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A. O. LUND
ELEVATOR CONTROL SYSTEM

2,641,337

Filed Jan. 17, 1951

2 Sheets-Sheet 1

Fig. 1.

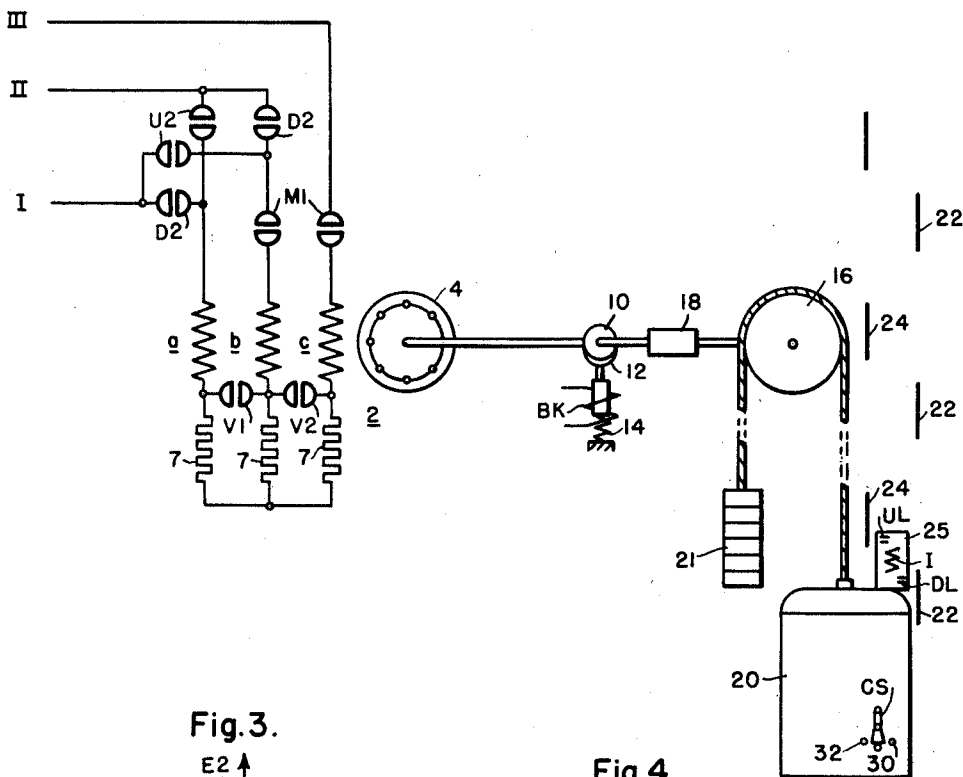


Fig. 3.

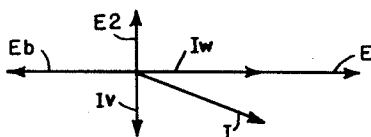
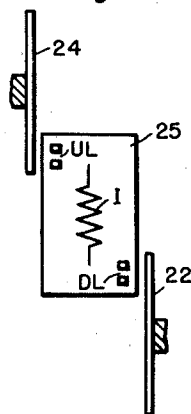


Fig. 4.



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2 Sheets-Sheet 2

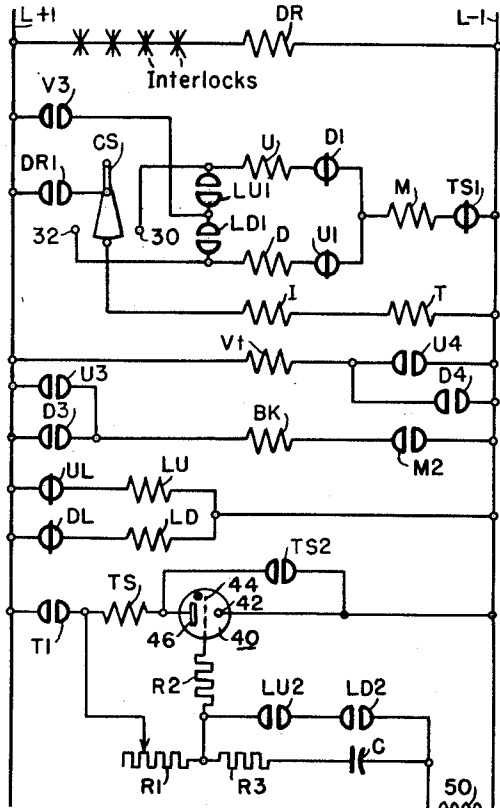


Fig. 2.

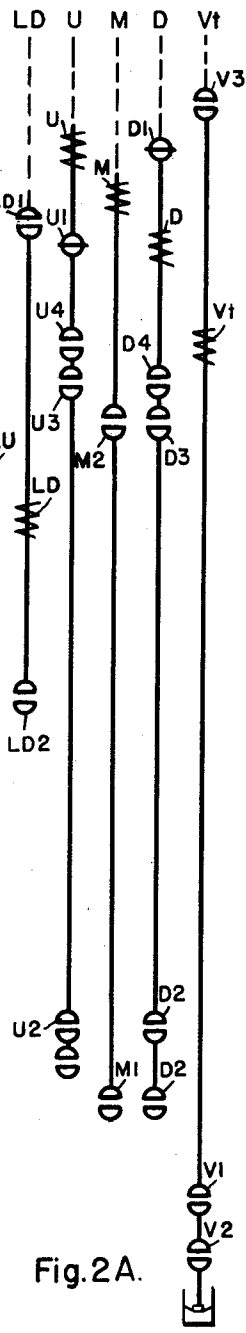
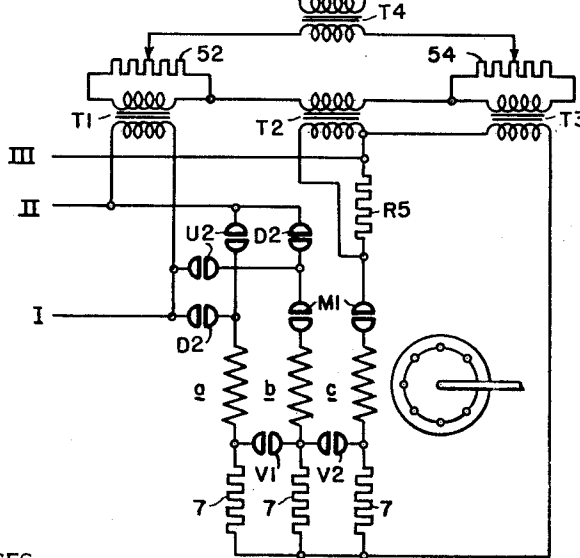


Fig. 2A.

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ELEVATOR CONTROL SYSTEM

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The invention relates to elevator control systems and more particularly to a system for controlling the landing or stopping of an elevator with respect to a floor where it is desired to stop.

In automatic elevators, particularly of the low speed type in which the hoisting motor frequently is a single speed alternating current induction motor, accurate landing of the elevator level with a floor has always presented a problem, primarily because the stopping distance, that is the distance required to stop when the brake is applied, varies considerably with the load on the car, as well as the direction of travel of the car. Although many systems and devices for obtaining an accurate stop have been suggested, it is believed that the one to be described herein is particularly effective and reliable.

It is an object of the invention to provide a system for controlling the stopping of an elevator car in such manner that the stopping operation is initiated at a distance from the floor which is inversely proportional to the load on the car in order to obtain a level stop.

It is a further object of the invention to provide an improved landing control scheme for an elevator car which is sensitive to the load on the car and is relatively inexpensive and reliable.

Further objects will appear from the accompanying drawings, in which:

Figure 1 is a schematic illustration of an elevator installation of a type with which the invention may be used;

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

Fig. 2A is a key diagram showing the positions of the various relays and contacts in lateral alignment with the positions shown in Fig. 2;

Fig. 3 is a vector diagram explanatory of the relations between certain electrical quantities encountered in the operation of the system of Fig. 2; and

Fig. 4 is a schematic showing of a relay of the induction type which may be employed in practicing the invention.

Referring to Fig. 1, an alternating-current elevator motor 2 is diagrammatically illustrated as comprising a squirrel cage rotor 4 and a three-phase stator consisting of windings *a*, *b* and *c* which are Y-connected and energized respectively from the three-phase conductors I, II and III. Resistors 7 are series-connected with

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the respective field windings *a*, *b* and *c*, to reduce the torque output of the motor on starting, and may be shunted by contacts V1 and V2 for normal-speed operation of the motor, in a manner to be described. Further, the direction of rotation of the armature 4 is reversible by reversing the connections of the phases I and II of the alternating current supply line, such as by the closing of up direction contacts U2 or by closing down direction contacts D2.

A brake drum 10 is mounted on the shaft of the motor armature and a brake shoe 12 cooperates with it to exert a braking force under the influence of spring 14 to stop the car. Brake magnet BK, when energized, exerts a force in opposition to the spring 14 to release the brake to permit operation of the car. An elevator driving sheave 16 is driven from the motor shaft through reduction gearing 18, and a cable cooperates with it to suspend the elevator car 20 and a suitable counterweight 21 in a conventional manner.

A relay 25 of the induction type is carried by the car 20 for controlling the stopping operation. This type of relay is well known in the art and disclosed, for example, in Santini Patent No. 2,298,174. The relay comprises, generally, a winding I to be energized during the slow-down of the car and includes a magnetic circuit which cooperates with plates 22 and 24 of magnetic material at fixed points in the hatchway to open normally closed contacts DL and UL carried by the relay. That is, although the relay winding I may be energized, it is not effective to open its normally closed contacts until the magnetic circuit is completed through the plates 22 and 24. Opening of these contacts controls the stopping of the elevator, as the car approaches the floor to be served. In Fig. 1 the car is represented as stopped level with a floor, with both contacts DL and UL open by reason of registration with plates 22 and 24.

Although the invention is applicable to many types of elevator circuits, as will be apparent, a relatively simple control is illustrated in the upper portion of Fig. 2 in which the starting of the car and the initiation of slowdown thereof is controlled by a manually operable car-switch CS mounted in the car. A relay DR will be energized when the corridor door is closed, assuming that the doors at other floors are also closed, and closes its contacts DR1 which connects the car switch operating contact with the positive supply line L+1.

The operator may then start the car by mov-

ing the car switch handle CS to engage contacts 30 or 32, depending upon the desired direction of car movement. Engagement of contact 30, for up travel, completes a circuit including the windings of up-direction switch U, the winding of relay M, and closed contacts D1 and TS1. Similarly, for down travel, movement of the car switch handle CS in the opposite direction effects engagement with contact 32 to energize down-direction switch D.

Energizing relay U opens contacts U1 to prevent energization of the down direction relay D, and closes contacts U3 in the circuit of the brake magnet winding BK.

Relay M being energized closes its contacts M1 in the supply leads II and III of the stator winding (Fig. 1) and also closes its contacts M2 in the circuit of the brake magnet BK to complete that circuit and thereby release the brake. Contacts U2 in supply leads I and II having also been closed upon energization of switch U, the car now starts upwardly.

Energizing up direction relay U also closes contacts U4 resulting in energizing the winding of relay Vt which operates with a time delay to subsequently close its contacts V1 and V2 establishing shunt circuits for the starting resistors 7 thereby permitting the application of full line voltage on the stator windings of the motor.

When it is desired to make a stop at a floor, the car switch handle may be centered to the position shown in Fig. 2, thereby breaking engagement with the contact 30. Although engagement between the car switch contact and contact 30 is broken, a holding circuit for switch U and relay M is established through contact V3, which closed upon the energizing of relay Vt, and closed contacts LU1. Contacts LU1 and LD1 are controlled by relays LU and LD, respectively, which are energized while the inductor relay contacts UL and DL are closed. Contacts UL and DL are normally closed until the car approaches a floor bringing the inductor relay into register with plates 22 and 24 adjacent to the floor.

Assuming that the car is travelling up, and the car switch CS is centered preparatory to making a stop, the inductor relay I is energized but its contacts UL and DL remain closed. Continued upward travel, however, brings the relay 25 into registration first with a plate 22 (Fig. 4) to open contacts DL, and further movement effects registration with plate 24 to open contacts UL. When DL opens, relay LD drops, opening its contacts LD1 in the holding circuit of direction relay D (the circuit of which is already open at contacts U1) and opens contacts LD2 in the timing circuit to be described. When inductor contacts UL open, relay LU drops, opening the contacts LU1, thereby deenergizing up direction relay U and relay M to stop the car, and opens contacts LU2 in the timing circuit.

Centering of the car switch handle also energizes the coil of relay T which closes its contacts T1 to complete a timing circuit for a relay TS which also may be effective to stop the car. The timing circuit includes a three-element tube 40, which may be a gas-filled triode, such as RCA-1C21, having a cathode 42, a control grid 44 and a plate or anode 46. A capacitor C controls the potential on the grid 44 and is connected across the direct current control circuits L+1 and L-1 in series with resistors R1 and R3 and the winding 50 of a transformer T4, the function of the latter to be described.

The capacitor C is normally bridged or short-

circuited by contacts LU2 and LD2 which are closed so long as LU and LD are energized; that is, until inductor contacts UL and DL are opened. The resistor R3 protects the contacts LU2 and LD2 and a resistor R2 is used to limit the grid current due to the alternating current output of transformer T4.

The plate 46 of the tube 40 is connected through a relay winding TS to the positive side of the supply line through contacts T1 which are normally open but which are closed when relay T is energized upon centering of the car switch. The cathode 42 of the tube is connected to the opposite side L-1 of the direct current supply.

It is to be understood, of course, that when there is no potential on the grid 44, or if there is a potential below a predetermined value, there will be no current flow through the tube, and hence the relay winding TS will not be energized. However, upon the opening of LU2 or LD2 which are in parallel with capacitor C, the capacitor will charge at a rate determined primarily by the values of C and R1, disregarding for the moment the resistance of transformer winding 50 and the value of R3 which is quite low merely to protect contacts LU2 and LD2. An increasing potential impressed on the grid 44 ultimately reaches a critical value at which the tube will "fire" and relay TS will be energized.

Relay TS when energized closes its contacts TS2, establishing a holding circuit for itself and also short-circuiting the tube 40.

Relay TS also opens its contacts TS1 in the circuit of up direction switch U, thereby deenergizing switch U and relay M which respectively open contacts U3, to deenergize the brake winding to permit application of the brake, and open contacts M1 in the motor supply leads II and III to deenergize the motor.

In accordance with the foregoing and disregarding for the moment winding 50 of transformer T4, and assuming that the car is travelling up with the car switch centered for a stop, when the inductor relay reaches a fixed point in the hatch, as defined by a plate 22, its contacts DL will open to drop relay LD which in turn opens its contacts LD2 to permit the capacitor C to charge. Of course, further car movement will open contacts UL upon registration with plate 24 to drop relay LU and open contacts LU2, but this will occur during the normal stopping sequence as controlled by contacts LU1 in circuit with directional relay U. The charging of the capacitor will ultimately impose a critical potential on grid 44 of the tube 40 and energize relay TS to stop the car. With fixed values of C and R1, the time-element of the circuit will be constant, and although this would be satisfactory for a given load condition and direction of car movement, variations in either of these factors would cause the car to stop at different points with respect to the floor level. It is desired therefore to vary this fixed time-element by the connections shown in the lower part of Fig. 2.

The three phase conductors I, II and III energize the motor stator windings a, b and c, as previously described in connection with Fig. 1. In addition, a line resistor R5 of very low value is series-connected in phase conductor III, and the primary winding of transformer T2 is connected to be energized in accordance with the voltage drop across resistor R5. Of course a current transformer could be used instead of the resistor R5 to obtain a voltage proportional to the motor current.

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The primary winding of a transformer T1 is connected for energization across the phase conductors I and II, and the primary winding of transformer T3 is connected across the motor winding c and resistor R5 to be energized in accordance with the phase voltage, the value of R5 being so low (a voltage drop of the order of one volt) that it has a negligible effect on the phase voltage.

The secondary windings of transformers T1, T2 and T3 are series connected with the primary winding of transformer T4, the secondary 50 of which is connected in the timer circuit including capacitor C and the grid of tube 40. The secondary windings of T1, T2 and T3 are connected and proportioned to obtain the desired phase relationships in their output voltages, and potentiometers 52 and 54 are included in the secondary circuits of T1 and T3 so that amplitudes of the voltages may be obtained.

The outlet of transformer T1 provides a potential 90° out of phase with the line current. The output of transformer T2 provides a potential proportional to the motor current, and the output of T3 provides a bias potential which is opposite to the in-phase voltage component of the motor current.

The primary winding of transformer T4 will be energized at a voltage inversely proportional to the in-phase component of the motor current, as may more readily be understood from the vector diagram of Figure 3, as follows.

Assuming a line current I which lags its phase voltage E as indicated, the current I has a power component I_w in phase with E and a component I_v in quadrature with voltage E. The current I_v represents the magnetizing current of the motor 2 and is substantially constant.

The transformer T1 is connected to provide a voltage component E2, which is 90° out of phase with the voltage E and opposite in direction to the current I_v . Transformer T3 produces a bias voltage Eb which is opposite in direction to the phase voltage E.

With the transformers T1, T2 and T3 properly proportioned and phased, and the taps of potentiometers 52 and 54 connected or positioned to obtain a satisfactory voltage amplitude for energizing the primary winding of transformer T4, when there is a full load on the motor in the up direction of car travel, the voltage Eb will be substantially equal to and opposite to the in-phase voltage component of the motor current I_w ; therefore, the energization of the primary winding of transformer T4 will be zero. Accordingly, the normal time of operation of the timing circuit as determined by R1 and C will not be affected. However, for a load on the car equivalent to substantially zero load on the motor, that is I_w is substantially zero, the voltage on the primary of T4 is equal to the bias voltage Eb, and an alternating voltage will be induced in winding 50, which when added to the direct current potential of capacitor C, decreases the time required to fire the tube and energize relay TS to stop the car.

Further, assuming a full load on the car in the down direction, constituting an overhauling load, a regenerative component from the motor results which when added to the bias voltage Eb increases the voltage on the input of T4 to its maximum value and results in substantially shortening the time required to energize relay TS.

In other words, with the heaviest load on the

motor (full-load-up), the input to T4 is zero resulting in the normal or basic time interval for the operation of relay TS as determined by C and R1. This is the longest time interval desired before the relay TS picks up to stop the car. For the opposite extreme, in the case of an overhauling load, the input to T4 is at a maximum, which added to the potential of C produces a high potential on the grid 44 of tube 40, causing relay TS to pick up almost immediately. Of course, between these two extremes, the input to transformer T4 will vary and the variation is inversely proportional to the in-phase component I_w of the motor current and, therefore, inversely proportional to the loading condition of the car.

Quite apparently modifications in the circuit arrangement disclosed, and the components thereof, may be made within the spirit of the invention, and it is intended that the disclosure is only illustrative of a practicable embodiment of the invention.

I claim as my invention:

1. In an elevator system including a car serving a plurality of floors, an alternating current motor for moving said car and means for energizing it, means for stopping said car at a selected floor and level therewith comprising relay means operable with a predetermined time-delay, for a certain value of load on said motor for deenergizing said motor prior to the arrival of the car at that floor, and means responsive to a lower value of load on said motor for decreasing said time delay.

2. In an elevator system including a car serving a plurality of floors, an alternating current motor for moving said car and means for energizing it, means for stopping said car at a selected floor and level therewith comprising a time-delay relay responsive to a critical minimum voltage and means for energizing it at a potential increasing at a constant rate for a given value of load on said motor, and means for impressing an additional potential on said relay which is inversely proportional to the load on said motor.

3. In an elevator system including a car serving a plurality of floors, an alternating current motor for moving said car and means for energizing it, means for stopping said car at a selected floor and level therewith comprising a relay responsive to a critical minimum voltage value, a capacitor and means for charging it at a constant rate and impressing the increasing potential thereof on said relay, and means responsive to the load on said motor for impressing an alternating current potential on said relay inversely proportional to the load on said motor.

4. In an elevator system including an elevator car serving a plurality of landings, an alternating current hoisting motor and a supply circuit therefor, means for controlling said motor to stop said car at a selected one of said landings comprising means operable as said car arrives at a fixed distance from such landing for stopping it with a fixed time-delay thereafter for one condition of loading thereof, and means responsive to a decreased loading condition for decreasing said time delay by an amount proportional to the decreased loading condition.

5. In an elevator system including a car serving a plurality of floors, an alternating current motor and a supply circuit therefor for moving said car, means for controlling said motor to stop said car at a selected one of said floors including means for disconnecting said motor from its supply circuit at distances from said

floor varying in inverse proportion to the load on said motor, said last named means including a relay operable with a predetermined time delay for a certain load on said motor, and means for decreasing said time delay in proportion to decreasing loads on said motor.

6. In an elevator system including a car, an electric hoisting motor therefor and means for starting said motor and thereafter initiating the retardation thereof preparatory to stopping said car at a floor, a brake for stopping said motor, and means responsive to the arrival of said car at a fixed distance from said floor for applying said brake with a time delay such that the car will stop level with said floor, said means including a timing circuit having a predetermined time constant and means for modifying said constant in proportion to the load current of said motor.

7. In an elevator system, an elevator car, an electric motor for moving said car in a hatchway past a plurality of floors, a supply circuit for said motor, means for starting said motor and means for subsequently initiating the retardation thereof, means for stopping said motor including a brake and means for interrupting said supply circuit, timing means operative when said car arrives at a fixed distance from a floor where it is to be stopped for causing the application of said brake and operation of said interrupting means, with a variable time delay, said timing means including a capacitor and a circuit for charging it from a source of constant potential, and means for superimposing on such circuit an alternating current potential proportional to the load current traversing said motor.

8. In an elevator installation including a car, an alternating current motor and a source of supply therefor for moving said car, relay means for disconnecting said motor from its supply for stopping the car, time-delay means for energizing said relay means including a triode having a control grid, a capacitor and means for initiating the charging thereof when the car passes a fixed point in its path of travel preparatory to stop-

ping, means for impressing the potential of said capacitor on said control grid, means for deriving a potential from the energizing circuit of said motor which is inversely proportional to the in-phase component of motor current, and means for impressing such potential on said grid.

9. In an elevator installation including a car, an alternating current motor and a source of supply therefor for moving said car, relay means for disconnecting said motor from its supply for stopping the car, time-delay means for energizing said relay means including a triode having a control grid, a capacitor and means for initiating the charging thereof when the car passes a fixed point in its path of travel preparatory to stopping, means for impressing the potential of said capacitor on said control grid, means for deriving from the supply circuit of said motor a control potential which is the instantaneous sum of a potential ninety degrees out-of-phase with respect to the supply potential, a potential proportional to the motor load and an in-phase bias potential, and means for impressing such control potential on the grid of said triode.

10. In an elevator system including a car serving a plurality of floors, an electric motor for moving said car, and an electrically controlled brake for said motor, means for stopping said car at a selected floor comprising relay means operable at a fixed distance from said floor for deenergizing said motor and applying said brake to stop the car level with the floor under one load condition on said motor, and means responsive to lighter load conditions on said motor for deenergizing said motor and applying said brake at inversely proportionally greater distances from said floor.

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