Feb. 24, 1942. A. PINTO 2,273,988

TIMING OF ELECTROMAGNETIC SWITCHES

Filed May 9, 1941 2 Sheets-Sheet 1

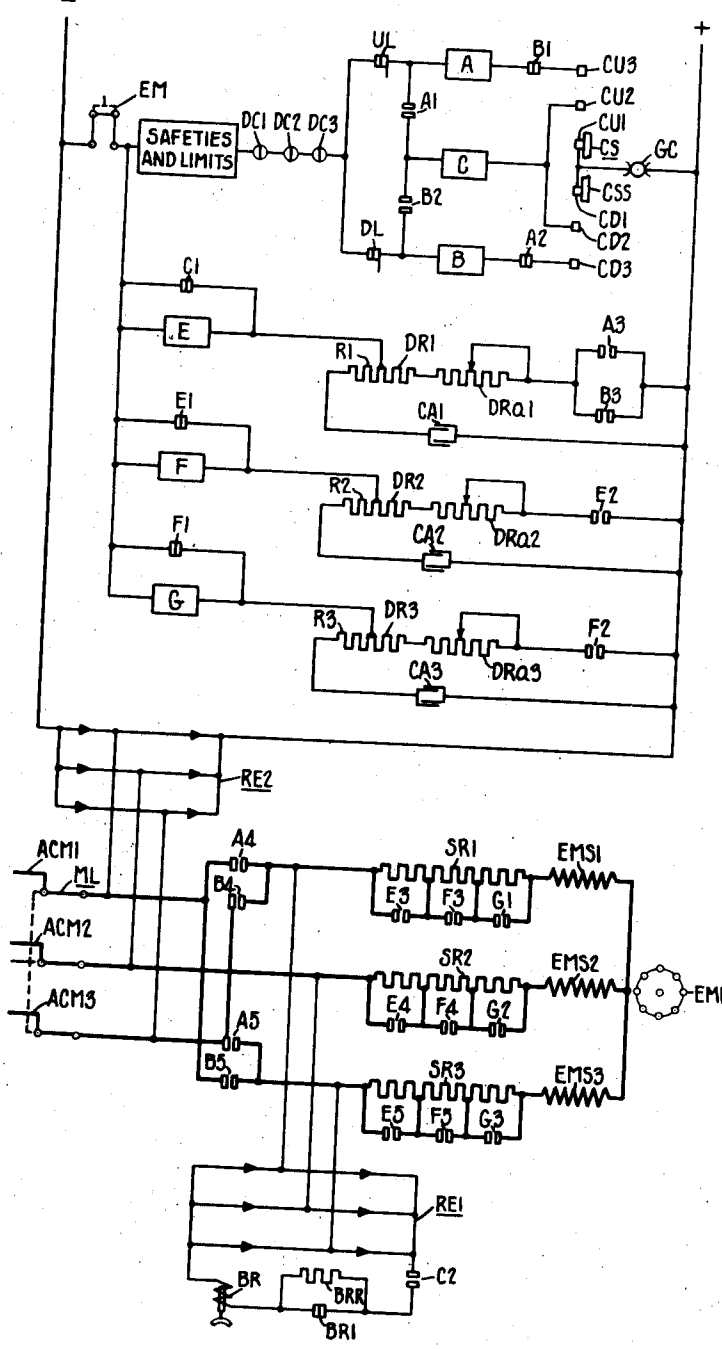


FIG. 1

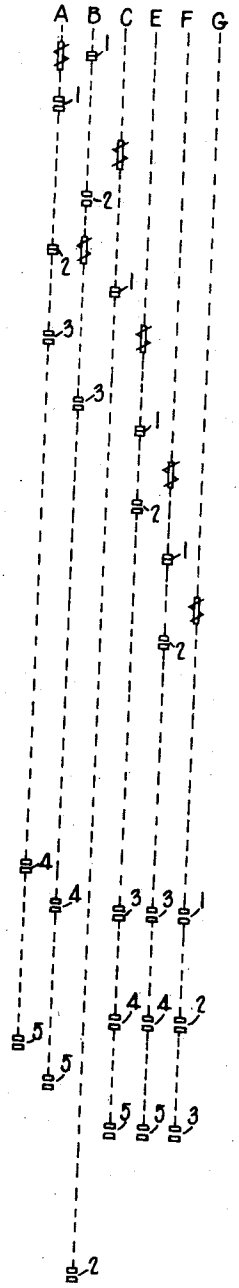


FIG. 1s

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TIMING OF ELECTROMAGNETIC SWITCHES

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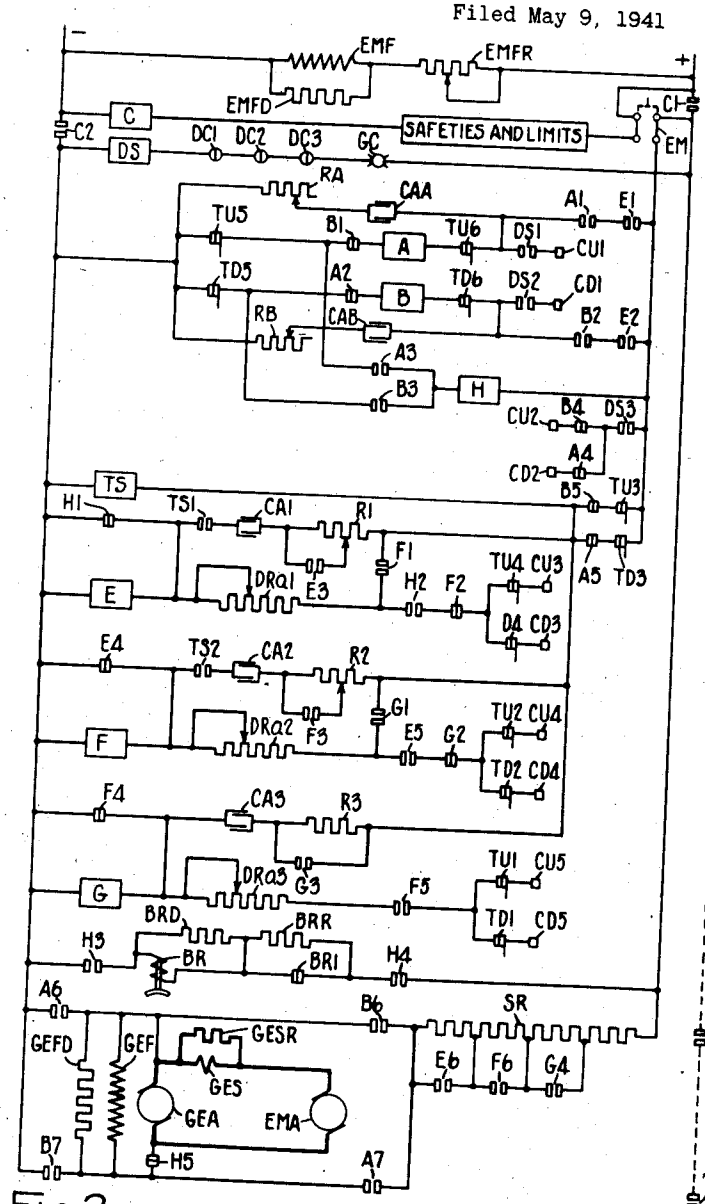


FIG. 2.

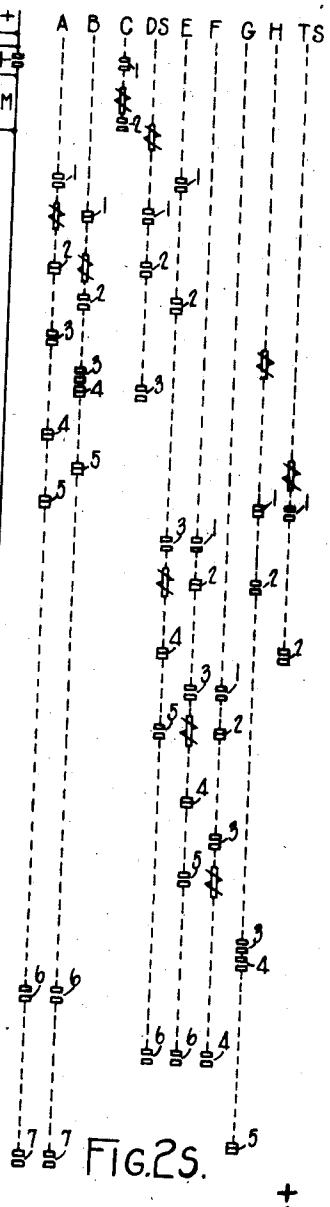


FIG. 2S.

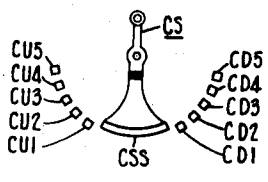


FIG. 3

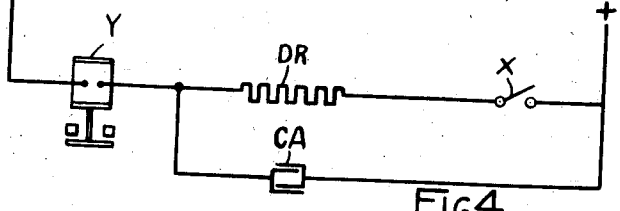


FIG. 4.

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Patented Feb. 24, 1942 2,273,988

UNITED STATES PATENT OFFICE

2,273,988

TIMING OF ELECTROMAGNETIC SWITCHES

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Application May 9, 1941, Serial No. 392,810

18 Claims. (Cl. 172—152)

The invention relates to timing the operation of electromagnetic switches, both in pulling in and dropping out, especially in connection with controlling acceleration and retardation of hoisting motors for elevators.

In most elevator installations, the voltage applied to the hoisting motor in starting is increased in steps in bringing the motor up to full speed. The control systems are usually arranged so that these steps are timed. Also, in some of these control systems, the retardation of the motor is effected in timed steps. Condensers associated with resistances have been utilized in timing switches where direct current is provided for the control circuits. If known arrangements were utilized in elevator control systems to control the operation of the accelerating switches to bring the hoisting motor up to full speed, the resistances would have to be of low enough value to enable sufficient voltage to be applied to the coils of the switches to operate the switches. Thus the condensers would have to be of relatively large capacity. Paper condensers of suitable size are relatively expensive whereas electrolytic condensers, although not expensive, are unreliable in timing in any of the arrangements heretofore proposed owing to the fact that their charging rate varies depending upon the length of time that the condenser has been discharged.

One feature of the invention is to provide a condenser timing circuit for a switch, especially suitable for electrolytic condensers, in which uniform timing of the operation of the switch is obtained.

Another feature of the invention is to provide a circuit in which the charging of the condenser is utilized to time the dropping out of the switch.

In carrying out the invention according to the arrangements which will be described, the timing condenser for the switch is in a charged state while the motor is at rest, being connected to the source in circuit with the coil of the switch. In starting the motor, discharge resistance is connected in series with the coil and in parallel with the condenser. Thus the voltage applied to the coil of the switch is delayed in building up by the delay in the discharge of the condenser. Each switch in operating initiates the timing of the next switch so that the accelerating switches are operated in timed sequence.

For timing the dropping out of the switches controlling retardation, the voltage applied to their coils is reduced to below hold in value by charging the condensers. This is effected quickly in the case of the first switch to drop out but is delayed in the case of each subsequent switch, to delay the dropping out of the switch. Each switch in dropping out starts an increase in the charge of the condenser for the next switch to drop out, thereby causing the switches to drop out in sequence.

A general idea of the invention, the mode of carrying it out which is at present preferred, and various features and advantages thereof will be gained from the above statements. Other features and advantages of the invention will be apparent from the following description and appended claims.

In the drawings:

Figure 1 is a simplified schematic wiring diagram of an elevator control system in which a polyphase alternating current induction motor is utilized for raising and lowering the car with the operation of the accelerating switches to accelerate the car controlled in accordance with the invention;

Figure 2 is a simplified schematic wiring diagram of an elevator control system in which a direct current motor is utilized for raising and lowering the car with the motor supplied with current from a variable voltage direct current generator and with the operation of the accelerating switches both to accelerate and retard the car controlled in accordance with the invention;

Figures 1*s* and 2*s* are key diagrams for Figures 1 and 2 respectively, showing the electromagnetic switches in spindle form with the contacts and coils arranged on the spindles in horizontal alignment with the corresponding contacts and coils in the wiring diagrams;

Figure 3 is a diagrammatic illustration of a car switch utilized in the circuits of Figure 2; and

Figure 4 is a regular wiring diagram of a simple circuit illustrating the control of the closing of a switch in accordance with the invention.

Referring first to Figure 4, a timing condenser CA for a switch Y is connected in series with the coil of this switch. With switch X open full line voltage is applied to the condenser which is in a charged state, while the voltage applied to the coil of the switch is zero. To operate switch Y, a discharge resistance DR is connected across the condenser by closing switch X. This causes the condenser to discharge at a rate determined by the capacity of the condenser and the value of the discharge resistance. As the condenser discharges, the voltage drop across resistance DR decreases while the voltage drop across the coil

of switch Y increases, the capacity of the condenser and the value of resistance DR being so coordinated to the value of the resistance of the coil that the voltage applied to the coil reaches a value to cause the switch to operate at the expiration of the desired time interval.

The circuits of Figures 1 and 2 are shown in "straight" or "across the line" form, in which the coils and contacts of the electromagnetic switches are separated in such manner as to render the circuits as simple and direct as possible. The relationship of these coils and contacts may be seen from Figures 1*s* and 2*s* where the switches are arranged in alphabetical order and shown in spindle form. The positions of these coils and contacts in the wiring diagrams may be found by referring to the respective spindle diagrams where the coils and contacts are positioned on the spindles in horizontal alignment with the corresponding coils and contacts in the wiring diagrams.

Referring first to Figures 1 and 1*s*, the alternating current supply mains are designated ACM1, ACM2 and ACM3. A triple-pole manually operable main line switch designated ML is provided for controlling the supply of current from the supply mains to the system. The rotor of the elevator motor is designated EMR, while the stator windings are designated EMS1, EMS2 and EMS3. The resistances in circuit with the stator windings are designated SR1, SR2 and SR3. The release coil of the electromechanical brake is designated BR. This coil is illustrated as supplied with direct current derived from the alternating current mains, a rectifier RE1 being interposed between the supply mains and the release coil for this purpose. Similarly, the control circuits for the elevator motor are illustrated as supplied with direct current derived from the alternating current mains, rectifier RE2 being interposed between the supply mains and the control circuits for this purpose.

The control system illustrated is of the type in which both the starting and stopping of the car is controlled by an operator in the car. A car switch CS is provided in the car for the use of the operator in effecting starting and stopping of the car, the car switch segment being designated CSS and the stationary contacts engaged thereby being designated CU1, CU2 and CU3 for up car travel and CD1, CD2 and CD3 for down car travel. The gate contacts are designated GC, while the door contacts are designated DC. Three sets of door contacts are shown as indicative of a three floor installation. EM is an emergency stop switch in the car, while UL and DL are limit switches. Other safety and limit switches for convenience are indicated by legend within a frame.

The electromagnetic switches have been designated as follows:

A—Up direction switch.
B—Down direction switch.
C—Potential switch.
E—First accelerating switch.
F—Second accelerating switch.
G—Third accelerating switch.

Throughout the description which follows, these letters will be applied to the coils of the above designated switches. Also, with reference numerals appended thereto they will be applied to the contacts of these switches, as for example B3. Similarly, the contacts operated by the brake upon being released are designated BR1. BRR is a cooling resistance for the brake release coil.

The condensers for controlling the operation of the accelerating switches are designated CA1, CA2 and CA3. R1, R2 and R3 serve as protective resistances for the condensers CA1, CA2 and CA3 respectively. DR1 and DR*a*1 are discharge resistances for condenser CA1, resistance DR*a*1 being adjustable. Similarly, DR2 and DR*a*2 are discharge resistance for condenser CA2 and DR3 and DR*a*3 are discharge resistances for condenser CA3. It is to be noted that with the car standing idle, the coil of each accelerating switch is short-circuited so that the condenser for that switch is connected through its protective resistance to the direct current feed lines. Thus, these condensers are charged to full line voltage.

Assume that the hatchway doors and car gate are closed. To start the car in the up direction the car switch segment is moved into position to bridge contacts CU1, CU2 and CU3. This completes a circuit through emergency stop switch EM, safeties and limits, door contacts DC1, DC2 and DC3, up limit switch UL, coil of switch A, interlock contacts B1, car switch contacts CU3 and CU1, and gate contacts GC. Switch A upon operation separates interlock contacts A2 in the circuit for the coil of down direction switch B. It engages contacts A4 and A5 to complete a circuit for the stator windings of the hoisting motor, establishing a phase rotation of the applied voltage for starting the car in the up direction. It also engages contacts A1 to complete a circuit through car switch contact CU2 for the coil of potential switch C. The potential switch upon operation engages contacts C2 to complete a circuit for brake release coil BR to effect the release of the brake. The brake upon releasing separates contacts BR1 to insert cooling resistance BRR in circuit with the coil.

The potential switch upon operation also separates contacts C1, removing the short-circuit for the coil of first accelerating switch E. At the same time, contacts A3 of the up direction switch engage, connecting the coil of switch E across the line in series with discharge resistances DR1 and DR*a*1. The first accelerating switch does not operate immediately as at this instant the voltage drop across resistances DR1 and DR*a*1 is substantially the voltage of the condenser so that the voltage applied to the coil of the switch is substantially zero. However, as the condenser discharges into resistances DR1 and DR*a*1, its voltage and thus the voltage drop across these resistances gradually decreases so that the voltage applied to the coil of the switch gradually builds up. Eventually a condition is reached where the coil of the switch has sufficient excitation to cause the switch to operate. The point at which this condition is reached and thus the time which elapses before the switch operates depends upon the capacity of the condenser and the value of the various resistances including that of the coil of the switch. It is of advantage to have the value of resistance DR1 and the effective portion of resistance DR*a*1 substantially equal to that of the resistance of the coil. With such arrangement the switch coil would be wound for half line voltage.

The first accelerating switch upon operation engages contacts E3, E4 and E5 to short-circuit a step of each of resistances SR1, SR2 and SR3 respectively to increase the available torque of the hoisting motor. It also separates contacts E1 to remove the short-circuit for the coil of

second accelerating switch F and engages contacts E2 to connect this coil in series with discharge resistance DR2 and DRa2 to the feed lines. As in the case of the first accelerating switch, switch F does not operate immediately being delayed until condenser CA2 has discharged to a point which permits sufficient current to be supplied to the coil of the switch to cause the switch to operate.

The second accelerating switch upon operation engages contacts F3, F4 and F5 to short-circuit a further step of each of resistances SR1, SR2 and SR3 respectively to further increase the available torque of the hoisting motor. Switch F also separates contacts F1 to remove the short-circuit for the coil of the third accelerating switch G and engages contacts F2 to connect discharge resistances DR3 and DRa3 in series with this coil to the feed lines. The operation of the third accelerating switch is similarly delayed until condenser CA3 discharges to a point where the voltage across the coil of switch G reaches a value at which the switch operates.

Switch G upon operation engages contacts G1, G2 and G3 to short-circuit the remaining steps of resistances SR1, SR2 and SR3 respectively to bring the available torque of the hoisting motor up to full value for full speed operation.

The car is started in the down direction in a similar manner. The car switch segment is moved into position to bridge contacts CD1, CD2 and CD3. This causes the operation of down direction switch B and potential switch C to cause the application of voltage to the stator windings of the elevator hoisting motor and the release of the brake for starting the car. Switch B in engaging contacts B4 and B5 establishes a phase rotation of the voltage applied to the elevator hoisting motor for starting the car in the down direction. The separation of contacts C1 removes the short-circuit for the coil of first accelerating switch E, while the engagement of contacts B3 connects this coil in series with discharge resistances DR1 and DRa1 to the feed lines. As in the case of starting the car in the up direction, switch E operates as soon as condenser CA1 discharges to a point to make the excitation of the coil of the switch sufficient to cause the switch to operate. Switch E upon operation removes the short-circuit for the coil of switch F and connects this coil to the supply lines in series with resistances DR2 and DRa2. Switch F, upon operation after the time delay provided by the discharge of condenser CA2, removes the short-circuit for the coil of third accelerating switch G and connects this coil to the feed lines in series with resistances DR3 and DRa3. Upon the expiration of the time delay provided by the discharge of the condenser CA3 switch G operates. Thus, the accelerating switches are operated in timed sequence as in starting the car in the up direction.

To stop the car, the car switch segment is centered breaking the circuit for the coils of the operated direction switch and potential switch. These switches upon dropping out disconnect the stator windings of the elevator hoisting motor from the supply lines and deenergize the brake release coil to apply the brake, bringing the car to a stop. Also, the dropping out of these switches breaks the discharge circuit for condenser CA1 and short-circuits the coil of switch E, causing switch E to drop out and condenser CA1 to recharge to full line potential. Similarly, the dropping out of switch E causes the dropping out of switch F and the recharging of condenser CA2 to full line potential and the dropping out of switch F causes the dropping out of switch G and the recharging of condenser CA3 to full line potential. This places the system in condition for the next starting operation.

Referring now to Figures 2 and 2s, in which the invention is shown applied to a variable voltage system, the armature of the elevator hoisting motor is designated EMA and the field winding EMF. EMFR is a regulating resistance for the field winding while EMFD is a discharge resistance therefor. The armature of the supply generator for the elevator hoisting motor armature is designated GEA, its separately excited field winding GEF and its series field winding GES. GESR is a shunt resistance for the series field winding, while GEFD is a discharge resistance for the separately excited field winding. The voltage regulating resistance for the generator separately excited field winding is designated SR. The driving motor for the generator is not shown. Also, the source of supply for the feed lines to the control circuit is not shown, it being understood that these may be supplied from an exciter driven by the generator driving motor or by a separate driving motor or they may be supplied in other ways, as for example, direct from the supply lines to the building where these lines are direct current supply lines of the proper voltage.

Various parts of the system are the same as in the circuit of Figures 1 and 2, and therefore will not be listed in detail. The electromagnetic switches in addition to switches A, B, C, E, F and G have been designated as follows:

DS—Door contact switch.
H—Brake switch.
TS—Terminal switch.

The potential switch C instead of being subject to the car switch is arranged in circuit with various safeties and limit switches designated by legend and the emergency stop switch EM.

The car switch is provided with five stationary contacts on each side of neutral, those for up car travel being designated CU1, CU2, CU3, CU4 and CU5, and those for down car travel being designated CD1, CD2, CD3, CD4 and CD5. To avoid cross-overs of wires, the corresponding contacts on each side of neutral have been grouped to form pairs. The car switch segment CSS for bridging the car switch contacts is not shown in Figure 2, but the construction of the car switch is diagrammatically shown in Figure 3, to which reference may be made to facilitate an understanding of the operation of Figure 2. Contacts of a terminal stopping switch are included in the circuits, those contacts which open as the car reaches the upper terminal floor being designated TU1, TU2, TU3, TU4, TU5 and TU6 being opened in the order named. The contacts which are opened as the car approaches the lower terminal floor are designated TD1, TD2, TD3, TD4, TD5 and TD6, and also are opened in the order named. BRD is a discharge resistance for the release coil of the electromechanical brake BR.

The discharge resistances for condensers CA1, CA2, and CA3 are shown as single adjustable resistances designated DRa1, DRa2 and DRa3. Resistances R1, R2 and R3 are controlled by the accelerating switches to control the charging time of the condensers and thus to time the dropping out of the accelerating switches during

retardation. A discharge condenser CAA and regulating resistance RA are provided for coil of up direction switch A to time the dropping out of this switch. Similarly, discharge condenser CAB and regulating resistance RB are provided for the coil of down direction switch B to time the dropping out of this switch. As in the case of the arrangement of Figure 1, with the car standing idle, the coil of each accelerating switch is short-circuited so that the condenser for that switch is connected through resistance to the direct current feed lines. Thus, these condensers are charged to full line voltage.

Assume that power is supplied to the feed lines + and —, potential switch C is operated and contacts C1 and C2 in these feed lines are engaged. Also with the potential switch operated, terminal switch TS is operated. With the hatchway doors and car gate closed, door contact switch DS is also operated. To start the car in the up direction the car switch segment is moved into position to bridge contacts CU1, CU2, CU3, CU4 and CU5. The bridging of contacts CU1 and CU2 completes a circuit from the negative supply line through contacts TU5 and B1, coil of up direction switch A, contacts TU6, DS1, B4 and DS3 and the right hand blade of emergency stop switch EM to the positive supply line. The up direction switch upon operation separates interlock contacts A2, A4 and A5. It also engages contacts A3 to complete a circuit through contacts TU5 for the coil of brake switch H. Switch H upon operation separates contacts H5 to disconnect the generator separately excited field winding GEF from the generator armature. It also engages contacts H3 and H4 to complete a circuit for the release coil of the electromechanical brake BR to release the brake for the starting operation. At the same time the up direction switch engages contacts A6 and A7 completing a circuit for generator field winding GEF through resistance SR, the polarity of the excitation of the generator field winding thus obtained being for causing voltage to be applied to the armature EMA of the elevator hoisting motor for starting the car in the up direction. The brake upon being released separates brake contacts BR1 to insert cooling resistance BRR in circuit with the release coil.

The brake switch H upon operation also separates contacts H1 to remove the short-circuit for the coil of first accelerating switch E and engages contacts H2 to connect this coil in series with discharge resistance DR*a*1 through contacts F2 and TU4, car switch contacts CU3 and CU2, contacts B4 and DS3 and emergency stop switch EM to the feed lines. As in the case of the arrangement of Figure 1, switch E does not operate immediately, being delayed by the delay in discharging condenser CA1, the discharge circuit for the condenser being through contact TS1, resistance DR*a*1, contacts H2, F2, TU4, CU3, CU2, B4, DS3, TU3 and B5, and resistance R1. As soon as the condenser discharges to a certain point, the coil of the accelerating switch is excited sufficiently to cause the switch to operate. Switch E upon operation engages contacts E1 to complete a holding circuit through contacts A1 for the coil of up direction switch A, bypassing car switch contacts CU1. It engages contacts E3 to short-circuit a portion of resistance R1. It also engages contacts E6 to short-circuit one step of resistance SR in circuit with the generator field winding, causing increase in the voltage applied to the armature of the elevator hoisting motor.

The first accelerating switch also separates contacts E4 to remove the short-circuit for the coil of second accelerating switch F and engages contacts E5 to connect this coil to the supply lines in series with discharge resistance DR*a*2 through contacts G2 and TU2 and car switch contacts CU4 and CU2. This also completes the discharge circuit for condenser CA2 through contacts TS2, resistance DR*a*2, contacts E5, G2 TU2, CU4, CU2, B4, DS3, TU3 and B5, and resistance R2. Switch F, upon operation after the time delay provided by the discharge of condenser CA2, engages contact F1 to establish a holding circuit for the coil of first accelerating switch E, by-passing the car switch. This also established a by-pass for contacts H2, F2, TU4, CU3, CU2, B4, DS3, TU3 and B5 in the discharge circuit for condenser CA1. At the same time it separates contacts F2 to obviate a possible unwanted circuit. It engages contacts F3 to short-circuit a portion of resistance R2. It also engages contacts F6 to short-circuit another step of resistance SR in circuit with the generator field winding causing further increase in the voltage applied to the armature of the elevator hoisting motor.

The second accelerating switch also separates contacts F4 to remove the short-circuit for the coil of third accelerating switch G and engages contacts F5 to connect this coil to the supply lines in series with discharge resistance DR*a* 3 through contacts TU1 and car switch contacts CU5 and CU2. This also establishes the discharge circuit for condenser CA3 through resistance DR*a*3, contacts F5, TU1, CU5, CU2, B4, DS3, TU3 and B5, and resistance R3. Upon expiration of the time delay provided by the discharge of condenser CA3, switch G operates to engage contacts G4, short-circuiting the last step of resistance SR to bring the generator voltage up to full value, thereby bringing the elevator car up to full speed. It also engages contacts G1 to establish a holding circuit for the coil of second accelerating switch F by-passing the car switch. This also establishes a by-pass for contacts E5, G2, TU2, CU4, CU2, B4, DS3, TU3 and B5 in the discharge circuit for condenser CA2. At the same time it separates contacts G2 to obviate a possible unwanted circuit. It also engages contacts G3 to short-circuit resistance R3.

The car is started in the down direction in a similar manner by throwing the car switch to its opposite position to bridge contacts CD1, CD2, CD3, CD4 and CD5. Other than the fact that the circuits are through the down contacts of the car switch and terminal stopping switch and that the down direction switch B is operated instead of the up direction switch A to cause the car to travel in the down direction, the operation is the same as described for starting the car in the up direction and will not be set forth.

To stop the car, the car switch is returned to neutral position. This breaks the discharge circuit for condenser CA3, leaving the coil of third accelerating switch G in series with the condenser across the feed lines. Thus, switch G is maintained operated until condenser CA3 charges sufficiently to reduce the voltage applied to the coil of switch G to below sustaining value. Inasmuch as resistance R3 is all short-circuited, the condenser charges very quickly so that switch G drops out practically immediately. Accelerating switches E and F, however, do not drop out

at this time, being maintained operated by their holding circuits previously described. In dropping out, switch G separates contacts G4 to reinsert a step of resistance SR in circuit with the generator field winding, decreasing the generator voltage to initiate slowing down of the car.

The third accelerating switch in dropping out also separates contacts G1 to break the discharge circuit for condenser CA2, leaving the coil of second accelerating switch F in series with the condenser across the feed lines. As in the case of switch G, switch F is maintained operated until condenser CA2 charges sufficiently to reduce the voltage applied to the coil of switch F to below sustaining value. Inasmuch as a portion of resistance R2 is in the charging circuit, the charging of the condenser is delayed so that switch F is timed in dropping out, the extent of the time depending upon the value of resistance R2 in the charging circuit. In dropping out switch F separates contacts F6 to reinsert another step of resistance SR in circuit with the generator field winding, decreasing the generator voltage to further slow down the car. It also engages contacts F4 to short-circuit the coil of accelerating switch G.

The second accelerating switch in dropping out also separates contacts F1 to break the discharge circuit for condenser CA1, leaving the coil of first accelerating switch E in series with the condenser across the feed lines. Thus, switch E is maintained operated until condenser CA1 charges sufficiently to reduce the voltage applied to the coil of switch E to below sustaining value, this being delayed by the portion of resistance R1 remaining in circuit with the condenser. In dropping out, switch E separates contacts E6 to reinsert the remaining step of resistance SR in circuit with the generator field winding to further decrease the generator voltage and further slow down the car. It also engages contacts E4 to short-circuit the coil of accelerating switch F.

The first accelerating switch in dropping out also separates contacts E1 and E2. Assuming that the car has been travelling in the up direction and up direction switch A is operated, the circuit for the coil of switch A is broken by the separation of contacts E1. Switch A does not drop out immediately being delayed by the discharge of condenser CAA into its coil. Upon the voltage across the coil decreasing to a certain value the direction switch drops out to separate contacts A6 and A7 breaking the circuit for the generator field winding. At the same time it separates contacts A3 to break the circuit for the coil of brake switch H which drops out to separate contacts H3 and H4. This breaks the circuit for the release coil of the electromechanical brake and the brake is applied to bring the car to a stop. At the same time contacts H5 engage to connect the generator field winding across the generator armature, the polarity of this connection being such as to oppose the voltage of the generator.

In making a stop at a terminal floor under conditions where the car switch is held in on position, the dropping out of the accelerating switches and direction switch is controlled by the terminal stopping switch. Asume that the car is approaching the upper terminal floor with the car switch held in on position. As it arrives a certain distance from this floor, terminal stopping switch contacts TU1 separate breaking the discharge circuit for condenser CA3 permitting the voltage applied to the condenser to build up to the voltage of the feed lines. This takes place very quickly so that voltage applied to the coil of switch G is reduced to below sustaining value almost immediately, causing switch G to drop out. It is to be noted that the separation of contacts G1 does not break the discharge circuit for condenser CA2 as contacts G2 engage to maintain this discharge circuit through the car switch contacts. As the car continues its movement, terminal stopping switch contacts TU2 separate to break the discharge circuit for condenser CA2. Thus the dropping out of switch F is delayed until the voltage across condenser CA2 reaches a value to reduce the voltage applied to the coil of switch F to below sustaining value. However, further movement of the car opens the terminal stopping switch contacts TU3 which breaks the circuit for the coil of terminal stopping switch TS. This switch drops out to separate contacts TS1 and TS2, contacts TS2 breaking the circuit for the coil of switch F which drops out immediately. Upon further movement of the car to open terminal stopping switch contacts TU4 the circuit for the coil of first accelerating switch E is broken and, contacts TS1 being separated, this switch drops out immediately. Just before the car reaches the upper terminal floor, terminal stopping switch contacts TU5 and TU6 open breaking the circuit for the coil of up direction switch A. The discharge circuit for condenser CAA being connected outside contacts TU5 and TU6, this also breaks the discharge circuit for this condenser so that the up direction switch A drops out immediately. Switch A in dropping out reengages contacts A5 which reestablishes the circuit for the coil of switch TS which operates to engage contacts TS1 and TS2 to reestablish the charging circuits for condensers CA1 and CA2 respectively. Thus, in making the stop at a terminal floor, distance control of the retardation is effected. However, should the car switch be centered during the stopping of the car in response to the operation of the terminal stopping switch say for the upper terminal floor, as for example immediately after the opening of terminal stopping switch contacts TU3, immediate dropping out of the up direction switch and thus a sudden stop is prevented by the discharge of condenser CAA into the coil of the direction switch to maintain this switch operated.

It is seen therefore that the timing of the operation of the switches is controlled in a very simple and reliable manner by delaying the building up of the voltage applied to the coils of these switches by the discharge of condensers. The duration of the time delay is dependent upon the capacity of the condensers and the value of the discharge resistances employed for these condensers, any fine adjustments being effected by adjusting the value of the discharge resistances. In controlling acceleration of a motor, each switch upon operation initiates the timing of the next switch, thereby causing their operation in timed sequence. Also, a very simple and reliable control of the timing of the dropping out of switches is effected by delaying the building up of the voltage across the condensers to decrease the voltage applied to coils of the switches to below sustaining value. Duration of the time delay in the dropping out of the switches is dependent upon the amount of resistance in series with the condensers. In controlling retardation, each switch upon dropping out initiates the building up of the voltage applied to the con-

denser for the next switch to drop out, thereby causing the switches to drop out in timed sequence.

It is to be understood that the systems of control illustrated are simply by way of example. The number of accelerating steps in each case depends upon the requirements of the particular installation, three being shown as illustrative. The dropping out of the last accelerating switch to operate may be controlled so as to make it instantaneous, if desired, as for example by opening the charging circuit of its condenser by a relay operated in response thereto and held in until after the next switch drops out. Also, in certain instances, the short-circuits for the coils of the switches may be omitted. Although a car switch control elevator system has been described, it is to be understood that the invention is applicable to other forms of elevator systems such as push button control systems. The invention is equally applicable to elevator systems in which acceleration is timed but with retardation distance controlled, as for example in the systems shown in the patent to Waters et al. No. 2,074,575 granted March 23, 1937, and the patent to Waters et al. No. 2,100,176 granted November 23, 1937. The invention also is applicable to other control systems in which the acceleration of a motor is timed or in which both the acceleration and retardation of the motor are timed.

Many elevator control systems are very complex and admit many variations. In applying the invention to such control systems changes may be made with the view of adapting the invention more readily to such systems. Other changes may also be made which do not depart from the spirit and scope of the invention. It is therefore intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An electromagnetic switch, a source of direct current, a condenser connected to said source in circuit with the coil of said switch so as to be charged to the voltage of said source with the coil deenergized, resistance, and means for energizing said coil to cause operation of said switch comprising means for connecting said resistance in series with said coil and in parallel with said condenser to delay operation of said switch until the condenser discharges to a point where the voltage applied to said coil reaches operating value.

2. An electromagnetic switch, a source of direct current, a condenser connected to said source in circuit with the coil of said switch, and discharge resistance for said condenser adapted to be connected in series with the coil of the switch and in parallel with said condenser to cause the operation of said switch by discharging said condenser so as to build up the voltage applied to said coil.

3. A plurality of electromagnetic switches, a source of direct current, a condenser for each switch, each condenser being connected to said source in circuit with the coil of the switch for which it is provided so as to be charged to the voltage of said source with such coil deenergized, resistance for each switch, and means for causing operation of said switches in sequence comprising means for connecting said resistance for one of said switches in series with the coil of such switch and in parallel with the condenser for such switch to delay operation of such switch until the condenser discharges to a point where the voltage applied to such coil reaches operating value and means operable by each switch until all of said switches have operated for connecting said resistance for another of said switches in series with the coil of such other switch and in parallel with the condenser for such other switch to delay operation of such other switch until such condenser discharges to a point where the voltage applied to such coil reaches operating value.

4. A plurality of electromagnetic switches operating in sequence to control the starting of an electric motor, a source of direct current, a condenser for each switch connected to said source in circuit with the coil of such switch while the motor is at rest, and discharge resistance for each condenser adapted to be connected in series with the coil of the switch for which the condenser is provided and in parallel with such condenser to cause the operation of such switch by discharging such condenser so as to build up the voltage applied to such coil.

5. A plurality of electromagnetic switches for controlling the operation of an electric elevator hoisting motor during starting, a source of direct current, means shunting the coils of said switches while the elevator car is at rest, a condenser for each switch connected in series with the shunted coil of such switch to said source while the car is at rest, discharge resistance for each condenser adapted to be connected in parallel therewith, and means for each switch for opening the shunt circuit for the coil of such switch and connecting the discharge resistance for the condenser for such switch in parallel with such condenser to delay the decrease in voltage across such condenser and thus the building up of the voltage applied to the coil of such switch thereby delaying the operation of the switch.

6. A plurality of electromagnetic switches operating in sequence to control the operation of an electric elevator hoisting motor during starting, a source of direct current, means for shunting the coils of said switches while the elevator car is at rest, a condenser for each switch connected in series with the shunted coil of such switch to said source while the car is at rest, discharge resistance for each condenser adapted to be connected across the condenser upon the opening of said shunt for the coil of the switch for which the condenser is provided to delay the decrease in voltage across the condenser and thus the building up of the voltage applied to such coil thereby delaying the operation of the switch, and means responsive to starting of the car for opening said shunt for the coil of one of said switches and for connecting the discharge resistance for the condenser for such switch across said condenser and to the operation of each switch for opening said shunt for the coil of the next switch and for connecting the discharge resistance for the condenser for such switch across said condenser.

7. A plurality of electromagnetic switches operating in sequence to control the starting of an electric hoisting motor for an elevator car, a source of direct current, means for each switch for shunting the coil of the switch while the car is at rest, a condenser for each switch connected in series with the shunted coil of such switch to said source so as to be charged to the voltage of the source while the car is at rest, discharge resistance for each condenser adapted to be connected across the condenser, means operable in starting the car for opening said shunt for the coil of one of said switches and for connecting

the discharge resistance for the condenser for such switch across said condenser, and means responsive to the operation of each switch for opening said shunt for the coil of the next switch and for connecting the discharge resistance for the condenser for such switch across said condenser, the discharge of each condenser and thus the decrease in voltage across the condenser thus being delayed upon the opening of the shunt for the coil of the switch for which the condenser is provided and the connection of the discharge resistance for such condenser across the condenser, thereby delaving the operation of such switch.

8. A plurality of electromagnetic accelerating switches for short-circuiting resistance in steps for controlling the operation of an electric hoisting motor for an elevator car during starting, a source of direct current, means for each switch for short-circuiting the coil of the switch while the car is at rest, a condenser for each switch connected in series with the short-circuited coil of such switch to said source so as to be charged to the voltage of the source while the car is at rest, discharge resistance for each condenser adapted to be connected across the condenser to delay the discharge thereof and therefore the decrease in voltage across the condenser upon the removal of the short-circuit for the coil of the switch for which the condenser is provided, thereby delaying the building up of the voltage applied to such coil and thus delaying the operation of the switch, means operable in starting the car for causing operation of said short-circuiting means for the coil of one of said switches to open the short-circuit and for connecting the discharge resistance for the condenser for such switch across said condenser, and means responsive to the operation of each switch for causing operation of said short-circuiting means for the coil of the next switch to open said short-circuit and for connecting the discharge resistance for the condenser for such switch across said condenser.

9. A plurality of accelerating switches for short-circuiting resistance in steps to control the acceleration of an electric hoisting motor for an elevator car, means for each accelerating switch for short-circuiting the coil of the switch, a source of direct current, a condenser for each switch connected in series with the short-circuited coil of such switch to said source so as to be charged to the voltage thereof while the car is at rest, resistance for each condenser connected in series therewith, discharge resistance for each condenser adapted to be connected across the condenser and its series resistance to delay the discharge of the condenser upon the removal of the short-circuit for the coil of the switch for which the condenser is provided, thereby delaying the building up of the voltage applied to such coil and thus delaying the operation of the switch, means operable in starting the car for causing operation of said short-circuiting means for the coil of one of said accelerating switches to break the short-circuit and for connecting the discharge resistance for the condenser for such switch across said condenser and its series resistance, and means responsive to the operation of each accelerating switch for causing operation of said short-circuiting means for the coil of the next accelerating switch to break the short-circuit and for connecting the discharge resistance for the condenser for such switch across said condenser and its series resistance.

10. An electromagnetic switch, a source of direct current, a condenser connected to said source in series with the coil of the switch, a shunt circuit for said condenser, means for breaking said shunt circuit to increase the charge of said condenser to the voltage of said source to cause the dropping out of said switch, and resistance connected in series with said condenser to delay charging of said condenser and thus delay the decrease in the voltage applied to such switch.

11. A plurality of electromagnetic switches for controlling retardation of an electric motor, a source of direct current, a condenser for each switch connected in series with the coil of such switch to said source while the motor is running, a shunt circuit for each condenser, means for breaking the shunt circuits for said condensers to cause the dropping out of the switches for which the condensers are provided, and resistance for each condenser in series with such condenser to delay the dropping out of the switch for which the condenser is provided upon breaking the shunt circuit for such condenser.

12. A plurality of electromagnetic switches for controlling retardation of an electric hoisting motor for an elevator car, a source of direct current, a condenser for each switch connected in series with the coil of such switch to said source while the car is running, a shunt circuit for each condenser, means for breaking the shunt circuits for said condensers to cause increase in the voltage across such condensers and thus decrease in the voltage across the coils of the switches for which the condensers are provided to cause said switches to drop out, and resistance for each condenser in series with such condenser to delay the increase in the voltage across such condenser to time the dropping out of the switches.

13. A plurality of electromagnetic switches for controlling retardation of an electric hoisting motor for an elevator car, a source of direct current, a condenser for each switch connected in series with the coil of such switch to said source while the car is running, a shunt circuit for each condenser, means operable in initiating retardation of the car for breaking the shunt circuit for the condenser for one of said switches to cause increase in the voltage across such condenser and thus decrease in the voltage across the coil of such switch to cause such switch to drop out, means operable upon dropping out of each switch for breaking the shunt circuit for the condenser for another of said switches to cause increase in the voltage across such condenser and thus decrease in the voltage across the coil of such switch to cause such switch to drop out, and resistance for each condenser connected in series therewith for delaying the increase in the voltage across such condenser and thus delaying the decrease in the voltage across the coil of the switch for which the condenser is provided to time the dropping out of the switch.

14. A plurality of electromagnetic switches for controlling retardation of an electric hoisting motor for an elevator car, a source of direct current, resistance for each switch connected in series with the coil of such switch to said source while the car is running, a condenser for each switch connected in shunt to the resistance for such switch, means operable in initiating retardation of the car for breaking the circuit for the resistance for one of said switches leaving the coil of such switch connected to said source in series with the condenser for such switch, caus-

ing increase in the voltage across such condenser and thus decrease in the voltage across the coil of such switch to cause such switch to drop out, means operable upon dropping out of each switch for breaking the circuit for the resistance for another of said switches leaving the coil of such switch connected to said source in series with the condenser for such switch, causing increase in the voltage across such condenser and thus decrease in the voltage across the coil of such switch to cause such switch to drop out, and resistance for each condenser connected in series therewith and with the coil of the switch for which the condenser is provided for delaying the increase in the voltage across such condenser and thus delaying the decrease in the voltage across such coil to time the dropping out of such switch.

15. A plurality of electromagnetic switches operable in sequence to control the operation of an electric motor during acceleration and retardation, a source of direct current, a condenser for each switch connected to said source in series with the coil of such switch while the motor is at rest, discharge resistance for each condenser adapted to be connected across the condenser to delay the decrease in voltage across the condenser, thereby delaying the building up of the voltage applied to the coil of the switch for which the condenser is provided, to time the operation of the switches during acceleration, means for breaking the discharge circuits for said condensers to cause the dropping out of the switches for which the condensers are provided for retarding the motor, and resistance for the condenser for each switch except the first to drop out during retardation connected in series with such condenser to delay the increase in the voltage across the condenser and thus the decrease in the voltage applied to the coil of such switch upon the breaking of the discharge circuit for such condenser, to time the dropping out of the switches during retardation.

16. A plurality of electromagnetic switches operating in sequence to control the operation of an electric elevator hoisting motor during acceleration and retardation, a source of direct current, a condenser for each switch connected in series with the coil of such switch to said source while the elevator car is at rest so as to be charged to the voltage of said source with the coil deenergized, discharge resistance for each condenser adapted to be connected across the condenser to delay the decrease in voltage across the condenser and thus the increase in voltage applied to the coil of the switch for which the condenser is provided thereby delaying the operation of the switch, means operable in starting the car for connecting the discharge resistance for the condenser for one of said switches in parallel with such condenser, means responsive to the operation of each switch for connecting the discharge resistance for the condenser for the next switch in parallel with such condenser, means for breaking the discharge circuit for the condenser for one of said switches to initiate slow down of the car, means operable by each switch upon dropping out for breaking the discharge circuit for the condenser for another operated switch, and resistance for the condenser for each switch except the first to drop out during retardation connected in series with such condenser to delay the dropping out of the switch upon the breaking of the discharge circuit for such condenser.

17. A plurality of accelerating switches for controlling the acceleration and retardation of an electric elevator hoisting motor, a source of direct current, means short-circuiting the coils of said switches, a condenser for each acelerating switch connected in series with the short-circuited coil of such switch to said source so as to be charged to the voltage of the source while the elevator car is at rest, discharge resistance for each condenser adapted to be connected across the condenser to delay the decrease in voltage across the condenser upon the breaking of the short-circuit for the coil of the switch for which the condenser is provided, thereby delaying the building up of the voltage applied to such coil, means operable in starting the car for breaking the short-circuit for the coil of one of said accelerating switches and for connecting the discharge resistance for the condenser for such switch across such condenser, means responsive to the operation of each accelerating switch for breaking the short-circuit for the coil of the next switch and for connecting the discharge resistance for the condenser for such switch across said condenser, means for breaking the discharge circuit for the condenser for the last accelerating switch to initiate slow down of the car, means operable by each accelerating switch upon dropping out for breaking the discharge circuit for the condenser for the accelerating switch next previously operated during acceleration, and resistance for the condenser for each accelerating switch except the last to operate during acceleration connected in series with such condenser to delay the building up of the voltage across the condenser and thus delay decreasing the voltage applied to the coil of the switch for which the condenser is provided to below sustaining value to delay the dropping out of the switch upon the breaking of the discharge circuit for such condenser.

18. A plurality of accelerating switches for controlling resistance in steps to control acceleration and retardation of an electric hoisting motor for an elevator car, a source of direct current, means for short-circuiting the coils of the switches while the car is at rest, a condenser for each accelerating switch connected in series with the short-circuited coil of such switch to said source so as to be charged to the voltage of the source while the car is at rest, a resistance for each condenser connected in series therewith, discharge resistance for each condenser adapted to be connected across the condenser to delay the discharge thereof and therefore the decrease in voltage across the condenser upon the removal of the short-circuit for the coil of the switch for which the condenser is provided, thereby delaying the building up of the voltage applied to such coil and thus delaying the operation of the switch, means operable in starting the car for breaking the short-circuit for the coil of one of said accelerating switches and for connecting the discharge resistance for the condenser for such switch across such condenser, means responsive to the operation of each accelerating switch for breaking the short-circuit for the coil of the next accelerating switch and for connecting the discharge resistance for the condenser for such switch across said condenser, means responsive to the operation of the last accelerating switch for short-circuiting said first named resistance in series with the condenser for such switch to cause the voltage across the condenser to build up quickly and thus the voltage applied to the

coil of the switch quickly to decrease to below sustaining value to cause said switch to drop out without appreciable delay upon the breaking of the discharge circuit for such condenser, means responsive to the operation of each previously operated accelerating switch for short-circuiting only a portion of said first named resistance in series with the condenser for such switch to delay the building up of the voltage across the condenser and thus delay decreasing the voltage applied to the coil of the switch to below sustaining value to delay the dropping out of the switch upon the breaking of the discharge circuit for such condenser, means for breaking the discharge circuit for the condenser for said last accelerating switch to initiate slow down of the car, and means operable by each accelerating switch upon dropping out for breaking the discharge circuit for the condenser for the accelerating switch next previously operated during acceleration.

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