

ELEVATOR DRIVING APPARATUS

This invention relates to an elevator driving apparatus wherein a suspension member for supporting a cage is wound for raising or lowering the cage.

Recently, houses have changed from two-storied ones to three- or more-storied ones. In such houses, rooms for common use such as a kitchen and private rooms such as bedrooms are disposed on different floors, and inter-floor traffic is inevitable. Moreover, in such multistoried residences, it is troublesome to carry goods to or from the third floor. Therefore, the installation of an elevator in such residences has been proposed; and a small-sized and simple elevator has been desired.

Figure 1 shows a known elevator driving apparatus. In the figure, numeral 1 designates a cage, numeral 2 a balance weight, numeral 3 a suspension member which is formed of a main rope coupled to both the cage 1 and the balance weight 2, numeral 4 a sheave winder round which the main rope 3 is wound, and numeral 5 an electric motor which is coupled to the winder 4 through a shaft

6. Numeral 7 indicates an electromagnetic brake which is coupled to the shaft 6. Normally, i.e., when a magnet coil 7a is deenergized, the electromagnetic brake 7 generates a braking force, and when the magnet coil 7a is energized by a D.C. power source 7b, the electromagnetic brake 7 is released to nullify the braking force. Letters R, S and T indicate the phases of a three-phase A.C. power source which feeds electric power to the motor 5. Symbols 11a and 11b denote ascent direction contactors, the input terminals of which are respectively connected to the phases R and S of the three-phase A.C. power source. When closed, they energize the motor 5 so as to raise the cage 1. An ascent direction brake contact 11c is opened or closed in synchronism with the ascent direction contactors 11a and 11b. This contact deenergizes the magnet coil 7a during stopping of the cage, and energizes it during the operation thereof. Symbols 12a and 12b denote descent direction contactors, the input terminals of which are respectively connected to the phases R and S of the three-phase A.C. power source, and the output terminals of which are respectively connected to the output terminals of the ascent direction contactors 11b and 11a. When closed, they energize the motor 5 in the reverse rotational direction so as to lower the cage 1.

A descent direction brake contact 12c is opened or closed in synchronism with the descent direction contactors 12a and 12b, and deenergizes and energizes the magnet coil 7a similarly to the aforementioned contact 11c. Controlled rectifier elements 13a and 13b are formed of bidirectional thyristors the input terminals of which are respectively connected to the output terminals of the ascent direction contactors 11a and 11b. Shown at 14a, 14b and 14c are driving contactors, the input terminals of which are respectively connected to the output terminal of the bidirectional thyristor 13a, the output terminal of the bidirectional thyristor 13b and the pahase T of the three-phase A.C. power source, and the output terminals of which are all connected to the motor 5. The driving contactors turn ON and OFF the A.C. power source to the motor 5.. Symbols 15a and 15b denote braking contactors the input terminals of which are respectively connected to output terminals of the bidirectional thyristors 13a and 13b. They are closed when the driving contactors 14a - 14c are open, whereas they are open when the driving contactors 14a - 14c are closed. A rectifier circuit 16 performs the full wave rectification of alternating currents supplied through the braking contactors 15a and 15b, to feed direct current to the motor 5.

(18)

In the elevator driving apparatus constructed as described above, during the ascent operation, the ascent direction contactors 11a, 11b and the driving contactors 14a - 14c are respectively closed to connect the motor 5 to the three-phase A.C. power source R, S, T through the bidirectional thyristors 13a, 13b, and the ascent direction brake contact 11c is closed to release the electromagnetic brake 7. The gates of the bidirectional thyristors 13a, 13b are gradually opened to accelerate the motor 5. When they have been fully opened, the cage 1 ascends at a fixed speed. When the cage 1 has ascended a predetermined distance on this side of a destination floor, the driving contactors 14a - 14c are opened, and the braking contactors 15a 15b are closed, so that direct current is supplied to the motor through the rectifier circuit 16 so as to generate a braking torque in the motor 5. This braking torque is controlled by the bidirectional thyristors 13a, 13b, and smoothly decelerates the cage 1. When the cage 1 has ascended

up to a fixed point, the ascent direction contactors 11a, 11b and the braking contactors 15a, 15b are respectively opened to deenergize the motor 5, and the brake contact 11c is opened to generate the braking force of the electromagnetic
5 brake 7 so as to hold the cage 1 at the fixed point through the sheave winder 4.

Next, during the descent operation, the descent direction contactors 12a, 12b are closed to connect the motor 5 to the three-phase A.C. power source R, S, T in the
10 opposite polarity, and the descent direction brake contact 12c is closed to release the electromagnetic brake 7. Thenceforth, likewise to the case of the ascent operation, the cage 1 is controlled and operated down to a fixed point.

In the elevator driving apparatus, the sheave
15 winder 4 is disposed over the cage 1 while supporting the total weight of the cage 1 and the balance weight 2. Therefore, the building must bear the total weight, the weight of the winder itself, and the motor etc. Pillars inevitably thicken to render the building expensive.

20 The three-phase A.C. power source R, S, T is connected to the motor 5 with the phase sequence changed for the ascent direction operation and the descent direction operation. This leads to the disadvantage that the ascent direction contactors 11a, 11b and the descent direction
25 contactors 12a, 12b are respectively required to render the control complicated.

This invention has for its object to provide a simple elevator driving apparatus.

The invention resides in an elevator driving apparatus comprising a winder which takes up a suspension member for supporting
5 a cage, so as to raise and lower the cage, an electric motor which drives said winder, a three-phase A.C power source connected so as to energize said motor in the direction of raising the cage, a controlled rectifier element connected in at least one phase, and control means controlling the said rectifier element(s) to
10 connect the motor to the three-phase source or to a lower-power A.C power source obtained by rendering one phase of the three-phase A.C power source ineffective by means of said controlled rectifier element(s), thereby to perform ascent and descent operations.

BRIEF DESCRIPTION OF THE DRAWINGS

15 Figure 1 is an electric circuit diagram of a known elevator driving apparatus;

Figure 2 is an electric circuit diagram of an elevator driving apparatus showing an embodiment of this invention;

20 Figure 3 is a diagram for explaining the operation of the embodiment in Figure 2;

Figure 4 is an electric circuit diagram of an elevator driving apparatus showing another embodiment of this invention; and

Figure 5 is a diagram for explaining the operation of the embodiment in Figure 4.

25 Throughout the drawings, the same symbols indicate identical or corresponding parts.

(21)

Figure 2 shows an embodiment of this invention. Numeral 20 designates a hoisting drum type winder including a drum which takes up the suspension member 3 formed of the main rope for suspending the cage 1, so as to raise or lower the cage 1. Shown at numeral 21 is control means. The control means 21 includes main contactors 21a - 21c which have input terminals thereof respectively connected to the phases R, S and T of the three-phase A.C. power source and the output terminals thereof respectively connected to the bidirectional thyristor 13a, the bidirectional thyristor 13b and the motor 5, so as to rotate the motor 5 in the direction of raising the cage 1 by mechanically opening or closing the respective electric paths. These main contactors 21a - 21c and the bidirectional thyristors 13a, 13b constitute the control means 21. Symbol 21d denotes a brake contact which is opened and closed in synchronism with the main contactors 21a - 21c, to deenergize and energize the magnet coil 7a Numerals 22, 23 and 24 indicate first, second and third floors to be served by the cage 1, respectively.

The operation of the elevator control apparatus of the above construction will be described with reference to Figures 2 and 3.

First, it is assumed that the cage 1 should stop at the second floor 23 and ascend to the third floor 24. The main contactors 21a - 21c are closed to be connected to the respective phases R, S and T of the three-phase A.C. power source, and the brake contact 21d is also closed to relase the electromagnetic brake 7. The bidirectional thyristor 13a is fully conductive, while the bidirectional thyristor 13b is in the nonconductive state at first. Since, at this time, the voltage of reduced-power A.C. power source composed of the A.C. power source phases R and T is applied to the motor 5, the torque to be generated has a value indicated by a torque curve 31 in Figure 3. As the bidirectional thyristor 13b is controlled to become more conductive, the torque increases. When the bidirectional thyristor 13b has been rendered fully conductive, the torque becomes as indicated by a torque curve 32. Accordingly, the torque of the motor 5 changes in a range of region A from the torque corve 31 toward the torque curve 32. Meanwhile, assuming that a load torque based on the cage 1 has a value corresponding to a torque corve 33 in Figure 3, the motor 5 accelerates the cage 1 with the torque indicated by the region A and raises the cage 1 at a fixed speed corresponding to a motor speed n_1 at the point of intersection between the torque curve 32 and the torque curve 33.

When the cage 1 has ascended to a predetermined distance before the third floor 24, the bidirectional thyristor 13a is rendered nonconductive, and the bidirectional thyristor 13b is variably controlled.

5 Then, the torque of the motor 5 changes in a range indicated by a region B in Figure 3. Owing to the weight of the cage 1 itself, a force in the descending direction acts on the winder 20 at all times.

Therefore, as the bidirectional thyristor 13b is
10 controlled to reduce the torque of the motor 5, the cage 1 is decelerated by its own weight and stops at the third floor 24. The main contactors 21a - 21c and the brake contact 21d are opened, and the brake 7 generates the braking force to restrain the cage 1.

15 Now, there will be explained a case of lowering the cage 1 from the second floor 23 to the first floor 22. Likewise to the case of the ascent from the second floor 23 to the third floor 24, the main contactors 21a - 21c and the brake contact 21d are opened. The bidirectional
20 thyristor 13a is rendered nonconductive, and the bidirectional thyristor 13b is variably controlled, to feed the motor 5 with the variable voltage of the reduced-power A.C. power source. In accordance with the value of this variable voltage, the motor 5 generates a
25 torque in a range indicated by a region C in Figure 3.



When the bidirectional thyristor 13b has been rendered fully conductive, the motor 5 generates a torque indicated by the torque curve 31 which is the outer edge of the region C. The descent operation is accelerated by the descending direction drive force of the motor 5 indicated by the region C, besides the weight of the cage 1 itself. When the bidirectional thyristor 13b has been rendered fully conductive, the cage 1 descends at a fixed speed which corresponds to motor speed n_3 at the point of intersection between the torque curve 31 and the torque curve 33.

When the cage 1 has descended to a predetermined distance before the first floor 22, the bidirectional thyristor 13a is rendered fully conductive, and the bidirectional thyristor 13b is controlled to gradually increase in conduction. Consequently, the power source to feed the motor 5 changes to the three-phase one, and the torque of the motor shifts from the region C to a region D in Figure 3. The ascending direction torque 32 exceeds the value indicated by the torque curve 33 to decelerate the cage 1 and to cause it to stop at the first floor 22, at which the cage 1 is restrained by the brake 7.

According to the embodiment described above, the cage 1 is driven by taking up the main rope 3 with the hoisting drum type winder 20. Therefore, the balance weight is dispensed with, and the burden due to weight on the building is reduced. Further, the ascending direction operation and the descending direction operation are permitted by the simple control of rendering the bidirectional thyristor 13a fully conductive or nonconductive. In addition, the acceleration control and the deceleration control can be performed by the simple control of the ignition angle control of the bidirectional thyristor 13b. Therefore, the control apparatus is simplified, and the elevator is comfortable to ride in.

In the embodiment described above, the acceleration and deceleration controls have been performed by the ignition angle control of the bidirectional thyristor 13b. Since, however, the elevator of this type operates at low speed, the following measure may well be taken. That is, the full-voltage starting of the motor 5 with the three-phase power source is executed in the ascent operation, and the full-voltage starting with the lower-power source is executed in the descent operation, to realize acceleration and constant-speed operations respectively, and the electromagnetic brake 7 is immediately actuated at the stoppage.

The lower-power A.C. power source can be obtained by rendering one phase of the three-phase A.C. power source nonconductive by rendering non-conductive a bidirectional thyristor connected to that phase.

- 5 Conversely, the bidirectional thyristors may well be connected to all the three phases so as to control the elevator operation similarly to the described embodiment.

A chain may be used as the suspension member, with the cage attached to one end of the chain, the winder
10 furnished with a sprocket wheel, and the other end of the chain wound round the sprocket wheel and suspended.

Figure 4 shows another embodiment of this invention. In the figure, the same symbols as in Figure 1 indicate identical or corresponding parts. Numeral 20
15 designates a hoisting drum type winder which takes up the suspension member 3 formed of the main rope for suspending the cage 1, so as to raise or lower the cage 1. Numeral 210 designates control means. The control means 210 includes main contactors 21a - 21c which have
20 input terminals thereof respectively connected to the thyristors 13a, 13b and the phase T of the three-phase A.C. power source, and the output terminals thereof respectively connected to the motor 5, so as to rotate the motor 5 in the direction of raising the cage 1 by
25 mechanically opening or closing the respective electric

27

paths. Symbols 25a - 25d denote main contactors similar to those of 21a - 21c, which operate alternatively to the main contactors 21a - 21c so as to supply the motor 5 with the direct current of the rectifier circuit 16.

5 The control means 210 is composed of the main contactors 21a - 21c and 25a - 25d. Numeral 26 indicates a brake contact which deenergizes and energizes the magnet coil 7a. Numerals 22 - 24 indicate first - third floors to be served by the cage 1, respectively.

10 The operation of the elevator control apparatus of the above construction will be described with reference to Figures 4 and 5.

First, it is assumed that the cage 1 should stop at the second floor 23 and ascend up to the third floor 24. The main contactors 21a - 21c are closed to be connected to the respective phases R, S, through the respective thyristors 13a and 13b, and T of the three-phase A.C. power source, and the brake contact 26 is also closed to release the electromagnetic brake 7.

15 24. The main contactors 21a - 21c are closed to be connected to the respective phases R, S, through the respective thyristors 13a and 13b, and T of the three-phase A.C. power source, and the brake contact 26 is also closed to release the electromagnetic brake 7.

20 On this occasion, the main contactors 25a - 25d are open. The bidirectional thyristor 13a is fully conductive, and the bidirectional thyristor 13b is in the nonconductive state at first. Since, at this time, the voltage of the A.C. power source composed of the

25 A.C. power source phases R and T is applied to the motor

5, the torque to be generated has a value indicated by a torque curve 31 in Figure 5. As the bidirectional thyristor 13b is controlled to become more conductive, the torque increases. When the bidirectional thyristor 13b has been rendered fully conductive, the torque becomes as indicated by a torque curve 32. Accordingly, the torque of the motor 5 changes in a range of region A from the torque curve 31 toward the torque curve 32. Meanwhile, assuming that a load torque based on the cage 1 has a value corresponding to a torque curve 33 in Figure 5, the motor 5 accelerates the cage 1 with the torque indicated by the region A and raises the cage 1 at a fixed speed corresponding to motor speed n_1 at the point of intersection between the torque curve 32 and the torque curve 33.

When the cage 1 has ascended to a predetermined distance before the third floor 24, the bidirectional thyristor 13a is rendered nonconductive, and the bidirectional thyristor 13b is variably controlled. Then, the torque of the motor 5 changes in a range indicated by a region B in Figure 5.

Further, the bidirectional thyristor 13b is rendered nonconductive, the main contactors 21a - 21c are opened, the main contactors 25a - 25d are closed, and the bidirectional thyristor 13b is thereafter subjected to

29

13a

the ignition angle control. Then, the torque changes in a range indicated by a region E enclosed with a curve 34 in Figure 5, any desired deceleration is attained, and the cage deceleratedly arrives at the third floor 24.

5 Subsequently, the main contactors 25a - 25d and the brake contact 26 are opened, and the brake 7 generates the braking force to restrain the cage 1.

There will now be explained a case of lowering the cage 1 from the second floor 23 to the first floor 22.

10 Likewise to the case of the ascent from the second floor 23 to the third floor 24, the main contactors 25a - 25d are opened, and the main contactors 21a - 21c and the brake contact 26 are closed. The bidirectional thyristor 13a is rendered nonconductive, and the

15 bidirectional thyristor 13b is variably controlled, to feed the motor 5 with the variable voltage of the lower-power A.C. power source R-T. In accordance with the value of this variable voltage, the motor 5 generates a torque in a range indicated by a region C in

20 Figure 5. When the bidirectional thyristor 13b has been rendered fully conductive, the motor 5 generates a torque indicated by the torque curve 31 which is the outer edge of the region C. The descent operation is accelerated by the descending-direction drive force of

25 the motor 5 indicated by the region C, besides the weight of the cage 1 itself. When the bidirectional thyristor 13b has been rendered fully conductive, the cage 1 descends at a fixed speed which corresponds to motor speed n_3 at the point of intersection between

30 the torque curve 31 and the torque curve 33.

When the cage 1 has descended to a predetermined distance before the first floor 22, the bidirectional

thyristors 13a, 13b are rendered nonconductive, the main contactors 21a - 21c are opened, the main contactors 25a - 25d are closed, and the bidirectional thyristor 13b is thereafter subjected to the ignition angle control, 5 whereby the induction motor 5 generates a D.C. braking torque indicated by a region F enclosed with a curve 5 in Figure 5, so as to decelerate the cage. Thereafter, when the cage has reached the third floor 24, the bidirectional thyristor 13b is rendered nonconductive, 10 whereupon the main contactors 25a - 25d are opened. Thus, the main contactors 25a - 25d are relieved from cutting off the power surge and have their lifetimes prolonged.

Attention is drawn to our U. K. Patent No. 2116791, 15 which describes and claims a winding drum type elevator control in which a winding drum driven by an induction motor is provided, and in the upward movement operation a cage thereof is run by winding a main cable thereof on said winding drum, while in the downward movement 20 operation said cage is run by unwinding said main cable from said winding drum and comprising first switching means which, for the upward movement operation, are closed to apply electric power to said motor to allow the latter to operate in a normal full torque mode, 25 second switching means which, for the downward movement operation, are closed to apply electric power to said motor to allow the latter to start in a low torque mode and third switching means for applying electric power to said motor to allow the latter to operate in said normal 30 full torque mode, said switching means operating automatically when the downward speed of said cage reaches a predetermined value or when the cage has been in motion for a predetermined time.

**CLAIMS:**

1. An elevator driving apparatus comprising a winder which takes up a suspension member for supporting a cage, so as to raise and lower the cage, an electric motor which drives said winder, a three-phase A.C. power source connected so as to energize said motor in the direction of raising the cage, a controlled rectifier element connected in at least one phase, and control means controlling the said rectifier element(s) to connect the motor to the three-phase source or to a lower-power A.C. power source obtained by rendering one phase of the three-phase A.C. power source ineffective by means of said controlled rectifier element(s), thereby to perform ascent and descent operations.
2. An elevator driving apparatus according to claim 1, wherein said winder is a hoisting drum type winder having a drum which takes up and delivers a rope for suspending the cage.
3. An elevator driving apparatus according to claim 1 or 2, wherein said control means is arranged to control the conductive and nonconductive states and conduction angle of the said controlled rectifier element(s).
4. An elevator driving apparatus according to claim 1, 2, or 3 wherein said control means connect the said



three-phase A.C. power source to said motor so as to perform the ascent operation, and connect the said lower-power A.C. power source to said motor so as to perform the descent operation.

5. An elevator driving apparatus according to claim 1, 2, or 3 wherein said controlled rectifier elements are connected in at least two phases, and for ascent acceleration, said control means energizes said motor with the three-phase A.C. power source obtained by rendering the controlled rectifier element of one phase conductive and controlling the controlled rectifier element of the other phase or phases, while during ascent deceleration, the control means energizes said motor with the said lower-power A.C. power source obtained by rendering the controlled rectifier element of one phase nonconductive and variably controlling the controlled rectifier element of the other phase or phases.

6. An elevator driving apparatus according to claim 5, wherein during the ascent acceleration, said controlled rectifier element of one phase is rendered fully conductive, while said controlled rectifier element of the other phase or phases is controlled so as to gradually increase in conduction from an initial nonconductive state.



32

7. An elevator driving apparatus according to claim 6, wherein during the ascent deceleration, said controlled rectifier element of one phase, which was rendered conductive during the ascent acceleration, is rendered nonconductive, while said controlled rectifier element of the other phase or phases has its conduction controlled.

8. An elevator driving apparatus according to claim 7, wherein during the ascent deceleration of the cage, the weight of the cage acting on said winder is used for decelerating the cage.

9. An elevator driving apparatus according to claim 1, 2 or 3, wherein said control means has controlled rectifier elements connected in at least two phases, and during ascent deceleration, said control means energizes said motor with the lower-power A.C. power source obtained by rendering the controlled rectifier element of one phase nonconductive and controlling the controlled rectifier element of the other phase or phases, while during descent deceleration, the control means energizes said motor with the three-phase A.C. power source obtained by rendering said controlled rectifier element of one phase conductive and variably controlling said controlled rectifier element of the other phase or phases.



10. An elevator driving apparatus according to claim 9, wherein during the descent acceleration of the cage, said controlled rectifier element of one phase is held in its fully nonconductive state, while said controlled rectifier element of the other phase or phases has its conduction controlled to feed said motor with a varying A.C. voltage.

11. An elevator driving apparatus according to claim 10, wherein during the descent acceleration of the cage, the weight of the cage acting on said winder is used for accelerating the cage.

12. An elevator driving apparatus according to claim 9, 10 or 11 wherein during the descent deceleration of the cage, said controlled rectifier elements of one phase, which was rendered nonconductive during the descent acceleration of the cage, is held in its fully conductive stage, while said controlled rectifier element of the other phase or phases is controlled so as to gradually increase in conduction.

13. An elevator driving apparatus according to claim 12, wherein said motor is fed with three-phase alternating current to generate a torque in the cage ascent direction, and the ascent direction torque is gradually increased to decelerate and stop the cage.



35

14. An elevator driving apparatus according to claim 1 or 2, wherein said control means comprises contactors which connect the three-phase A.C. power source to said motor so as to rotate said motor in the direction of raising the cage, and the controlled rectifier elements are two bidirectional thyristors which are respectively connected between two phases of the three-phase A.C. power source and said motor.

15. An elevator driving apparatus according to claim 14, wherein said contactors have a contact which actuates a braking device disposed in said winder, in synchronism with the supply of three-phase alternating current to said motor.

16. An elevator driving apparatus according to any preceding claim, further including a rectifier circuit which rectifies alternating current fed from said A.C. power source to provide a direct current, said control means being arranged to selectively supply said motor with the A.C. voltage provided via said controlled rectifier elements or with a D.C. voltage provided by said rectifier circuit so as to perform cage ascent and descent operations.

17. An elevator driving apparatus according to claim 16, wherein in an ascent deceleration operation of the cage,



said control means renders one of said controlled rectifier elements nonconductive and controls conduction of the other controlled rectifier element so as to supply alternating current to said rectifier circuit, whereupon the alternating current is rectified by said rectifier circuit into the direct current which is supplied to said motor.

18. An elevator driving apparatus according to claim 16 or 17, wherein in the descent operation of the cage, said control means supplies said motor with alternating current, and in decelerating the descending cage, it rectifies the alternating current obtained by rendering one of said controlled rectifier elements nonconductive into direct current through said rectifier circuit and supplies said motor with said direct current.

19. An elevator driving apparatus according to claim 16 or 17 or 18, wherein said controlled rectifier elements are connected in at least two phases of said A.C. power source; first switching means are connected between said controlled rectifier elements and said motor; and second switching means are connected between said controlled rectifier elements and said motor in a manner to bypass said first switching means; said rectifier elements being connected in the bypass circuit formed by said second switching means.



37

21

20. An elevator driving apparatus according to claim 19, wherein said first switching means and said second switching means are contactors which mechanically open and close electric paths, and these switching means are switched after said controlled rectifier elements have been rendered fully nonconductive.

21. Elevator driving apparatus, substantially as herein described with reference to figures 2 and 3 or figures 4 and 5 of the accompanying drawings.
