely the main flow line of the elevator passengers. The elevator cars are individuated as "#1", "#2", "#3" and "#4". The "elevator car 1" is represented by "#1" and the "elevator car 2" is represented by"#2". A symbol under the elevator car number represents the order of elevator cars to go stand-by mode. The first car to go stand-by mode is represented by "S1", while the second car, the third car and the fourth car to go stand-by mode are represented by "S2", "S3" and "S4", respectively.

In the case of the layout shown in FIG. 12A, it is preferred to place the elevator cars in stand-by mode, for example, in the order of the elevator car 4 "#4" B06, the elevator car 3 "#3" B05, the elevator car 2 "#2" B04 and the elevator car 1 "#1" B03, as indicated by a sequence table B07 on the right side of the layout drawing. The sequence tables B07, B16 and B25 shown in FIGS. 12A to 12C are specific examples of the on/off sequence table 505 described with reference to FIG. 2.

The reason for defining the sequence of elevator cars off in this manner is that the farther from the entrance B01 on the flow line B02 of the largest number of passengers, the elevator car is more prioritized in the

stand-by mode sequence. Accordingly, the elevator cars B03, B04 more accessible and closer to the main flow line of passengers are less likely to go stand-by mode. This permits the passengers arriving at the hall to board the nearest available elevator car so that the passengers need not walk to the innermost recess of the hall. Thus is enhanced the passenger convenience.

Since the running elevator car(s) are close to the entrance on the main passenger flow line B02, the running elevator car(s) are more likely to come into view of the elevator passengers. Therefore, the passengers quickly notice the running elevator car(s) and hence, can board the elevator car quickly.

A sequence in which the elevator cars in stand-by mode are made to go run mode is the reverse of the sequence set forth in the sequence table B07. Namely, the elevator cars go run mode in the order of the elevator car 1 "#1" B03, the elevator car 2 "#2" B04, the elevator car 3 "#3" B05 and the elevator car 4 "#4" B06.

Thus, the elevator car 1 "#1" B03, which is the closest to the entrance on the main passenger flow line B02, is the last to go stand-by mode and the first to go run mode. The elevator car 1 "#1" B03, which is the most convenient for the elevator passengers, is so controlled as to run for the longest operating time among all the

elevator cars. By assigning the longest operating time to the elevator car "#1" which is the most accessible to the elevator passengers, the elevator system can ensure the passenger convenience and prevent the increase in the wait time.

Conversely, the elevator car 4 "#4" B06, the farthest from the entrance on the main passenger flow line B02, is the first to go stand-by mode and the last to go run mode. The elevator car 4 "#4" B06, which is farthest away from the entrance on the main passenger flow line and most inconvenient for the passengers, is so controlled as to run for the shortest operating time. Thus, the elevator car 4 "#4" B06 which is least accessible to the elevator passengers can be increased in stand-by mode time so that the stand-by energy consumption is decreased to ensure the energy saving effect.

In the case making the elevator cars go stand-by mode, the elevator car farther away from the elevator passengers and less recognizable is faster to go stand-by mode, while the elevator car closer to the elevator passengers and more recognizable is slower to go stand-by mode. Conversely in the case of making the elevator cars in the stand-by mode go run mode again, the elevator car closer to the elevator passengers and more recognizable is faster to go run mode, while the elevator car farther away

from the elevator passengers and less recognizable is slower to go run mode. The same is also applied to other cases (b) and (C) which are described as below.

FIG. 12B shows an example where six elevator cars in total (three elevator cars on either side) are arranged in face-to-face relation. The hall has a "blind alley" arrangement where an entrance B08 is disposed only on the left side as seen in the figure. Most elevator passengers move along a main passenger flow line B09 to enter the hall through the entrance B08 in a direction of the arrow.

In the case of the layout shown in FIG. 12B, the most noticeable elevator car to the passengers moving along the main flow line is an elevator car 4 "#4" B13 and the noticeability decreases in the order of elevator car 5 "#5" B14, elevator car 6 "#6" B15, elevator car 1 "#1" B10, elevator car 2 "#2" B11 and elevator car 3 "#3" B12.

As set forth in a sequence table B16 shown on the right side of FIG. 12B, therefore, a sequence of elevator cars off is defined as the reverse of the order in which the elevator cars decrease in the noticeability to the elevator passengers. Namely, the elevator cars go stand-by mode in the order of elevator car 3 "#3" B12, elevator car 2 "#2" B11, elevator car 1 "#1" B10, elevator car 6 "#6" B15, elevator car 5 "#5" B14 and elevator car 4 "#4" B13. A sequence of elevator cars on is the reverse of the

above described sequence of elevator cars off.

FIF.12C shows an example where three elevator cars are arranged on either side of the hall in face-to-face relation similarly to the layout of FIG. 12B. However, the elevator hall of FIG. 12C is narrower than that of FIG. 12B.

Most elevator passengers move along a main passenger flow line B18 in a direction of the arrow, entering the hall from the only one entrance B17 on the left side as seen in the figure. The hall of FIG. 12C has such a small area that it takes a long time in busy hours for the passengers to reach the elevator car (e.g., elevator car 3 "#3" B21 or elevator car 6 "#6" B24) in the innermost recess of the elevator hall. It is therefore desirable to run the elevator car closest to the entrance B17 as long as possible and to hold the elevator car farthest away from the entrance B17 in stand-by mode as long as possible.

In the case of a layout shown in FIG. 12C, therefore, the elevator cars are made to go stand-by mode in the order of elevator car 3 "#3" B21, elevator car 6 "#6" B24, elevator car 2 "#2" B20, elevator car 5 "#5" B23, elevator car 1 "#1" B19 and elevator car 4 "#4" B22, as set forth in a sequence table B25 on the right side as seen in the figure. A sequence of elevator cars on is the reverse of the sequence of elevator cars off: elevator car 4 "#4" B22,

elevator car 1 "#1" B19, elevator car 5 "#5" B23, elevator car 2 "#2" B20, elevator car 6 "#6" and elevator car 3 "#3" B21.

The sequence of elevator cars off defined in this manner can permit the elevator passengers to easily reach the nearest, accessible elevator car to board it, even in the case of increase in the number of elevator cars in stand-by mode. Hence, the elevator system can prevent the decrease in the passenger convenience while achieving the energy saving effect.

FIG. 13 is a flow chart showing the steps of processing of determining whether an elevator car selected as the stand-by mode object can go stand-by mode or not. The processing is mainly performed by the stand-by mode decision part 506. The processing is described sequentially as below.

First, the elevator system 1 determines whether there is any elevator car to go stand-by mode anew or not (FD01). If there is no elevator car to go stand-by mode anew (FD01: NO), this processing is terminated. If there is some elevator car to go stand-by mode anew (FD01: YES), the elevator system retrieves the designation of the elevator car(s) as the stand-by mode object (any information that permits the identification of the elevator car(s) of interest) and the number of elevator

cars to go stand-by mode 'J5' from the elevator car selector 503 (FD02).

Next, the elevator system 1 determines whether the elevator car(s) as the stand-by mode object satisfy predetermined stand-by mode conditions or not (FD03). The predetermined stand-by mode conditions include the following, for example:

(1): that the elevator car has the door closed and is stopped in a floor;

(2): that the status of condition (1) continues for a predetermined period of time (e.g., 3 minutes).

In a case where information on a hall call or car call assigned to the elevator car as the stand-by mode object is acquirable, the condition (1) may further include an additional term that the elevator car has no call assigned.

If the elevator car as the stand-by mode object satisfies both of the conditions (1) and (2) (FD03: YES), the elevator system 1 determines that the elevator car of interest can go stand-by mode and sends a stand-by mode command to the elevator car as the stand-by mode object (FD04).

If the elevator car as the stand-by mode object does not satisfy one of the conditions (1) and (2) (FD03: NO), the elevator system 1 defers the stand-by mode of the

elevator car as the stand-by mode object (FD05). The elevator system 1 does not send the stand-by mode command to the elevator car the stand-by mode of which is to be deferred. After the lapse of a predetermined period of time, the elevator system determines again whether the elevator car with the deferred stand-by mode satisfies the stand-by mode conditions or not (FD05).

After sending the stand-by mode command to the elevator car as the stand-by mode object, the elevator system 1 decrements the number of elevator cars to go stand-by mode 'J5' (FD06). The elevator system 1 repeats the above-described determination steps FD03 to FD06 till the number of elevator cars to go stand-by mode 'J5' is decreased to 'zero' (namely, till all the elevator cars as the stand-by mode object are checked).

In this embodiment, the above-described stand-by mode determination processing is performed to confirm that the elevator car of interest is not operated and thereafter, the power supply to the elevator car of interest is shut down. Hence, the embodiment can ensure safety.

FIG. 14 shows an exemplary structure of the status indicator 600. FIG. 14A shows an example where information on the run or stand-by mode of all the elevator cars is collectively displayed at the elevator

hall. A display unit 601 is fixed on a wall at the entrance to the elevator hall, for example. The display unit 601 displays information pieces received by means of a wireless device 602. The display unit 601 provides current information pieces regarding the run mode or stand-by mode of the individual elevator cars.

The display unit 601 is adapted to show, for example, the layout of the elevator hall and the run mode or stand-by mode of the individual elevator cars in corresponding relation with the hall layout. Thus, the display unit can provide guidance easier for the elevator passengers to follow.

The display unit 601 may also indicate the power use rate. By doing so, the display unit can gain passengers' understanding for placing some elevator cars in the stand-by mode.

In a case where the number of running elevator cars is controlled based on the time schedule, the display unit 601 may show the time schedule regarding the run mode or stand-by mode of the elevator cars, the illustration of which is omitted. This permits the elevator passengers to move with the knowledge of the schedule, resulting in the improved passenger convenience.

FIG. 14B shows a case where the information is provided on a per-elevator-car basis. Individual display

units 610a, 610b are provided on a front side of each of the elevator cars. The display unit 610a corresponding to the elevator car in the stand-by mode displays "stand-by".

In contrast, the display unit 610b corresponding to the running elevator car displays nothing for power saving purpose.

The energy-saving type elevator system of the embodiment involves a fear that the elevator passengers less attuned to this system may be bewildered by the system because the number of running elevator cars change each time the power usage status and the number of waiting passengers, tec. fluctuate. However, this embodiment is provided with the status indicator 600 for supplying the elevator passengers with the information regarding the run mode or stand-by mode of the individual elevator cars. Therefore, the embodiment can make the elevator passengers less bewildered, preventing the decrease in the passenger convenience.

It is to be noted that the invention is not limited by the above-described embodiments and those skilled in the art may contemplate various modifications and changes without departing from the spirit and scope of the invention. For example, the text display may be replaced by or combined with voice guidance to inform the elevator passengers of the run mode or stand-by mode of the

elevator cars. An alternative structure may also be adopted such that the information regarding the run mode or stand-by mode of the elevator cars or the time schedule is sent to passengers' information terminals (including cell phones, as well) in the form of electronic mail.

What is claimed is:

1. An elevator system for controlling a plurality of elevator cars travelling through a plurality of floors comprising:

a detector of number of waiting passengers that detects the number of waiting passengers for an elevator car at least at any one of the plural floors;

a calculation part for sum of numbers of waiting passengers that calculates, as the sum of the numbers of waiting passengers, the sum of the numbers of waiting passengers detected by the detector of number of waiting passengers; and

a control part for running of elevator cars that calculates the number of running elevator cars out of the plural elevator cars based on the sum of the numbers of waiting passengers and controls the running of the plural elevator cars based on the calculated number of running elevator cars.

2. The elevator system according to Claim 1,

wherein the control part for running of elevator cars sets the number of running elevator cars in response to the increase or decrease in the sum of the numbers of waiting passengers.

3. The elevator system according to Claim 2,

wherein the control part for running of elevator cars increases or decreases the number of running elevator cars in response to the increase or decrease in the sum of the numbers of waiting passengers and according to a predetermined sequence of elevator cars on/off.

4. The elevator system according to Claim 3,

wherein the calculation part for sum of numbers of waiting passengers calculates the sum of the numbers of waiting passengers by multiplying the number(s) of waiting passengers detected at predetermined floor(s) out of the plural floors by a factor of 1 or more.

5. The elevator system according to any one of Claims 1 to 4,

wherein the control part for running of elevator cars calculates the number of running elevator cars in a manner that the number of running elevator cars decreases according to the decrease in the sum of the numbers of waiting passengers.

6. The elevator system according to any one of Claims 1 to 5,

wherein the control part for running of elevator cars decreases power supply to stand-by mode elevator car(s) of the plural elevator cars to less than power supplied to the running elevator cars of the plural elevator cars.

7. The elevator system according to Claim 6,

wherein the control part for running of elevator cars shuts down the power supply to the stand-by mode elevator car(s).

8. The elevator system according to Claim 7,

wherein the control part for running of elevator cars shuts down power supply to motor(s) driving the stand-by mode elevator car(s) in a case where the stand-by mode elevator car(s) have door(s) closed and remain stopped in floors for not less than a predetermined period of time.

9. The elevator system according to any one of Claims 1 to 8,

wherein the stand-by mode elevator car(s) are selected in a given sequence previously defined based on a layout of an elevator hall.

10. The elevator system according to Claim 9,

wherein the stand-by mode elevator car(s) are selected from the plural elevator cars in order of decreasing distance to passengers' access flow at the elevator hall.

11. The elevator system according to Claim 9,

wherein the stand-by mode elevator car(s) are selected in order of decreasing distance from an entrance of the elevator hall.

12. The elevator system according to Claim 1,

wherein based on information regarding energy consumption of the plural elevator cars, the control part for running of elevator cars calculates a second number of running elevator cars that indicates the number of elevator cars to go run mode, out of the plural elevator cars, and selects one of the number of running elevator cars and the second number of running elevator cars by comparing the number of running elevator cars calculated based on the sum of the numbers of waiting passengers with the second number of running elevator cars.

13. The elevator system according to Claim 12,

wherein the control part for running of elevator cars selects the second number of running elevator cars in a case where the second number of running elevator cars is less than the number of running elevator cars.

14. The elevator system according to Claim 1,

wherein even in a case where the second number of running elevator cars is equal to or more than the number of running elevator cars, the control part for running of elevator cars selects the second number of running elevator cars if a command to decrease the energy consumption is previously given.

15. The elevator system according to Claim 12,

wherein the information regarding the energy

consumption is defined based on limit on the amount of power used in a building where the plural elevator cars are installed or in a predetermined area where the building is located.

16. The elevator system according to Claim 1,

wherein the control part for running of elevator cars calculates the number of running elevator cars based on an average of the sum of the numbers of waiting passengers as determined in a predetermined period of time.

17. The elevator system according to Claim 1,

wherein based on predetermined schedule information, the control part for running of elevator cars calculates a third number of running elevator cars that indicates the number of elevator cars to go run mode, out of the plural elevator cars, and selects one of the number of running elevator cars and the third number of running elevator cars by comparing the number of running elevator cars calculated based on the sum of the numbers of waiting passengers with the third number of running elevator cars.

18. The elevator system according to Claim 17,

wherein an indicator for displaying the schedule information is provided at the elevator hall.

19. A control method of elevator for controlling a plurality of elevator cars travelling through a plurality of floors by using a computer, the computer performing:

a waiting passenger number detection step of detecting the number of waiting passengers for an elevator car at least at any one of the plural floors;

a summation step of calculating the sum of the detected numbers of waiting passengers as the sum of numbers of waiting passengers;

a running-car number calculation step of calculating the number of elevator cars to go run mode, out of the plural elevator cars, based on the sum of the numbers of waiting passengers; and

a control step of controlling the running of the plural elevator cars based on the calculated number of running elevator cars.