

TITLE OF THE INVENTION

ELEVATOR CONTROL APPARATUS

BACKGROUND OF THE INVENTION

5 The present invention relates to an elevator control apparatus, which converts an alternating current supplied from an AC power supply to a direct current, further converts the direct current to an alternating current by an inverter, and supplies the direct current to an electric motor to move an elevator
10 car up and down.

In a conventional elevator system provided in a building, a rope provided with a cage and a counterweight at both ends is hung on a sieve of a motor provided in the upper side of an up-and-down
15 path. Usually, the weight of a counterweight is adjusted to the weight substantially equal to the weight of an elevator car filled to half of its loading capacity. Therefore, if a load of an elevator car is not half of its capacity, the car and counterweight are
20 unbalanced. Thus, a brake unit is incorporated to hold an elevator car at a standstill to prevent it from running out of control, when stopping an unloaded elevator car at each floor and halting the driving force of a motor.

25 The brake unit has a mechanism, which brakes by a frictional force generated by pressing a brake shoe to a moving part (a rotary drum) by an energizing force of

a spring, in a state that power is not turned on. When
starting a motor braked by this brake unit, send a
brake release signal to the brake unit, open the spring
by a magnetic force of an electromagnet, for example,
5 and separate the brake shoe from the movable part
(rotary drum). Therefore, in the state that the
elevator system is not working, the brake unit is held
in the state of braking the motor.

In the other states than the above normal
10 operation state, when any error is detected in an
elevator and an elevator car is urgently stopped, the
braking force of this brake unit is used.

If the brake unit incorporated in an elevator
fails and the brake shoe is left separated from the
15 movable part (rotary drum) when the power is
interrupted, an elevator car runs out of control and
falls into a dangerous state unless the car and
counterweight are balanced, even if a brake signal is
sent to the brake unit when the elevator car is stopped
20 at each floor.

If an error is detected and an elevator is
urgently stopped while the brake unit fails, a braking
force for urgently decelerate an elevator car is lost
or decreased, and an elevator car is not sufficiently
25 braked, cannot be stopped before a terminal end of an
up-and-down path, and goes into a dangerous state.

To avoid the above dangerous state caused by a

trouble of a brake unit, Published Japanese Patent No. 2,526,732 proposes technology to concurrently use a brake unit and regenerative braking at an emergency stop. This regenerative braking is also called a
5 dynamic brake, which obtains a braking force by connecting a braking impedance to a winding of a motor, and consuming an induced voltage generated in the winding by the braking impedance.

The regenerative braking function is effective for
10 a motor which can establish a field magnetic flux without supplying power to a power winding, or for a permanent magnet synchronized motor in which a field magnetic flux is always established, or a separately excited DC motor or a linear motor.

15 However, the dynamic brake configured as above needs a load resistance to consume regenerative energy generated in a motor, a contact to separate each load resistance from a power line in normal operation, and a contact to separate a motor and a load resistance from
20 an inverter at the time of braking. As a result, the manufacturing cost of the whole elevator control apparatus is increased, and the size of the elevator control apparatus is increased.

BRIEF SUMMARY OF THE INVENTION

25 It is an object of the present invention to provide an elevator control apparatus, which can realize a regenerative braking function by reducing the

manufacturing cost and size of the apparatus.

Namely, an elevator control apparatus according to the invention comprises a rectifier circuit to convert AC power from an AC power supply to DC power; a
5 smoothing capacitor to smooth a ripple of the DC power converted by the rectifier circuit; an inverter which is formed by connecting diodes and switching elements in the form of a bridge, and outputs the smoothed DC power by converting to variable voltage/frequency AC
10 power; an electric motor which moves an elevator car up and down by driving from the AC power output from the inverter; and a brake unit which controls energizing/interruption of each switching element of the inverter so that the variable voltage/frequency AC
15 power is output according to a predetermined operation pattern, and mechanically brakes movement of an elevator car; wherein the electric motor is regeneratively braked by operating the brake unit to brake the elevator car when the elevator car arrives at
20 a floor, and closing the switching elements of one polarity side of the inverter, and opening the switching elements of the other polarity side, if a malfunction of the brake unit is detected when the elevator car arrives at a floor.

25 BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a view showing an example of configuration of a dynamic brake of an elevator control

apparatus according to a first embodiment of the present invention;

FIG. 2 is a view showing an example of configuration of a dynamic brake of a conventional elevator control apparatus;

FIG. 3 is a view showing an example of configuration of an elevator control apparatus according to a first embodiment of the invention;

FIG. 4 is a view showing an example of configuration of an elevator control apparatus according to a second embodiment of the invention;

FIG. 5 is a view showing an example of configuration of an elevator control apparatus according to a third embodiment of the invention;

FIG. 6 is a view showing an example of configuration of an elevator control apparatus according to a fourth embodiment of the invention;

FIG. 7 is a view showing an example of configuration of an elevator control apparatus according to a fifth embodiment of the invention; and

FIG. 8 is a view showing an example of configuration of an elevator control apparatus according to a sixth embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will be explained hereinafter with reference to the accompanying drawings.

(Embodiment 1)

A first embodiment of the present invention will be explained.

First, a dynamic brake is explained. FIG. 1 shows
5 an example of configuration of a dynamic brake of an elevator control apparatus according to the first embodiment of the invention.

In the dynamic brake shown in FIG. 1, a three-
phase alternating current supplied from an AC power
10 supply is full-wave rectified to a direct current by a rectifier circuit 11. A ripple of the rectified direct current is absorbed by a smoothing capacitor 10, and the direct current is supplied to an inverter circuit. At both ends of the smoothing capacity 10, a serial
15 circuit composed of a damping resistor 8 and a damping resistor energizing element 9 is provided.

In the inverter circuit, six parallel circuits 7
composed of diodes 33 and switching elements 34 are
connected in the form of a bridge. By energizing and
20 interrupting each switching element 34 of the inverter circuit by a pulse-width modulation (PWM) signal from a not-shown operation control unit, the input direct current is converted to a three-phase alternating current having optional frequency and voltage, and
25 supplied to an electric motor 1.

When stopping the electric motor 1, the operation control unit sends a voltage command to open three

switching elements 34 on the positive side of the inverter circuit, and to close three switching elements 34 on the negative side.

5 A closed circuit is formed by the closed switching elements 34 on the negative side of the inverter circuit and the field winding of the motor 1.

Therefore, the regenerative energy produced by the electromotive force generated in the field winding is consumed in each field winding in a process wherein the
10 regenerative current flows in the above closed circuit. Therefore, a braking force is applied to the motor 1, and the motor 1 is stopped within a short time.

FIG. 2 shows an example of configuration of a dynamic brake of a conventional elevator.

15 In the dynamic brake shown in FIG. 2, a three-phase alternating current supplied from an AC power supply is full-wave rectified to a direct current by a rectifier circuit 11. A ripple of the rectified direct current is absorbed by a smoothing capacitor 10, and
20 the direct current is supplied to an inverter circuit in a later stage. At both ends of the smoothing capacity 10, a serial circuit composed of a damping resistor 8 and a damping resistor energizing element 9 is provided.

25 In the inverter circuit, six parallel circuits 7 composed of diodes 33 and switching elements 34 are connected in the form of a bridge. By energizing and

interrupting each switching element 34 of the inverter circuit by a pulse-width modulation (PWM) signal from a not-shown operation control unit, the input direct current is converted to a three-phase alternating current having optional frequency and voltage, and supplied to an electric motor 1 through a conductor contact 31 and a power line.

A load resistor 30 for consuming regenerative energy is connected between the power lines through the conductor contact 32.

In such an elevator control apparatus, in the normal state, the conductor contact 31 is closed, and the conductor contact 32 is opened. Therefore, the motor 1 is driven by the three-phase alternating current supplied from the inverter circuit.

When stopping the electric motor 1, the operation control unit operates the brake unit for mechanical braking, turns off all PMW signals for the switching elements 34 of the inverter circuit, stops the DC/AC conversion of the inverter circuit, opens the conductor contact 31, and closes the conductor contact 32. Therefore, the regenerative energy generated in the motor 1 is consumed by the load resistor 30, the braking force is applied to the motor 1, and the motor 1 is stopped within a short time.

Comparing the dynamic brakes shown in FIG. 1 and FIG. 2, the dynamic brake shown in FIG. 1 does not need

the load resistor 30 and conductor contacts 31 and 32 shown in FIG. 2, and the manufacturing cost can be decreased and the apparatus size can be reduced.

5 Next, explanation will be given on an elevator control apparatus having the dynamic brake shown in FIG. 1. FIG. 3 shows an example of configuration of the elevator control apparatus according to the first embodiment of the invention.

10 In the configuration shown in FIG. 3, the explanation on the same components as those of the configuration shown in FIG. 1 will be omitted. In the elevator control apparatus shown in FIG. 3, the motor 1 controls rotation of a main sieve 41. A rope 2 whose both ends are fixed to a ceiling 44 of an up-and-down path is hung on the main sieve 41 and two sub-sieves 42 and 43. Each of the sub-sieves 42 and 43 is provided with an elevator car 3 and a counterweight 4.

15 The elevator control apparatus has a run command unit 12, a speed-control command unit 13, a current-control command unit 14, a current detector 15, a PWM signal generator 16, a winding short-circuit command unit 17, and a brake error detector 18.

20 A current value between the inverter circuit and motor 1 is detected by the current detector 15, and applied to the current-control command unit 14.

25 Three first switches 45 are provided between the winding short-circuit command unit 17 and PWM signal

generator 16. These first switches 45 are connected one-to-one to terminals of three second switches 46 and three terminals of the winding short-circuit command unit 17. The second switches 46 can be switched
5 between the terminals of the current-control command unit 14 and a ground terminal.

The run command unit 12 outputs a brake open signal, and connects the second switch 46 to the current-control command unit 14, when running the
10 elevator car 3.

The run command unit 12 also outputs the brake open signal to the brake error detector 18. The brake error detector 18 has a function of switching the first switch 45. The brake error detector 18 receives the
15 brake open signal from the run command unit 12, and connects the first switch 45 to the current-control command unit 14.

A rotation angle detector 6 detects a rotation angle of the motor 1. The detection result by the rotation angle detector 6 is input to the speed-control
20 command unit 13. The speed-control command unit 13 calculates the rotation speed of the motor 1 based on the rotation angle sent from the rotation angle detector 6.

25 The speed-control command unit 13 outputs a torque current command of the motor 1 to the current-control command unit 14, so that the calculated speed meets the

acceleration/deceleration speeds and constant speed of the elevator car in a process of operating the elevator car 3 from a starting floor to an arriving floor.

5 The current-control command unit 14 outputs a three-phase voltage command to the PWM signal generator 16, so that the current detected by the current detector 15 meets the current equivalent to the torque current command. The PWM signal generator 16 sends a PWM signal to each switching element 34 of the inverter
10 circuit, so that a voltage equivalent to the voltage command is output to the motor 1. Namely, the PWM signal generator 16 functions as a run control unit which controls energizing and interrupting power to each switching element 34 of the inverter circuit, so
15 that a variable voltage/frequency AC power is output according to a predetermined operation pattern.

When the elevator car 3 runs close to an object floor, the run command unit 12 sends a brake signal to the brake error detector 18 and a friction brake unit 5
20 that is a brake to mechanically brake the movement of the elevator car 3, sets the friction brake unit 5 to a state of braking the motor 1, and switches the second switch 46 to the ground terminal side. Namely, when the elevator car 3 arrives at a floor, the run command
25 unit 12 functions as a brake control unit to actuate the friction brake unit 5 in order to stop the movement of the elevator car 3.

The friction brake unit 5 sends a state signal indicting the open/close state of the friction brake to the brake error detector 18. The brake error detector 18 receives the brake signal from the run command unit 5 12, and regards the friction brake as being not closed when the state signal from the friction brake unit 5 indicates opening of the friction brake. The brake error detector 18 sends a command signal to stop the elevator car 3 to the run command unit 12, in order to 10 operate the dynamic brake, and switches the first switch 45 connected to the PWM signal generator 16 from the current-control command unit 14 to the winding short-circuit command unit 17. Namely, the brake error detector 18 functions as an error detector to detect a 15 malfunction of the friction brake unit 5 when the elevator car 3 arrives at a floor.

The winding short-circuit command unit 17 outputs a control signal to open three switching elements on one side of the circuit, here the three switching 20 elements 34 on the positive side, and to close three switching elements 34 on the other side.

The PWM signal generator 16 receives the signal from the winding short-circuit command unit 17, opens three switching elements 34 on the positive side, and 25 closes three switching elements 34 on the negative side.

Then, a closed circuit is formed by the three

switching elements 34 closed on the negative side of the inverter circuit and the field winding of the motor 1. Therefore, the regenerative energy produced by the electromotive power generated in the field winding is consumed by each field winding in the process wherein the regenerative current flows in the above closed circuit. As a result, a braking force is applied to the motor 1, and the motor 1 is stopped within a short time.

10 Namely, when a malfunction of the friction brake unit 5 is detected, the PWM signal generator 16 and the winding short-circuit command unit 17 closes three switching elements 34 on one side of the inverter circuit, and opens three switching elements 34 on the other side, and functions as a regenerative braking control unit for regeneratively braking the motor 1.

15 As explained above, the elevator control apparatus according to the first embodiment of the invention can prevent the elevator car 3 from running out of control when arriving at a floor, even if the friction brake unit 5 does not work normally. Therefore, safety of the elevator can be increased. In addition, since the dynamic brake is operated by opening/closing the switching elements 34 of the inverter circuit, a load resistor and a conductor contact conventionally required become unnecessary, and the manufacturing cost can be reduced and the apparatus size can be made

compact.

(Embodiment 2)

A second embodiment of the invention will be explained. Among the components of the elevator control apparatus according to the following
5 embodiments, the explanation on the same components as those shown in FIG. 1 will be omitted. In the operation of the elevator control apparatus according to the following embodiments, the operations from
10 normal start of operation to arrival at a floor are almost the same as those explained in the first embodiment, and the detailed explanation on them will be omitted.

FIG. 4 shows an example of configuration of an elevator control apparatus according to the second
15 embodiment of the invention.

As shown in FIG. 4, the elevator control apparatus according to the second embodiment of the invention is provided with a stop position memory 19 and a first
20 free-run detector 20, instead of the brake error detector 18 explained in the first embodiment.

When running the elevator car 3, the run command unit 12 outputs a brake open signal, and connects the second switch 46 to the current-control command unit
25 14.

The run command unit 12 also outputs the brake open signal to the first free-run detector 20 through

the stop position memory 19. The first free-run detector 20 has a function of switching the first switch 45, and connects the first switch 45 to the current-control command unit 14 when receiving the
5 brake open signal from the run command unit 12.

When the elevator car runs close to an object floor, the run command unit 12 sends a brake signal to the friction brake unit 5 and stop position memory 19, and sets the friction brake unit 5 to a state of
10 braking the motor 1. The run command unit 12 switches the second switch 46 to the ground terminal side.

Receiving the brake signal, the stop position memory 19 outputs the signal to the first free-run detector 20, and stores the value of rotation angle indicated by the rotation angle detector 6 as a result
15 of detection.

Receiving the brake signal, the first free-run detector 20 inputs the value of rotation angle indicated by the rotation angle detector 6 as a result
20 of detection, and compares the input value with the value of rotation angle stored in the stop position memory 19. When the difference between the compared values is over a predetermined reference value, the first free-run detector 20 judges that the elevator car
25 3 has started free running caused by a defect of the friction brake. Then, to operate the dynamic brake, the first free-run detector 20 outputs a command signal

to stop the elevator car 3 to the run command unit 12, and switches the first switch 45 connected to the PWM signal generator 16 from the current-control command unit 14 to the winding short-circuit command unit 17.

5 Namely, the first free-run detector 20 functions as an abnormal-run detector, which detects start of abnormal running of the elevator car 3 after the car arrives at a floor.

10 The winding short-circuit command unit 17 outputs a control signal to open three switching elements on one side of the inverter circuit, here the three switching elements 34 on the positive side, and to close the three switching elements 34 on the other side.

15 The PWM signal generator 16 receives the signal from the winding short-circuit command unit 17, opens three switching elements 34 on the positive side, and closes three switching elements 34 on the negative side.

20 Then, a closed circuit is formed by the three switching elements 34 closed on the negative side of the inverter circuit and the field winding of the motor 1. Therefore, the regenerative energy produced by the electromotive power generated in the field winding is
25 consumed by each field winding in the process wherein the regenerative current flows in the above closed circuit. As a result, a braking force is applied to

the motor 1, and the motor 1 is stopped within a short time.

As explained above, in the elevator control apparatus according to the second embodiment of the invention, free running of the elevator car 3 can be
5 stopped by operating the dynamic brake when the elevator car starts free running after once stopping.

Therefore, safety of the elevator can be increased.

10 (Embodiment 3)

A third embodiment of the invention will be explained. FIG. 5 shows an example of configuration of the elevator control apparatus according to the third embodiment of the invention.

15 As shown in FIG. 5, the elevator control apparatus according to the third embodiment of the invention is provided with a second free-run detector 21, instead of the brake error detector 18 explained in the first embodiment.

20 When running the elevator car 3, the run command unit 12 outputs a brake open signal, and connects the second switch 46 to the current-control command unit 14.

The run command unit 12 also outputs the brake
25 open signal to the second free-run detector 21. The second free-run detector 21 has a function of switching the first switch 45, and connects the first switch 45

to the current-control command unit 14 when receiving the brake open signal from the run command unit 12.

When the elevator car runs close to an object floor, the run command unit 12 sends a brake signal to the friction brake unit 5 and second free-run detector 21, and sets the friction brake unit 5 to the state of braking the motor 1. The run command unit 12 switches the second switch 46 to the ground terminal side.

Receiving the brake signal, the second free-run detector 21 inputs the result of detection by the rotation angle detector 6 by two or more times at a predetermined time interval, and calculates the rotation speed based on the values of the rotation angles as the result of detection.

When the calculated rotation speed is higher than the predetermined reference value, the second free-run detector 21 judges that the elevator car 3 has started free running caused by a defect of the friction brake. Then, to operate the dynamic brake, the second free-run detector 21 outputs a command signal to stop the elevator car 3 to the run command unit 12, and switches the first switch 45 connected to the PWM signal generator 16 from the current-control command unit 14 to the winding short-circuit command unit 17.

Namely, the second free-run detector 21 functions as an abnormal-run detector, which detects start of abnormal running of the elevator car 3 after the car

arrives at a floor.

The winding short-circuit command unit 17 outputs a control signal to open three switching elements on one side in the inverter circuit, here the three
5 switching elements 34 on the positive side, and to close the three switching elements 34 on the other side.

The PWM signal generator 16 receives the signal from the winding short-circuit command unit 17, opens
10 three switching elements 34 on the positive side, and closes three switching elements 34 on the negative side.

Then, a closed circuit is formed by the three switching elements 34 closed on the negative side of
15 the inverter circuit and the field winding of the motor 1. Therefore, the regenerative energy produced by the electromotive power generated in the field winding is consumed by each field winding in the process wherein the regenerative current flows in the above closed
20 circuit. As a result, a braking force is applied to the motor 1, and the motor 1 is stopped within a short time.

As explained above, in the elevator control apparatus according to the third embodiment of the
25 invention, free running of the elevator car 3 can be stopped by operating the dynamic brake when the elevator car is judged to have started free running

based on the rotation speed of the motor 1 after the elevator car is once stopped. Therefore, safety of the elevator can be increased.

(Embodiment 4)

5 A fourth embodiment of the invention will be explained. FIG. 6 shows an example of configuration of the elevator control apparatus according to the fourth embodiment of the invention.

10 As shown in FIG. 6, the elevator control apparatus according to the fourth embodiment of the invention is provided with an abnormal acceleration detector 22, instead of the brake error detector 18 explained in the first embodiment. When running the elevator car 3 at a low speed in a controlled operation mode, for example,
15 the run command unit 12 outputs a brake open signal, and connects the second switch 46 to the current-control command unit 14.

 The run command unit 12 also outputs the brake open signal to the abnormal acceleration detector 22.
20 The abnormal acceleration detector 22 has a function of switching the first switch 45, and connects the first switch 45 to the current-control command unit 14 when receiving the brake open signal from the run command unit 12.

25 After switching the first switch 45, the abnormal acceleration detector 22 inputs the result of detection by the rotation angle detector 6 by two or more times

at a predetermined time interval, and calculates the rotation speed based on the values of the rotation angles as the result of detection.

When the calculated rotation speed is higher than
5 the predetermined reference value, the abnormal acceleration detector 22 judges that the elevator car 3 has started abnormal acceleration caused by a defect of the motor 1. Then, to operate the dynamic brake, the abnormal acceleration detector 22 outputs a command
10 signal to stop the elevator car 3 to the run command unit 12, and switches the first switch 45 connected to the PWM signal generator 16 from the current-control command unit 14 to the winding short-circuit command unit 17.

15 Namely, when the elevator car 3 runs at a predetermined speed lower than a normal running speed, the abnormal acceleration detector 22 functions as an abnormal acceleration detector, which detects abnormal acceleration of the elevator car 3 when the elevator
20 car speed is higher than a predetermined value.

The winding short-circuit command unit 17 outputs a control signal to open three switching elements on one side of the inverter circuit, here the three
switching elements 34 of the positive side, and to
25 close the three switching elements 34 of the other side.

The PWM signal generator 16 receives the signal

from the winding short-circuit command unit 17, opens three switching elements 34 on the positive side, and closes three switching elements 34 on the negative side.

5 Then, a closed circuit is formed by the three switching elements 34 closed on the negative side of the inverter circuit and the field winding of the motor 1. Therefore, the regenerative energy produced by the electromotive power generated in the field winding is
10 consumed by each field winding in the process wherein the regenerative current flows in the above closed circuit. As a result, a braking force is applied to the motor 1, and the motor 1 is stopped within a short time.

15 As explained above, in the elevator control apparatus according to the fourth embodiment of the invention, abnormal acceleration of the elevator car 3 can be stopped by operating the dynamic brake when the elevator car is judged to have started abnormal
20 acceleration based on the rotation speed of the motor 1 while the elevator car is running at a low speed in a controlled operation mode. Therefore, safety of the elevator can be increased.

(Embodiment 5)

25 A fifth embodiment of the invention will be explained. FIG. 7 shows an example of configuration of the elevator control apparatus according to the fifth

embodiment of the invention.

As shown in FIG. 7, the elevator control apparatus according to the fifth embodiment of the invention is provided with an emergency stop unit 23, instead of the
5 brake error detector 18 explained in the first embodiment.

When running the elevator car 3, the run command unit 12 outputs a brake open signal, and connects the first switch 45 and second switch 46 to the current-
10 control command unit 14.

The emergency stop unit 23 detects a running speed of the elevator car 3, and when the detected speed exceeds a predetermined reference value, outputs a control signal indicating the excess speed to the run
15 command unit 12, and urgently and mechanically stops the elevator car 3, and holds the elevator car in that state.

Namely, the emergency stop unit 23 functions as an emergency brake unit, which mechanically stops movement
20 of the elevator car 3 in an emergency.

Receiving the control signal from the emergency stop unit 23, the run command unit 12 regards the up-and-down movement of the elevator car 3 as being mechanically stopped by the emergency stop unit 23,
25 sends the run command unit 12 a command signal to stop the elevator car 3 in order to actuate the dynamic brake to prevent the mechanical stop from being reset

by jump-up of the elevator car 3, and switches the first switch 45 connected to the PWM signal generator 16 from the current-control command unit 14 to the winding short-circuit command 17.

5 The winding short-circuit command unit 17 outputs a control signal to open three switching elements on one side of the inverter circuit, here the three switching elements 34 on the positive side, and to close three switching elements 34 on the other side.

10 The PWM signal generator 16 receives the signal from the winding short-circuit command unit 17, opens three switching elements 34 on the positive side, and closes three switching elements 34 on the negative side.

15 Then, a closed circuit is formed by the three switching elements 34 closed on the negative side of the inverter circuit and the field winding of the motor 1. Therefore, the regenerative energy produced by the electromotive power generated in the field winding is
20 consumed by each field winding in the process wherein the regenerative current flows in the above closed circuit. As a result, a braking force is applied to the motor 1, and the motor 1 is stopped within a short time.

25 As explained above, in the elevator control apparatus according to the fifth embodiment of the invention, free running of the elevator car 3 can be

stopped by operating the dynamic brake to prevent resetting of the emergency stop while the elevator car 3 is in an emergency stop. Therefore, safety of the elevator can be increased.

5 (Embodiment 6)

A sixth embodiment of the invention will be explained. FIG. 8 shows an example of configuration of the elevator control apparatus according to the sixth embodiment of the invention.

10 As shown in FIG. 8, the elevator control apparatus according to the sixth embodiment of the invention is provided with an insufficient deceleration detector 24, instead of the brake error detector 18 explained in the first embodiment.

15 When running the elevator car 3, the run command unit 12 outputs a brake open signal, and connects the second switch 46 to the current-control command unit 14.

20 The run command unit 12 also outputs the brake open signal to the insufficient deceleration detector 24. The insufficient deceleration detector 24 has a function of switching the first switch 45, and connects the first switch 45 to the current-control command unit 14 when receiving the brake open signal from the run
25 command unit 12.

To stop the elevator car 3 in an emergency, the run command unit 12 sends an emergency brake signal to

the friction brake unit 5 and insufficient deceleration detector 24, and sets the friction brake unit 5 to the state of braking the motor 1. The run command unit 12 switches the second switch 46 to the ground terminal side.

Receiving the brake signal, the insufficient deceleration detector 24 inputs the result of detection by the rotation angle detector 6 by two or more times at a predetermined time interval, and calculates a degree of deceleration of the rotation speed based on the value of the rotation angles as the result of detection. Namely, the insufficient deceleration detector 24 functions as a deceleration detector, which detects the degree of deceleration of the rotation speed of the motor 1 at the time of braking by the friction brake unit 5.

When the calculated the degree of deceleration of the rotation speed is less than a predetermined reference value, the insufficient deceleration detector 24 judges that the elevator car 3 cannot be normally stopped in an emergency caused by a defect in the motor 1. In this case, the insufficient deceleration detector 24 sends the run command unit 12 a command signal to stop the elevator car 3, and switches the first switch 45 connected to the PWM signal generator 16 from the current-control command unit 14 to the winding short-circuit command unit 17.

The winding short-circuit command unit 17 outputs a control signal to open three switching elements on one side of the inverter circuit, here the three switching elements 34 on the positive side, and to
5 close three switching elements 34 on the negative side.

The PWM signal generator 16 receives the signal from the winding short-circuit command unit 17, opens three switching elements 34 on the positive side, and closes three switching elements 34 on the negative
10 side.

Then, a closed circuit is formed by the three switching elements 34 closed on the negative side of the inverter circuit and the field winding of the motor 1. Therefore, the regenerative energy produced by the
15 electromotive power generated in the field winding is consumed by each field winding in the process wherein the regenerative current flows in the above closed circuit. As a result, a braking force is applied to the motor 1, and the motor 1 is stopped within a short
20 time.

As explained above, in the elevator control apparatus according to the sixth embodiment of the invention, free running of the elevator car 3 can be stopped by operating the dynamic brake to prevent
25 resetting of the emergency stop when normal emergency stop of the elevator car is judged impossible based on the degree of deceleration of the rotation speed of the

motor 1, while the elevator car 3 is in an emergency stop. Therefore, safety of the elevator can be increased.

5 In the above explained embodiments, the dynamic brake configured as shown in FIG. 1 is used. However, the dynamic brake shown in FIG. 2 may be used. In this case, when detecting a brake error, the brake error detector 18 explained in the first embodiment may operates the dynamic brake by sending a command signal
10 to actuate the dynamic brake to the conductor contacts 31 and 32, separating each switching element 34 from the three-phase winding of the motor 1 by the conductor contact 31, and connecting the three-phase winding of the motor 1 to the load resistor 30 through the
15 conductor contact 32.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments
20 shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. An elevator control apparatus comprising:
 - a rectifier circuit to convert AC power from an AC power supply to DC power;
 - 5 a smoothing capacitor to smooth a ripple of the DC power converted by the rectifier circuit;
 - an inverter which is formed by connecting diodes and switching elements in the form of a bridge, and outputs the smoothed DC power by converting to variable
 - 10 voltage/frequency AC power;
 - an electric motor which moves an elevator car up and down by driving from the AC power output from the inverter;
 - a run control unit which controls
 - 15 energizing/interruption of each switching element of the inverter so that the variable voltage/frequency AC power is output according to a predetermined operation pattern;
 - a brake unit which mechanically brakes movement of
 - 20 the elevator car;
 - a brake control unit which operates the brake unit to brake movement of the elevator car when the elevator car arrives at a floor;
 - an error detector which detects a malfunction of
 - 25 the brake unit when the elevator car arrives at a floor; and
 - a regenerative brake control unit which

regeneratively brakes the electric motor by closing the switching elements of one of the positive polarity side and negative polarity side of the inverter, and opening the switching elements of the other polarity side, when
5 a malfunction of the brake unit is detected by the error detector.

2. An elevator control apparatus comprising:

a rectifier circuit to convert AC power from an AC power supply to DC power;

10 a smoothing capacitor to smooth a ripple of the DC power converted by the rectifier circuit;

an inverter which is formed by connecting diodes and switching elements in the form of a bridge, and outputs the smoothed DC power by converting to variable
15 voltage/frequency AC power;

an electric motor which moves an elevator car up and down by driving from the AC power output from the inverter;

a run control unit which controls
20 energizing/interruption of each switching element of the inverter so that the variable voltage/frequency AC power is output according to a predetermined operation pattern;

a brake unit which mechanically brakes movement of
25 the elevator car;

a brake control unit which operates the brake unit to brake movement of the elevator car when the elevator

car arrives at a floor;

an abnormal-run detector which detects start of abnormal running of the elevator car when the elevator car arrives at a floor; and

5 a regenerative brake control unit which regeneratively brakes the electric motor by closing the switching elements of one of the positive polarity side and negative polarity side of the inverter, and opening the switching elements of the other polarity side, when
10 abnormal running of the elevator car is detected by the abnormal-run detector.

3. The elevator control apparatus according to claim 2, further comprising a rotation angle detector which detects a rotation angle of the electric motor,
15 wherein the abnormal-run detector detects start of abnormal running of the elevator car, when the rotation angle detected by the rotation angle detector is changed by satisfying a predetermined condition after the elevator car arrives at a floor.

20 4. The elevator control apparatus according to claim 2, further comprising a rotation angle detector which detects a rotation angle of the electric motor, wherein the abnormal-run detector calculates a rotation speed of the electric motor based on the rotation angle
25 detected by the rotation angle detector, and detects start of abnormal running of the elevator car when the rotation speed becomes a predetermined value.

5. An elevator control apparatus comprising:

a rectifier circuit to convert AC power from an AC power supply to DC power;

5 a smoothing capacitor to smooth a ripple of the DC power converted by the rectifier circuit;

an inverter which is formed by connecting diodes and switching elements in the form of a bridge, and outputs the smoothed DC power by converting to variable voltage/frequency AC power;

10 an electric motor which moves an elevator car up and down by driving from the AC power output from the inverter;

a run control unit which controls energizing/interruption of each switching element of the inverter so that the variable voltage/frequency AC power is output according to a predetermined operation pattern;

15

an abnormal acceleration detector which detects abnormal acceleration of the elevator car, when the elevator car is running at a predetermined speed lower than a normal running speed, and the elevator car speed is higher than a predetermined value; and

20

a regenerative brake control unit which regeneratively brakes the electric motor by closing the switching elements of one of the positive polarity side and negative polarity side of the inverter, and opening the switching elements of the other polarity side, when

25

abnormal acceleration of the elevator car is detected by the abnormal acceleration detector.

6. An elevator control apparatus comprising:

5 a rectifier circuit to convert AC power from an AC power supply to DC power;

a smoothing capacitor to smooth a ripple of the DC power converted by the rectifier circuit;

10 an inverter which is formed by connecting diodes and switching elements in the form of a bridge, and outputs the smoothed DC power by converting to variable voltage/frequency AC power;

an electric motor which moves an elevator car up and down by driving from the AC power output from the inverter;

15 a run control unit which controls energizing/interruption of each switching element of the inverter so that the AC power with a variable voltage/frequency is output according to a predetermined operation pattern;

20 an emergency brake unit which mechanically brakes movement of the elevator car in an emergency; and

a regenerative brake control unit which regeneratively brakes the electric motor by closing the switching elements of one of the positive polarity side and negative polarity side of the inverter, and opening the switching elements of the other polarity side, when
25 the elevator car is stopped by the emergency brake

unit.

7. An elevator control apparatus comprising:

a rectifier circuit to convert AC power from an AC power supply to DC power;

5 a smoothing capacitor to smooth a ripple of the DC power converted by the rectifier circuit;

an inverter which is formed by connecting diodes and switching elements in the form of a bridge, and outputs the smoothed DC power by converting to variable
10 voltage/frequency AC power;

an electric motor which moves an elevator car up and down by driving from the AC power output from the inverter;

a run control unit which controls
15 energizing/interruption of each switching element of the inverter so that the variable voltage/frequency AC power is output according to a predetermined operation pattern;

a brake unit which mechanically brakes movement of
20 the elevator car;

a deceleration speed detector which detects a degree of deceleration of the rotation speed of the electric motor at the time of braking by the brake unit; and

25 a regenerative brake control unit which regeneratively brakes the electric motor by closing the switching elements of one of the positive polarity side

and negative polarity side of the inverter, and opening the switching elements of the other polarity side, when the value detected by the deceleration speed detector is lower than a predetermined reference value.