

TITLE OF THE INVENTION

DRIVE APPARATUS OF ELEVATOR APPARATUS

FIELD OF THE INVENTION

The present invention relates to an elevator apparatus
5 which is installed in a building and carries passengers and
goods, and particularly to a drive apparatus of an elevator
apparatus including a charge/discharge device for controlling
the charge/discharge of an electric storage device such as a
storage battery or a capacitor connected to a hoisting rotator
10 of an elevator.

BACKGROUND OF THE INVENTION

In an elevator apparatus including an electric storage
device, in general, power stored in an electric storage device
15 is discharged and supplied to a hoisting rotator during power
running (e.g., an operating state of lifting an elevator car),
and power generated by the hoisting rotator is charged to the
electric storage device during regenerative running (e.g., an
operating state of lowering the elevator car). Thus, the
20 hoisting rotator functions as a motor and also as a generator,
and the following description will be made on a hoisting motor.

In the elevator apparatus, the hoisting motor hoists a
rope connected to the elevator car to lift and lower the elevator
car. This hoisting system includes a drum system and a traction
25 system.

In the drum system, the hoisting motor lifts and lowers the elevator car, with a rope being wound on the drum. In the traction system, the elevator car and a balance weight are used, and the hoisting motor lifts and lowers the elevator car and
5 the balance weight, utilizing the balance.

The above-described charge/discharge control of the electric storage device applies to the drum system, and differs slightly from that of the traction system. More specifically, in the traction system, typically the ascent of the elevator
10 car carrying a rated number of passengers and the descent of the elevator car carrying no passengers place large loads on the hoisting motor.

Accordingly, discharge control is performed so that the electric storage device supplies power to the hoisting motor
15 at least in the ascent of the elevator car carrying a rated number of passengers and in the descent of the elevator car carrying no passengers. Further, it is needless to say that discharge might be performed during other operations.

Further, in charging, by determining the state of charge
20 (SOC) of the electric storage device and the state of power generated by the hoisting motor, power is charged to the electric storage device accordingly.

Japanese Unexamined Patent Publication No. 2001-261246 (Patent Document 1) and Japanese Unexamined Patent Publication
25 No. 2001-187677 (Patent Document 2) disclose elevator

apparatuses including such an electric storage device.

Patent Document 1 proposes a control technique of permitting the charge/discharge of the electric storage device and prohibiting discharge or charge in accordance with the
5 operating state of the elevator apparatus.

Patent Document 2 proposes a switching control technique of repeating at regular intervals (50 microseconds) the operation of turning on switching elements in the charge/discharge device and turning off the switching elements
10 after supplying predetermined power during power running to adjust the ratio between powers from a power supply and the electric storage device to the hoisting motor.

However, in the techniques described in Patent Documents 1 and 2, the switching elements constituting the
15 charge/discharge device perform a switching operation at a constant frequency.

For example in Patent Document 2, in a charge/discharge operation, the gate of a charge/discharge control circuit is turned on at intervals of 50 microseconds to measure discharge
20 current from a charge/discharge circuit.

Further, in terms of loads on the hoisting motor, despite the difference in discharged electric energy between high and low loads, the switching elements perform the switching operation at the constant frequency without distinguishing
25 between the high and low loads. In this case, power is controlled

by the so-called duty control for varying a switch-on time.

Further, as to a state of not performing charge/discharge, in Patent Document 1, when the input voltage of an inverter becomes a voltage command value, the switching operation is performed so that the on time and off time of two transistors become equal, thereby preventing charge/discharge. Therefore, the switching operation is performed even at the time of no charge/discharge.

Thus, in the related art, there is a problem that even at the time of low load or no charge/discharge, the switching is performed at the constant frequency and the switching frequency is not controlled, so that the switching elements are operated more than necessary, which reduces the life of the switching elements. Further, a concomitant problem of causing power loss in the charge/discharge device occurs as a side effect.

It is an object of the present invention to provide a charge/discharge device of an elevator apparatus that can maintain the longevity of switching elements in the charge/discharge device for controlling the charge/discharge of an electric storage device connected to a hoisting motor.

SUMMARY OF THE INVENTION

A drive apparatus of an elevator apparatus according to the invention includes a rotator drive circuit which drives

a hoisting rotator for lifting and lowering an elevator car as well as having a power generation capability, an electric storage device which supplies power to the hoisting rotator and stores power generated by the hoisting rotator, and a
5 charge/discharge device which discharges power from the electric storage device to the hoisting rotator and charges power generated by the hoisting rotator to the electric storage device. The charge/discharge device includes a switching unit which performs charge or discharge by a switching operation
10 of a switching element provided in the charge/discharge device and a charge/discharge control unit which decreases a switching frequency of the switching element or stops the switching operation when the elevator car is in a predetermined operating state.

15 According to the invention, in a specific operating state where a load on the hoisting motor is smaller than a predetermined threshold or a load quantity of the elevator car is less than a predetermined threshold, the switching frequency of an upper IGBT and a lower IGBT for switching in the charge/discharge
20 device is decreased or the switching operation is stopped, which can maintain the longevity of the switching elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is the circuit configuration of a charge/discharge
25 device used in an elevator apparatus according to an embodiment

of the present invention;

FIG. 2 is a characteristic graph showing the relationship between load and power consumption in a traction-type elevator apparatus;

5 FIG. 3 is a flowchart showing the determination logic of charge/discharge necessity determination means shown in FIG. 1;

FIG. 4 is an explanatory diagram showing the determination logic of the charge/discharge necessity determination means
10 shown in FIG. 1;

FIGS. 5A and 5B are charts showing a charge/discharge signal of a switching unit at the time of a large load on a motor of the charge/discharge device shown in FIG. 1;

15 FIG. 6 is a chart showing a charge/discharge signal of the switching unit at the time of a small load on the motor of the charge/discharge device shown in FIG. 1;

FIG. 7 is another chart showing a charge/discharge signal of the switching unit at the time of a small load on the motor of the charge/discharge device shown in FIG. 1;

20 FIG. 8 is the circuit configuration of the charge/discharge device used in an elevator apparatus according to another embodiment of the invention;

FIG. 9 is an explanatory diagram showing the determination logic of the charge/discharge necessity determination means
25 shown in FIG. 8;

FIG. 10 is the circuit configuration of the charge/discharge device used in an elevator apparatus according to yet another embodiment of the invention;

FIG. 11 is a flowchart showing the determination logic of the charge/discharge necessity determination means shown in FIG. 10;

FIG. 12 is the circuit configuration of the charge/discharge device used in an elevator apparatus according to still another embodiment of the invention;

FIG. 13 is the circuit configuration of the charge/discharge device used in an elevator apparatus according to further another embodiment of the invention; and

FIG. 14 is an explanatory diagram showing the determination logic of the charge/discharge necessity determination means shown in FIG. 13.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings. In the embodiments of the invention, the same reference numerals denote the same components or components having equivalent functions.

First Embodiment

FIG. 1 shows a traction-type elevator apparatus according to a first embodiment of the invention.

In FIG. 1, the elevator apparatus basically includes an elevator car 10, a balance weight 11 having a weight balancing with the elevator car 10, and a hoisting motor (hoisting rotator) 12 (hereinafter simply referred to as a motor) for lifting and lowering the elevator car 10 and the balance weight 11 in a well-bucket manner.

The balance weight 11 is set to the sum of half the rated load quantity of the elevator car 10 and the weight of the body of the elevator car 10.

10 A three-phase induction motor which enables power running and regenerative running is used as the motor 12 to which power is supplied from a commercial power source 13 through a converter 14, buses 15A and 15B, a discharge switch 16, and an inverter 17. Between the buses 15A and 15B, a capacitor 18 is connected, and the discharge switch 16 and a discharging resistor 19 which consumes power during regenerative running are connected. The discharge switch 16 is capable of being turned on when the capacitor 18 exceeds a given value so that the discharging resistor 19 consumes power, for overvoltage protection.

20 The converter 14 is capable of rectifying AC power from the commercial power source 13 into DC power. The discharge switch 16 is capable of being turned on and off in accordance with the voltage between the buses 15A and 15B. The inverter 17 is capable of converting DC from the converter 14 into AC which is supplied to the motor 12. These constitute a motor

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(rotator) drive circuit 20. The above configuration is well known and therefore detailed description is omitted.

An electric storage device 21 and a charge/discharge device 22 described below are connected to the motor drive
5 circuit 20 for the motor 12.

The charge/discharge device 22 includes a switching unit 26 composed of an upper IGBT 23 and a lower IGBT 24 which are switching elements for transferring power between the capacitor 18 provided in the motor drive circuit 20 and the electric storage
10 device 21 and a coil 25 connected to the midpoint between the upper IGBT 23 and the lower IGBT 24 and a charge/discharge control unit 27 for controlling the switching operation of the upper IGBT 23 and the lower IGBT 24.

The coil 25 provided in the switching unit 26 is connected
15 to one end of a capacitor constituting the electric storage device 21, and the other end of the capacitor is connected to the emitter of the lower IGBT 24.

Further, an instruction for changing the switching operation of the charge/discharge control unit 27 is sent to
20 the charge/discharge control unit 27 by charge/discharge necessity determination means 28. The charge/discharge necessity determination means 28 determines the magnitude of a load on the motor 12 by detecting, by power detection means 29, power sent to the motor 12 or power generated by the motor
25 12 and sent to the electric storage device 21.

The operation, related to the invention, of the charge/discharge device 22 with the above configuration will be described. FIG. 2 shows the relationship between load and power consumption of the motor in the traction system. In FIG. 2, the horizontal axis indicates the time, and the vertical axis indicates the power consumption. FIG. 2 shows two graphs at high load (solid line) and power consumption at low load (broken line).

In the traction system, the ascent of the elevator car carrying a rated number of passengers and the descent of the elevator car carrying no passengers place high loads on the hoisting motor, which increases the power consumption of the motor 12. Accordingly, in this state, it is necessary to discharge and supply large power from the charge/discharge device 22 to the motor 12.

On the other hand, when the elevator car carries more or less half of the rated number of passengers, the motor can lift and lower the elevator car 10 with small driving force due to the balance between the elevator car 10 and the balance weight 11, which reduces the load. Accordingly, in this state, no power or small power is discharged from the charge/discharge device 22.

From this point of view, in this embodiment, the power detection means 29 detects the load state of the motor 12, and based on the detection result, the charge/discharge control

unit 27 controls the switching operation of the IGBT 23 and the IGBT 24 in the switching unit 26.

FIG. 3 shows the determination logic of the charge/discharge necessity determination means 28. The determination logic is activated with predetermined interrupt timing. In FIG. 3, in step S50, the power P of the motor 12 is obtained from a signal from the power detection means 29.

The power P corresponds to the power consumption of the motor 12. Positive power P indicates a power-running state in which current flows from the inverter 17 to the motor 12, and negative power P indicates a regenerative-running state in which current flows from the motor 12 to the inverter 17 (negative power consumption signifies that the motor 12 generates power). That is, in this specification, positive power is defined as power supplied to the motor 12, and negative power is defined as power supplied from the motor 12.

Then, in steps S51 and S52, the state of the power P is determined by a method shown in FIG. 4. Specifically, since current flowing through the motor 12 in power running is opposite in direction to that in regenerative running; letting the direction of the power P flowing from the inverter 17 to the motor 12 be positive, large power P indicates that power flowing from the inverter 17 to the motor 12 is large.

On the other hand, small power P indicates that power flowing from the inverter 17 to the motor 12 is small or indicates

negative power which is regenerated from the motor 12 to the inverter 17. In FIG. 4, level 0 is a reversal value at which the direction of the power is reversed. An area above the reversal value mainly indicates a discharge state, and an area below the reversal value mainly indicates a charge state.

Accordingly, in FIG. 4, if the power P is equal to or more than a positive first power threshold $Pt1$ ($P \geq Pt1$), the charge/discharge control unit 27 allows a switching operation for discharge due to a large load. On the other hand, in FIG. 4, if the power P is equal to or less than a negative second power threshold $Pt2$ ($P \leq Pt2$), the charge/discharge control unit 27 allows a switching operation for charge due to a regenerative state.

Referring back to FIG. 3, in step S51, it is determined whether the power P is equal to or more than the positive first power threshold $Pt1$. If it is determined that the power P is equal to or more than the positive first power threshold $Pt1$, in step S53 the IGBT 23 and the IGBT 24 are switching-operated for charge/discharge control according to the load (discharge operation in this case).

In step S51 if it is determined that the power P is less than the positive first power threshold $Pt1$ ($Pt1 > P$), in step S52 it is determined whether the power P is equal to or less than the negative second power threshold $Pt2$ ($P \leq Pt2$). If it is determined that the power P is equal to or less than the

negative second power threshold P_{t2} , in step S53 the IGBT 23 and the IGBT 24 are switching-operated for charge/discharge control according to the load (charge operation in this case).

In step S53, the ON/OFF duty of the upper IGBT 23 and
5 the lower IGBT 24 is controlled in accordance with the magnitude (absolute value) of charged/discharged power, as shown in FIGS. 5A and 5B. For example, at the time of charging/discharging a large power (absolute value), the ON/OFF duty of the upper IGBT 23 and the lower IGBT 24 is increased as shown in FIG.
10 5A. At the time of charging/discharging a small power (absolute value), the ON/OFF duty of the upper IGBT 23 and the lower IGBT 24 is decreased as shown in FIG. 5B.

Next, assume that it is determined in step S51 that the power P is less than the positive first power threshold P_{t1}
15 and it is determined in step S52 that the power P is more than the negative second power threshold P_{t2} . In this case, the charged/discharged power (absolute value) is very small, which increases the ratio of switching loss to charged/discharged energy and thus decreases charge/discharge efficiency.
20 Accordingly, in step S54, the switching frequency of the upper IGBT 23 and the lower IGBT 24 is decreased, or the switching is stopped.

FIG. 6 shows a waveform in the case where the frequency is decreased, and FIG. 7 shows a waveform in the case where
25 the switching is stopped. In FIG. 6, control is performed so

as to shorten the conducting time as well as decrease the frequency. In FIG. 6, to decrease the frequency, a switching period T2 is made longer than a switching period T1 (see FIG. 5A, 5B) of the normal charge/discharge operation performed in
5 step S53.

When the switching is stopped, the whole of the charge/discharge device 22 is not stopped. That is, although the switching operation of the switching unit 26 is stopped, the operations of the other circuits in the charge/discharge
10 device 22 such as the charge/discharge control unit 27 and a power supply (not shown) for the charge/discharge device 22 are maintained.

Thus, if the power P is between the positive first power threshold Pt1 and the negative second power threshold Pt2, the
15 charge/discharge control unit 27 decreases the switching frequency of the IGBT 23 and the IGBT 24 in the switching unit 26 or stops the switching, which can advantageously reduce the number of operations of the IGBT 23 and the IGBT 24 and maintain the longevity of the switching elements in the charge/discharge
20 device for controlling the charge/discharge of the electric storage device connected to the hoisting motor.

Further, for the concomitant problem of causing power loss in the charge/discharge device, since the switching frequency of the IGBT 23 and the IGBT 24 is decreased or the
25 switching is stopped, it can be expected to suppress extra power

loss.

Further, if for example the electric storage device 21 is charged more than a predetermined charge amount, that is, the necessity of charge is low or charge is not necessary, the determination on the negative second power threshold $Pt2$ in step S52 may be skipped. That is, if the power P is less than the positive first power threshold $Pt1$, the flow proceeds to step S54, where the switching frequency of the upper IGBT 23 and the lower IGBT 24 is decreased or the switching is stopped.

Further, in the first embodiment, to cope with temporary fluctuations in the power P , hysteresis may be provided to the positive first threshold $Pt1$ and the negative second threshold $Pt2$ so as to avoid control hunting.

Further, the positive first threshold $Pt1$ and the negative second threshold $Pt2$ may be determined based on power during at least one of the power running and regenerative running of the elevator car 10 or power that is obtained based on contract demand, a building energy management system, or the like and can be charged/discharged by the elevator apparatus.

Second Embodiment

Next, a second embodiment of the invention will be described with reference to FIG. 8. In the first embodiment, the load on the motor 12 is detected with the power of the motor 12, whereas in the second embodiment, the switching frequency of the switching unit 26 is controlled based on the load quantity

W of the elevator car 10.

In FIG. 8, based on the load quantity W obtained from weight detection means 30 of the elevator car 10, the charge/discharge necessity determination means 28 performs determination as shown in FIG. 9 to control charge/discharge. In FIG. 9, a half load represents a state of balancing the elevator car 10 with the balance weight 11 in the traction system, for example a state of balancing the balance weight 11 set to the sum of half the rated load quantity of the elevator car 10 and the weight of the body of the elevator car 10 with the elevator car 10 loading passengers weighing a total of half the rated load quantity.

The weight detection means 30 provides an output proportional to the load quantity. Further, by the weight detection means 30, the load quantity may be measured during the operation of the elevator car, or may be measured before the elevator car 10 starts moving after its door closes.

The determination logic of the charge/discharge necessity determination means 28 is similar to that shown in FIG. 3. The power P is replaced with the load quantity W, the first power threshold Pt1 is replaced with a first load threshold Wt1, and the second power threshold Pt2 is replaced with a second load threshold Wt2. Unlike the first embodiment, the first load threshold Wt1 and the second load threshold Wt2 are both positive values. That is, the first load threshold $Wt1 > \text{the second}$

load threshold $Wt2 > 0$.

Accordingly, as in the first embodiment, in step S51 it is determined whether the load quantity W is equal to or more than the first load threshold $Wt1$. If it is determined that the load quantity W is equal to or more than the first load threshold $Wt1$, in step S53 the IGBT 23 and the IGBT 24 are switching-operated for charge/discharge control according to the load (in this case, discharge operation in power running during ascent, or charge operation in regenerative running during descent).

In step S51 if it is determined that the load quantity W is less than the first load threshold $Wt1$, in step S52 it is determined whether the load quantity W is equal to or less than the second load threshold $Wt2$. If it is determined that the load quantity W is equal to or less than the second load threshold $Wt2$, in step S53 the IGBT 23 and the IGBT 24 are switching-operated for charge/discharge control according to the load (in this case, discharge operation in power running during descent, or charge operation in regenerative running during ascent).

In step S53, the ON/OFF duty of the upper IGBT 23 and the lower IGBT 24 is controlled in accordance with the magnitude (absolute value) (proportional to the absolute value of the difference between the load quantity W and the half load) of charged/discharged power, as shown in FIGS. 5A and 5B. For

example, at the time of charging/discharging a large power (absolute value), the ON/OFF duty of the upper IGBT 23 and the lower IGBT 24 is increased as shown in FIG. 5A. At the time of charging/discharging a small power (absolute value), the ON/OFF duty of the upper IGBT 23 and the lower IGBT 24 is decreased as shown in FIG. 5B.

Next, assume that it is determined in step S51 that the load quantity W is less than the first load threshold $Wt1$ and it is determined in step S52 that the load quantity W is more than the second load threshold $Wt2$. In this case, the charged/discharged power (absolute value) is very small, which increases the ratio of switching loss to charged/discharged energy and thus decreases charge/discharge efficiency. Accordingly, in step S54, the switching frequency of the upper IGBT 23 and the lower IGBT 24 is decreased as shown in FIG. 6, or the switching is stopped as shown in FIG. 7.

With this control, if the load quantity W is between the first load threshold $Wt1$ and the second load threshold $Wt2$, the charge/discharge control unit 27 decreases the switching frequency of the IGBT 23 and the IGBT 24 in the switching unit 26 or stops the switching, which can advantageously reduce the number of operations of the IGBT 23 and the IGBT 24 and maintain the longevity of the switching elements in the charge/discharge device for controlling the charge/discharge of the electric storage device connected to the hoisting motor.

Further, for the concomitant problem of causing power loss in the charge/discharge device, since the switching frequency of the IGBT 23 and the IGBT 24 is decreased or the switching is stopped, it can be expected to suppress extra power
5 loss.

Further, to cope with temporary fluctuations in the load quantity W, hysteresis may be provided to the first load threshold Wt1 and the second load threshold Wt2 so as to avoid control hunting.

10 Further, as in the first embodiment, the first load threshold Wt1 and the second load threshold Wt2 may be determined based on power during at least one of the power running and regenerative running of the elevator car 10 or power that is obtained based on contract demand, a building energy management
15 system, or the like and can be charged/discharged by the elevator apparatus.

Further, an existing load quantity sensor provided in the elevator car 10 can be used as the weight detection means 30 without newly providing the power detection means 29 as in
20 the first embodiment, which can advantageously negate the need for a large modification of an existing elevator apparatus.

Third Embodiment

Next, a third embodiment of the invention will be described with reference to FIG. 10. This embodiment is a combination
25 of the first and second embodiments. Accordingly, in a specific

configuration, the power P detected by the power detection means 29 and the load quantity W detected by the weight detection means 30 are inputted to the charge/discharge necessity determination means 28. The determination logic thereof is shown in FIG. 11.

In FIG. 11, the determination logic is activated with predetermined interrupt timing. In step S55, the power P of the motor 12 is obtained from a power signal of the power detection means 29, and the load quantity W of the elevator car 10 is obtained from the weight detection means 30.

Then, in steps S56 and S57, the state of the load quantity W is determined by a method shown in FIG. 9. Accordingly, in FIG. 9, if the load quantity W is equal to or more than the first load threshold $Wt1$ ($W \geq Wt1$), it is determined that the load quantity is large. If the load quantity W is equal to or less than the second load threshold $Wt2$ ($W \leq Wt2$), it is determined that the load quantity is small. If Yes in step S56 or S57, the determination indicates the normal charge/discharge area in FIG. 9. If No in both steps S56 and S57, the determination indicates the hatched area (where the switching frequency is decreased or the switching is stopped) in FIG. 9.

The above determination is the same as in the second embodiment. Based thereon, in the third embodiment, the switching operation of the switching unit 26 is controlled with

greater accuracy by the ratio of power flowing into the motor 12 or the electric storage device 21.

If No in both steps S56 and S57, in step S58 it is determined whether the power P is equal to or less than the negative second power threshold $Pt2$. If it is determined that the power P is more than the negative second power threshold $Pt2$, in step S59 the switching frequency of the upper IGBT 23 and the lower IGBT 24 is decreased, or the switching is stopped.

On the other hand, in step S58 if it is determined that the power P is equal to or less than the negative second power threshold $Pt2$, in step S62 the IGBT 23 and the IGBT 24 are switching-operated for charge/discharge control according to the load. This control is the same as in the first embodiment.

If Yes in step S56 or S57, in step S60 it is determined whether the power P is equal to or more than the positive first power threshold $Pt1$, and in step S61 it is determined whether the power P is equal to or less than the negative second power threshold $Pt2$.

If Yes in step S60 or S61, the determination indicates the normal charge/discharge area in FIG. 4. If No in both steps S60 and S61, the determination indicates the hatched area (where the switching frequency is decreased or the switching is stopped) in FIG. 4.

If Yes in step S60 or S61, in step S62 the IGBT 23 and the IGBT 24 are switching-operated for charge/discharge control

according to the load. The control in this case is also the same as in the first embodiment.

If No in both steps S60 and S61, in step S59 the switching frequency of the upper IGBT 23 and the lower IGBT 24 is decreased,
5 or the switching is stopped.

The positive first power threshold $Pt1$, the negative second power threshold $Pt2$, the first load threshold $Wt1$, and the second load threshold $Wt2$ are appropriately selected by the design specification of the elevator apparatus.

10 Thus, by controlling the switching frequency of the switching unit 26, as in the first and second embodiments, the switching frequency of the IGBT 23 and the IGBT 24 in the switching unit 26 is decreased or the switching is stopped, which can advantageously reduce the number of operations of the IGBT 23
15 and the IGBT 24 and maintain the longevity of the switching elements in the charge/discharge device for controlling the charge/discharge of the electric storage device connected to the hoisting motor.

Further, for the concomitant problem of causing power
20 loss in the charge/discharge device, since the switching frequency of the IGBT 23 and the IGBT 24 is decreased or the switching is stopped, it can be expected to suppress extra power loss.

Further, an existing load quantity sensor provided in
25 the elevator car 10 can be used as the weight detection means

30, which can advantageously negate the need for a large modification of an existing elevator apparatus.

Further, although the original flow proceeds to step S59 where the switching frequency is decreased or the switching is stopped, in step S58 if it is determined that the power P is equal to or less than the negative second power threshold Pt2, in step S62 the IGBT 23 and the IGBT 24 are switching-operated for charge/discharge control according to the load. Accordingly, even if the load quantity W falls outside the normal charge/discharge range, step S58 makes it possible to charge power during regenerative running to the electric storage device 21, which can improve energy saving.

If the effect by step S58 is not necessary, step S58 may be omitted. In this case as well, the effects of the first and second embodiments can be obtained.

Fourth Embodiment

Next, a fourth embodiment of the invention will be described with reference to FIG. 12. This embodiment will be described based on the third embodiment, but can also be applied to the first and second embodiments.

In FIG. 12, the charge/discharge necessity determination means 28 sends to a display device 31 a signal for indicating the operation or stop of the elevator apparatus, the charge/discharge of the electric storage device 21, or the stop. This advantageously makes it possible to visually present

energy-saving effect to passengers and inform the operation state of the charge/discharge device 22 to the operation manager of the elevator apparatus.

Further, a change-over switch 32 is provided between the bus 15A and the upper IGBT 23. By turning off the change-over switch 32 at the time of stopping charge/discharge performed by the charge/discharge device 22, it is possible to prevent the upper IGBT 23 from being burdened.

Fifth Embodiment

Next, a fifth embodiment of the invention will be described with reference to FIGS. 13 and 14. This embodiment illustrates a drum system in place of the traction system. Accordingly, the balance weight 11 is not coupled to the elevator car 10, and the motor 12 directly lifts and lowers the elevator car 10. Further, in this embodiment, the signal of the weight detection means 30 for detecting the load quantity W of the elevator car 10 is inputted to the charge/discharge necessity determination means 28, as in the second embodiment.

The charge/discharge necessity determination means 28 performs charge/discharge control shown in FIG. 14, based on the load quantity W obtained from the weight detection means 30.

In this embodiment, the determination logic of the charge/discharge necessity determination means 28 is obtained by deleting step S52 regarding the second power threshold Pt2

(= second load threshold W_{t2}) from FIG. 3.

Accordingly, if it is determined that the load quantity W is equal to or more than the first load threshold W_{t1} ; in the normal charge/discharge area, the IGBT 23 and the IGBT 24
5 are switching-operated for charge/discharge control according to the load.

On the other hand, if it is determined that the load quantity W is less than the first load threshold W_{t1} , the switching frequency of the upper IGBT 23 and the lower IGBT
10 24 is decreased, or the switching is stopped.

As described above, according to the invention, in a predetermined operating state, the switching frequency of the switching elements in the switching unit of the charge/discharge device is decreased or the switching is stopped, which can
15 advantageously reduce the number of operations of the switching elements and maintain the longevity of the switching elements in the charge/discharge device for controlling the charge/discharge of the electric storage device connected to the hoisting motor.

20 Further, since the switching frequency of the switching elements is decreased or the switching is stopped, it can be expected to suppress extra power loss.

WHAT IS CLAIMED IS:

1. A drive apparatus of an elevator apparatus comprising:
a rotator drive circuit which drives a hoisting rotator
for lifting and lowering an elevator car as well as having a
5 power generation capability and is connected to a commercial
power source;

an electric storage device which supplies power to the
hoisting rotator and stores power generated by the hoisting
rotator; and

10 a charge/discharge device which discharges power from
the electric storage device to the hoisting rotator and charges
power generated by the hoisting rotator to the electric storage
device,

the charge/discharge device including:

15 a switching unit which performs charge or discharge by
a switching operation of a switching element provided in the
charge/discharge device; and

a charge/discharge control unit which decreases a
switching frequency of the switching element or stops the
20 switching operation when the elevator car is in a predetermined
operating state.

2. The drive apparatus of the elevator apparatus according
to claim 1,

25 wherein the predetermined operating state is determined

by charge/discharge necessity determination means for determining based on power supplied to the hoisting rotator or power supplied from the hoisting rotator or a load quantity of the elevator car.

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3. The drive apparatus of the elevator apparatus according to claim 2,

wherein in the case where positive power is defined as power supplied to the hoisting rotator and negative power is defined as power supplied from the hoisting rotator; if power
10 supplied to the hoisting rotator is less than a predetermined positive power threshold, the charge/discharge necessity determination means sends a signal for decreasing the switching frequency of the switching element or stopping the switching
15 operation to the charge/discharge device.

4. The drive apparatus of the elevator apparatus according to claim 2,

wherein in the case where positive power is defined as
20 power supplied to the hoisting rotator and negative power is defined as power supplied from the hoisting rotator; if the power is less than a predetermined positive first power threshold and more than a predetermined negative second power threshold, the charge/discharge necessity determination means sends a
25 signal for decreasing the switching frequency of the switching

element or stopping the switching operation to the charge/discharge device.

5. The drive apparatus of the elevator apparatus according
5 to claim 2,

wherein the elevator apparatus is an elevator apparatus that does not have a balance weight balancing with the elevator car, and if the load quantity of the elevator car is less than a predetermined load threshold, the charge/discharge necessity
10 determination means sends a signal for decreasing the switching frequency of the switching element or stopping the switching operation to the charge/discharge device.

6. The drive apparatus of the elevator apparatus according
15 to claim 2,

wherein the elevator apparatus is an elevator apparatus that has a balance weight balancing with the elevator car, and if the load quantity of the elevator car is less than a predetermined first load threshold and more than a predetermined
20 second load threshold less than the first load threshold, the charge/discharge necessity determination means sends a signal for decreasing the switching frequency of the switching element or stopping the switching operation to the charge/discharge device.

7. The drive apparatus of the elevator apparatus according to claim 6,

wherein the first load threshold is a threshold that is on a larger side of the load quantity of the elevator car with respect to a state of balancing the elevator car with the balance weight, and the second load threshold is a threshold that is on a smaller side of the load quantity of the elevator car with respect to the state of balancing the elevator car with the balance weight.

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8. The drive apparatus of the elevator apparatus according to claim 1,

wherein the predetermined operating state is determined by charge/discharge necessity determination means for determining based on both of power supplied to or from the hoisting rotator and a load quantity of the elevator car.

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9. The drive apparatus of the elevator apparatus according to claim 8, wherein

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(1) if the load quantity of the elevator car is less than a predetermined first load threshold and more than a predetermined second load threshold less than the first load threshold, the elevator apparatus being an elevator apparatus that has a balance weight balancing with the elevator car, and

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(2) if the power is more than a predetermined negative

second power threshold, positive power being defined as power supplied to the hoisting rotator and negative power being defined as power supplied from the hoisting rotator,

the charge/discharge necessity determination means sends
5 a signal for decreasing the switching frequency of the switching element or stopping the switching operation to the charge/discharge device.

10. The drive apparatus of the elevator apparatus according
10 to any one of claims 1 to 9,

wherein the charge/discharge device sends a signal indicating the state of a charge/discharge operation to a display installed in the elevator car or an elevator hall.