

PATENT SPECIFICATION

(11) 1 268 602

DRAWINGS ATTACHED

- (21) Application No. 4208/70 (22) Filed 28 Jan. 1970
 (31) Convention Application No. 6684 (32) Filed 31 Jan. 1969 in
 (33) Japan (JA)
 (45) Complete Specification published 29 March 1972
 (51) International Classification H 02 p 7/48 7/74
 (52) Index at acceptance
 H2J 1B 1H1 1K1 1L1 1L2 1N1 1N2 9D



(54) CONTROL SYSTEM FOR A.C. ELEVATOR

(71) We, HITACHI, LTD., a Japanese Body Corporate, of 5-1, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an elevator control system and more particularly to a control system for an A.C. elevator driven by an induction motor.

An elevator equipment using an induction motor (usually, a three-phase squirrel-cage induction motor or a three-phase wound-rotor induction motor for driving the traction sheave) is commonly called an A.C. elevator, and has been extensively employed since it can be manufactured at low cost and has a simple and stout structure as compared with a D.C. elevator. In such an elevator installation, the traction motor is controlled to produce at least two different magnitudes of torque in stages during acceleration or deceleration without discomfort to the passengers.

Consequently, a two-speed induction motor is generally employed so that its torque can be controlled over a plurality of stages by short-circuiting the control resistors connected in series with its primary or secondary windings. As a result, many contactors and contacts are required.

According to one aspect of the present invention there is provided an A.C. elevator comprising an induction motor means having a high speed motor section and a low speed motor section arranged so that the high speed motor section is operated at least during acceleration and the low speed motor section is operated during deceleration, a control system which includes common switching means for controlling the torques produced by each motor section, the common switching means having a single energizing coil circuit for actuating a plurality of contacts in the high speed motor section and the low speed motor section and being adapted to control

at least one of the torque in at least two stages.

According to another aspect of the present invention there is provided an A.C. elevator comprising an induction motor means having a high speed motor section and a low speed motor section arranged so that the high speed motor section is operated at least during acceleration and the low speed motor section is operated during deceleration, a control system comprising common switching means for controlling the torques produced by each motor section over at least two stages, the common switching means having a single energizing coil circuit for actuating a plurality of contacts in the high speed motor section and the low speed motor section.

Illustrative embodiments of the present invention will now be described with reference to the accompanying drawings, in which:—

Fig. 1 is a schematic illustration of an elevator installation of a type with which this invention is used;

Fig. 2 is a schematic diagram of an elevator control system in accordance with the present invention;

Fig. 3 is a graph showing the torque-slip characteristics of the motor for explaining the operation of the system of Fig. 1;

Fig. 4 is a schematic illustration of another embodiment of the present invention;

Fig. 5 is a graph showing the torque-slip characteristics of the motor for explaining the operation of the system of Fig. 4; and

Fig. 6 and Fig. 7 are schematic illustrations showing the installations according to the third and fourth embodiments of the invention respectively.

Referring to Fig. 1, a high speed and a low speed alternating current induction motor M1 and M2 are coupled to each other. In general, a two-speed induction motor may be divided into two broad types, one of which types comprises two motors of different synchronous speeds, each motor having rotor and a stator and both motors being directly and rigidly coupled to each other, while the other of which types consists of a motor having one

stator on which are mounted two windings (i.e., windings for providing high and low speeds, respectively). The former type described in conjunction with the embodiments of the present invention is called a tandem type and the latter a double winding type. Still another type for the same purpose comprises two separate motors coupled to each other by means of a coupling. Control resistors r_1 , r_2 and r_3 are connected in series with the respective armature windings of the high speed motor M1, and control resistors r_4 , r_5 and r_6 are connected in series with the respective armature windings of the low speed motor M2.

The contactors and relays employed in the system illustrated in Fig. 2 are designated as follows:

- 10: operation contactor
- 13: main contactor for high speed induction motor
- 14: main contactor for low speed induction motor
- T1, T2, T3, T4: time relay of which contacts are operated after predetermined period of time when it is deenergized.
- 21, 22: Main contactor for short-circuiting control resistors
- 11: up direction contactor
- 12: down direction contactor

Now, two types of contacts are employed for the contactors and relays. One type may be referred to as back or break contacts. Such contacts are closed when the associated contactor or relay is deenergized and dropped out. The contacts are opened when the associated contactor or relay is energized and picked up. Another type of contacts may be referred to as front or make contacts. Such contacts are opened when the associated contactor or relay is deenergized and dropped out. The contacts are closed when the associated relay is energized and picked up. In the drawings, make contacts are represented by a symbol $\circ \circ$ or $-|$ and break contacts are represented by a symbol $\circ \circ$. The contactors and relays employed in the control circuits may have numerous contacts. For this reason, each of the sets of contacts of a relay or contactor is identified by the same reference character employed for the relay or contactor, followed by a numeral or suffix indicating the specific set of contacts. For example, reference characters 10-1 and 10-2 indicate, respectively, the first and second sets of contacts for the operation contactor 10.

Assume now that a call is picked up when a car is standing at the first floor. The contacts 11-1, 11-2, 11-3 and 11-4 of up direction contactor 11 (not shown) are closed.

The engagement of the contacts 11-3 completes an energizing circuit for the operation

contactor 10 and the engagement of the contacts 11-4 establishes an energizing circuit for the main contactor 13.

Thus, in Fig. 1, the high speed motor M1 is connected to an A.C. power supply U, V, W with the control resistors r_1 , r_2 and r_3 connected in series with its primary windings. The high speed motor M1 is started along a torque curve τ_1 shown in Fig. 3 to produce a starting torque P1. In a predetermined period of time after the contacts 10-4 of contactor 10 are opened, the break contacts T1-2 of time relay T1 are closed. As a result of the closure of the contacts T1-2, the main contactor 21 is energized through the circuit:

$$(+E) \rightarrow 21 \rightarrow T1-2 \rightarrow 13-5 \rightarrow (-E)$$

As seen in Fig. 1, the two contacts 21-1 and 21-2 of contactor 21 are connected to the high speed motor M1 and low speed motor M2, respectively. However, the closure of the contacts 21-2 imparts no effect to the low speed motor M2 since the contacts 14-1 and 14-2 on the side of the low speed motor M2 are in their open position. The closure of the contacts 21-1 on the side of the high speed motor M1 results in the short-circuit of the control resistors r_1 and r_2 inserted in the U- and V- phase windings, and a resistance r_1 r_2

$r_3 + \frac{r_1 + r_2}{r_1 + r_2}$ is now inserted in the W-phase winding. Therefore, the torque imparted to the elevator along the torque-slip curve τ_1 in Fig. 3 is changed from a point P2 on the torque curve τ_1 to a point P3 on a torque curve τ_2 in the order of $P1 \rightarrow P2 \rightarrow P3$. The torque curve τ_2 is determined by the resistance r_1 r_2

$$r_3 + \frac{r_1 + r_2}{r_1 + r_2}$$

In a predetermined period of time after the opening of the contacts T1-1, the contacts T2-1 of time relay T2 are now closed in Fig. 2. An energizing circuit for the main contactor 22 is completed through the path:

$$(+E) \rightarrow 22 \rightarrow T2-1 \rightarrow 13-5 \rightarrow (-E)$$

Since the two contacts 22-1 and 22-2 of the main contactor 22 are connected to the high speed motor M1 and low speed motor M2, respectively, all the control resistors r_1 through r_6 for the two motors M1 and M2 are short-circuited. However, no driving effort is imparted to the low speed motor M2 because this motor is cut off from the A.C. power supply. Consequently, the torque imparted to the elevator along the torque-slip curve τ_2 shown in Fig. 3 is changed from a point P4 on the torque curve τ_2 to a point P5 on a torque curve τ_3 , and the control for the acceleration is completed.

When the elevator car reaches deceleration commanding point a decelerating relay 92 (not shown) is energized and its break contacts 92-1 are opened in Fig. 2. As a result of the opening of the contacts 92-1, the main contactor 13 is deenergized with the result that its contacts 13-1, 13-2, 13-4 and 13-5 are opened while its contacts 13-3 are closed. The closure of the contacts 13-3 results in the energization of the main contactor 14 through the contacts 10-3. The opening of the contacts 13-5 deenergizes the main contactors 21 and 22 with the result that the contacts 21-1, 21-2, 22-1 and 22-2 in Fig. 1 are opened and the control resistors r1 through r6 are connected to both the motors M1 and M2 again. Thus when the contacts 14-1 and 14-2 of main contactor 14 are closed, the low speed motor M2 is connected to the A.C. power supply U, V, W with the control resistors r4 through r6 connected thereto and the deceleration is commenced. This state is represented by a point P6 in Fig. 3 and the regenerative braking is applied to the motor M2 since the speed of the motor M2 is higher than its synchronous speed. In a predetermined period of time after the opening of the contacts 13-4, the contacts T3-2 of time relay T3 are closed and an energizing circuit for the contactor 21 is established. The control resistors r1, r2, r4 and r5 are short-circuited in a manner similar to that described with regard to the acceleration control.

In a predetermined period of time after the opening of the contacts T3-1, the time relay T4 is deenergized and its contacts T4-2 are closed to engage the main contactor 22. All the control resistors associated with the motor M2 are thus short-circuited and the deceleration control is finished. During this operation, no driving effort is imparted to the motor M1 because the contacts 13-1 and 13-2 of the main contactor 13 are in their open position. The deceleration control will be explained on the torque-slip curves shown in Fig. 3, from which it will be seen that the torque imparted to the elevator is changed in the order of $P6 \rightarrow P7 \rightarrow P8 \rightarrow P9 \rightarrow P10$ on the torque curves τ_4 , τ_5 and τ_6 .

It will be understood from the above description that the control system according to the present invention makes it possible to carry out the acceleration and deceleration control over three stages by the provision of two main contactors 21 and 22, whereas only the control over one stage is possible with prior art systems.

Fig. 4 shows another embodiment of the present invention in which it will be seen that control resistors r1 and r2 are connected in series with the W-phase winding of a high speed motor M1 while control resistors r4 and r5 are connected in series with the U-phase winding of a low speed motor M2. Contacts 21-1 and 21-2 of contactor 21 short-

circuit the control resistors r1 and r4, while contacts 22-1 and 22-2 of contactor 22 short-circuit the control resistors r2 and r5.

As will be seen from the torque-slip characteristic curves shown in Fig. 5, the arrangement of Fig. 4 utilizes the fact that any desired torque in the hatched area ranging from zero to normal starting torque τ_{st} can be freely selected during acceleration even though the single phase control is employed and that any desired torque in the hatched area ranging from τ_{D1} which is substantially half the normal deceleration torque τ_D to the normal deceleration torque τ_D can be freely selected during deceleration. In the embodiment shown in Fig. 4, the torque of the first stage is determined by the combined resistance $r1+r2$ of the control resistors r1 and r2, and the torque of the second stage is determined solely by the resistance r2 of the control resistor r2. Thus, this embodiment is featured by the fact that the magnitude of the torque of the second stage can be fairly freely selected.

In the embodiments shown in Figs. 1 and 4, control resistors are inserted non-symmetrically in the primary windings of motors for the control of the torque. A further embodiment shown in Fig. 6 differs from the embodiments shown in Figs. 1 and 4 in that two contacts 21-1 and 21-2 of contactor 21 having four contacts are associated with a high speed motor M1 while two contacts 21-3 and 21-4 of the same contactor 21 are associated with a low speed motor M2 so that these contacts can be operated simultaneously. This arrangement is advantageous in that a single main contactor can carry out the control of torque over two stages.

While the contacts of contactors 21 and 22 and the control resistors r1 through r6 are connected to the second terminals b11 through b13 of a stator in the embodiments described above (shown Fig. 1), it will be apparent that they may also be connected to the first terminals all through a12 as shown in Fig. 7.

When a motor of the wound rotor type is employed, control resistors may be connected in series with the secondary windings.

As will be appreciated from the foregoing description, the present invention is advantageous over prior art control systems in that it is capable of controlling the torque over a greater number of stages provided that the number of the main contactors is the same.

WHAT WE CLAIM IS:—

1. An A.C. elevator comprising an induction motor means having a high speed motor section and a low speed motor section arranged so that the high speed motor section is operated at least during acceleration and the low speed motor section is operated during de-



When the elevator car reaches deceleration commanding point a decelerating relay 92 (not shown) is energized and its break contacts 92-1 are opened in Fig. 2. As a result of the opening of the contacts 92-1, the main contactor 13 is deenergized with the result that its contacts 13-1, 13-2, 13-4 and 13-5 are opened while its contacts 13-3 are closed. The closure of the contacts 13-3 results in the energization of the main contactor 14 through the contacts 10-3. The opening of the contacts 13-5 deenergizes the main contactors 21 and 22 with the result that the contacts 21-1, 21-2, 22-1 and 22-2 in Fig. 1 are opened and the control resistors r1 through r6 are connected to both the motors M1 and M2 again. Thus when the contacts 14-1 and 14-2 of main contactor 14 are closed, the low speed motor M2 is connected to the A.C. power supply U, V, W with the control resistors r4 through r6 connected thereto and the deceleration is commenced. This state is represented by a point P6 in Fig. 3 and the regenerative braking is applied to the motor M2 since the speed of the motor M2 is higher than its synchronous speed. In a predetermined period of time after the opening of the contacts 13-4, the contacts T3-2 of time relay T3 are closed and an energizing circuit for the contactor 21 is established. The control resistors r1, r2, r4 and r5 are short-circuited in a manner similar to that described with regard to the acceleration control.

In a predetermined period of time after the opening of the contacts T3-1, the time relay T4 is deenergized and its contacts T4-2 are closed to engage the main contactor 22. All the control resistors associated with the motor M2 are thus short-circuited and the deceleration control is finished. During this operation, no driving effort is imparted to the motor M1 because the contacts 13-1 and 13-2 of the main contactor 13 are in their open position. The deceleration control will be explained on the torque-slip curves shown in Fig. 3, from which it will be seen that the torque imparted to the elevator is changed in the order of $P6 \rightarrow P7 \rightarrow P8 \rightarrow P9 \rightarrow P10$ on the torque curves τ_4 , τ_5 and τ_6 .

It will be understood from the above description that the control system according to the present invention makes it possible to carry out the acceleration and deceleration control over three stages by the provision of two main contactors 21 and 22, whereas only the control over one stage is possible with prior art systems.

Fig. 4 shows another embodiment of the present invention in which it will be seen that control resistors r1 and r2 are connected in series with the W-phase winding of a high speed motor M1 while control resistors r4 and r5 are connected in series with the U-phase winding of a low speed motor M2. Contacts 21-1 and 21-2 of contactor 21 short-

circuit the control resistors r1 and r4, while contacts 22-1 and 22-2 of contactor 22 short-circuit the control resistors r2 and r5.

As will be seen from the torque-slip characteristic curves shown in Fig. 5, the arrangement of Fig. 4 utilizes the fact that any desired torque in the hatched area ranging from zero to normal starting torque τ_{st} can be freely selected during acceleration even though the single phase control is employed and that any desired torque in the hatched area ranging from τ_{D1} which is substantially half the normal deceleration torque τ_D to the normal deceleration torque τ_D can be freely selected during deceleration. In the embodiment shown in Fig. 4, the torque of the first stage is determined by the combined resistance r1+r2 of the control resistors r1 and r2, and the torque of the second stage is determined solely by the resistance r2 of the control resistor r2. Thus, this embodiment is featured by the fact that the magnitude of the torque of the second stage can be fairly freely selected.

In the embodiments shown in Figs. 1 and 4, control resistors are inserted non-symmetrically in the primary windings of motors for the control of the torque. A further embodiment shown in Fig. 6 differs from the embodiments shown in Figs. 1 and 4 in that two contacts 21-1 and 21-2 of contactor 21 having four contacts are associated with a high speed motor M1 while two contacts 21-3 and 21-4 of the same contactor 21 are associated with a low speed motor M2 so that these contacts can be operated simultaneously. This arrangement is advantageous in that a single main contactor can carry out the control of torque over two stages.

While the contacts of contactors 21 and 22 and the control resistors r1 through r6 are connected to the second terminals b11 through b13 of a stator in the embodiments described above (shown Fig. 1), it will be apparent that they may also be connected to the first terminals a11 through a12 as shown in Fig. 7.

When a motor of the wound rotor type is employed, control resistors may be connected in series with the secondary windings.

As will be appreciated from the foregoing description, the present invention is advantageous over prior art control systems in that it is capable of controlling the torque over a greater number of stages provided that the number of the main contactors is the same.

WHAT WE CLAIM IS:—

1. An A.C. elevator comprising an induction motor means having a high speed motor section and a low speed motor section arranged so that the high speed motor section is operated at least during acceleration and the low speed motor section is operated during de-

- celeration, a control system which includes common switching means for controlling the torques produced by each motor section, the common switching means having a single energizing coil circuit for actuating a plurality of contacts in the high speed motor section and the low speed motor section and being adapted to control at least one of the torques in at least two stages.
2. An A.C. elevator comprising an induction motor means having a high speed motor section and a low speed motor section arranged so that the high speed motor section is operated at least during acceleration and the low speed motor section is operated during deceleration, a control system comprising common switching means for controlling the torques produced by each motor section over at least two stages, the common switching means having a single energizing coil circuit for actuating a plurality of contacts in the high speed motor section and the low speed motor section.
3. An A.C. elevator control system as claimed in claim 1 or 2, in which at least one control resistor is connected in series with each of the three-phase windings on the stators of the high and low speed motor sections, and the control resistors connected to the windings of all the phases are simultaneously and sequentially controlled by said common switching means during starting and deceleration.
4. An A.C. elevator control system as claimed in claim 1 or 2, in which at least one control resistor is connected in series with each of the three-phase windings on the stators of the high and low speed motor sections, and the control resistors connected to the windings of at least one phase are simultaneously and sequentially controlled by said common switching means during starting and deceleration.
5. An A.C. elevator control system as claimed in claim 1 or 2, in which at least one control resistor is connected in series with one of the three-phase windings on each stator of the high and low speed motor sections, and the control resistors are simultaneously and sequentially controlled by said common switching means during starting and deceleration.
6. An A.C. elevator control system as claimed in claim 1 or 2, in which at least one control resistor is connected in series with at least one of the three-phase windings on each stator of the high and low speed motor sections, and said control resistors are simultaneously and sequentially controlled by the common switching means during starting and deceleration.
7. An A.C. elevator control system as claimed in any one of claims 2 to 5, in which the control resistors and said common switching means are inserted in the three-phase windings on the rotors of the high and low speed motor sections.
8. An A.C. elevator control system substantially as hereinbefore described with reference to and as shown by Figures 1 to 3, Figures 4 and 5, Figure 6 or Figure 7 of the accompanying drawings.
- J. A. KEMP & CO.,
Chartered Patent Agents,
14 South Square,
Gray's Inn,
London, W.C.1.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1972.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

