My invention relates to control systems and has particular relation to systems of control for elevator hoists and similar machinery.

An object of my invention is to provide a control system for motors in which the acceleration and deceleration of the motor may be controlled automatically.

Another object of my invention is to provide a control system for motors wherein the rate of acceleration and deceleration is independent of the load upon the motor.

Another object of my invention is to provide a control system for motors having voltage-modifying devices for determining the speed of the motor, which devices will be automatically connected, in, and disconnected from, the circuit at rates determined by the load on the motor.

My invention will be described with reference to the accompanying drawing, wherein:

Figure 1 is a diagrammatic view of an elevator-control system wherein my invention is applied to control the acceleration and deceleration of the driving motor; and

Fig. 2 is a diagram embodying acceleration and deceleration curves to illustrate the effect of the application of my invention to the control system.

I have illustrated an elevator car C suspended upon a cable Cc which passes over a hoisting drum D to a suitable counterweight Cw. The driving device for the hoisting drum D is of the variable-voltage type and comprises an elevator motor EM having its armature EM' directly coupled to the hoisting drum D and having its field winding EMF connected to a source of power indicated by the reference characters L1 and L2.

The armature EM' is connected in loop circuit with the armature G' of a generator G illustrated as being of the compound-wound type having a separately excited field winding GF and a series field winding GSF. A means for driving the generator G is illustrated as a motor M, preferably of the shunt-wound type, having its armature M' directly coupled to the armature G' of the generator G and having its shunt field winding MF connected in parallel relation to the armature M'.

The direction and speed of operation of the hoisting motor EM is illustrated as controlled through the actuation of a car switch Cs which, in turn, controls an up-direction switch 1, a down-direction switch 2 and an accelerating switching device 9.

The accelerating switching device 9 comprises a switch arm 10 pivotally mounted, as at 11, upon a suitable base (not shown) and operated in a clockwise direction by means of a motor 12, coupled to the switch arm 10, by means of a suitable reduction gearing 13.

As will be hereinafter described, it is desirable that the speed of movement of the switch arm 10 should be controlled in accordance with the load upon the motor and, for this purpose, I have illustrated an eddy-current disc 14 connected for rotary movement under the influence of the motor 12 by means of suitable reduction gearing 15. A retarding magnet 16, similar to that used to damp or retard the movement of the electric meter elements, is arranged with its pole pieces 17 and 17' on opposite sides of the eddy-current disc 14. The magnet 16 comprises a core 18, preferably of soft iron, having thereon a voltage coil 19 and a calibrating coil 20. These coils are wound in opposition to each other and the coils are so selected that the effect of the voltage coil will be in excess of that of the calibrating coil for any value of current which may be passed through the calibrating coil, under the conditions hereinafter described.

Since it is desirable that the elevator should be arranged to be driven at a plurality of different speeds, I have provided means for driving it at a slow landing speed, an intermediate speed and a higher speed. When the elevator is being driven at the slow speed, the switch arm 10 will be in the position shown in Fig. 1, and will be restrained in that position by means of the spring 21. When the car is being driven at the higher speed, the switch arm will be in its extreme right hand position, or thereabouts, depending upon the load upon the elevator car C, and will be restrained in
that position by means of the motor 12, in a manner to be hereinafter described. When the car is being driven at the intermediate speed, the small lug 22 disposed upon the end of the switch arm 10 will be in between the latching members 23 and 24, and will thereby restrain the switch arm 10 in a position intermediate the extremities of its possible travel.

When the load on the elevator car C is negative, as is the case when lifting an empty car or in lowering a heavily loaded car, the movement of switch arm 10 will be limited by the latching member 112.

The latching member 23 normally extends into the path of travel of the lug 22, under the influence of the spring 29. Its extended end is so constructed that, when the switch arm 10 is moving in a clockwise direction, its motion is limited by the position of latching member 23 but, when the switch arm 10 is moving in a counter-clockwise direction, latching member 23 presents a surface to the lug 22 at such an angle that the force exerted on switch arm 10 by the spring 21 is sufficient to depress the latching member 23 and allow switch arm 10 to pass. Latching member 23 is retractable from its normal position by means of a suitable electromagnetic releasing coil 23', connectible for energization by operation of the car switch Cs. The latching member 24 is similar to latching member 23 but is disposed in the reverse position and arranged to be normally retracted, under the influence of a tension spring 30. It will be noted, therefore, that, when latching member 24 is in the extended position, it will limit the motion of switch arm 10 in the counter-clockwise direction but will permit it to pass when moving in the clockwise direction.

The latching member 112 also normally extends into the path of the lug 22 on switch arm 10, under the influence of its spring 115. Latching member 112 is wound with two coils 119' and 119", the former of which is connected in series relation with the armature of the generator G and the latter of which is connected across the terminals of the generator G. These coils are so arranged on the armature of latching member 112 that, under conditions of positive load, their magnetomotive forces will be additive and, under conditions of negative load, will be subtractive. They are so designed that their combined influence is sufficient to actuate latching member 112 to retract it from its normally extended position. When they are opposing, the member 112 will of course not be actuated. In a manner to be hereinafter described, latching member 112 acts to keep the motor speed constant under conditions of positive and negative load.

It is apparent that the torque developed by the motor 12 should always be in the same direction, independent of whether the car is moving upwardly or downwardly, or whether the elevator motor is driving the load or being driven by the load to return power to the line. To accomplish this, I have provided a reverse-power relay 5 and two auxiliary direction switches 3 and 4.

The reverse-power relay 5 is provided with two coils 27 and 28, the former of which is connected in series relation with the armatures of the generator and motor and the latter of which is connected across the terminals of the generator G.

The coils 27 and 28 are so disposed upon the core of reverse-power relay 5 that, when the elevator load is positive in either the up or the down direction, i.e., when the elevator motor is drawing power from the generator, their magnetomotive forces will be additive, and the relay 5 will therefore be actuated. However, when the load is negative, i.e., when the load on the elevator is driving the elevator motor as a generator to return power to the line, the direction of current flow through the series coil 27 is reversed, while the direction of current flow through the shunt coil 28 remains the same. Therefore, the magnetomotive forces of the two coils are subtractive and the relay assumes its normal position.

The response to power reversal when the car is moving in a given direction, determined, by the character of the load, as positive or negative, provided for by reverse-power relay 5, is transmitted to the armature 1 of motor 12 through the auxiliary direction switches 3 and 4, the coils of which are connected to the source of power through the normally open contact members, respectively, of reverse-power relay 5, as will be hereinafter described. The reversal of current flow, dependent upon the direction of travel of the car C, is transmitted to the armature of the motor 12 by means of contact members on the reversing direction switches 1 and 2, so that the current supplied to the armature 12 will always be in a direction to cause the motor to exert torque in the same direction independent of the character of the load.

It is, of course, necessary that the motor 12 shall exert torque only during acceleration of the car. To this end, I have provided that its armature circuit may be controlled through either of two relays 6 and 7, which relays are suitably controlled by the car switch Cs in a manner hereinafter described. It will be noted that relay 7 is suitably interlocked with relay 6 through a pair of normally closed contact members 5 on the latter relay. Relay 7 is further mechanically interlocked by means of the latch member 32 of latch magnet 7a, extendible into the path of the hook 31 formed at the end of the armature of relay 7 by means of the coil 7a' wound on magnet 7a and suitably controlled by the car switch Cs.
My system will best be understood with reference to an assumed operation. Assuming that it is desired to move the car upwardly, the car switch Cs may be moved in a counterclockwise direction to complete a circuit for energizing relay 7, which circuit extends from line conductor L1, through conductor 33, contact members 34, 35 and 36 of car switch Cs, conductors 37 and 38, normally closed contact members b of relay 6, conductor 39, the coil of switch 7 and conductor 40, to line conductor L2. The operation of relay 7 prepares a circuit for the armature of motor 12, which circuit is not completed until the operation of one of the direction switches 1 and 2 and one of the auxiliary direction switches 3 and 4.

If the car switch Cs is moved further in a counterclockwise direction, a circuit is completed for energizing the coil 7a' of latch magnet 7a, which circuit extends from line conductor L1, through conductor 33, contact members 34, 35 and 41 of car switch Cs, conductors 42 and 43, the coil 7a' of latch magnet 7a, and conductors 44 and 40, to line conductor L2. Now actuated, the latch member 32 moves to a position in the path of movement of the member 31 on the armature of relay 7. Since relay 7 is already energized, the actuation of latch magnet 7a is without effect. However, it will be noted that if relay 7 is deenergized while latch magnet 7a is energized, it will be impossible to actuate relay 7 to again close its contacts until latch magnet 7a is deenergized. As illustrated, the extended end of the latch member 32 is so formed as to permit passage of the member 31 in one direction but to restrain it from movement in the opposite direction.

If the car switch Cs is now moved further in a counterclockwise direction, a circuit is completed for energizing the up-direction switch 1 and relay 8, the circuit extending from line conductor L1, through conductor 33, contact members 34, 35 and 45 of car switch Cs, conductor 46, the coil of up-direction switch 1, conductors 47 and 48, the coil of relay 8, and conductor 49, to line conductor L2.

Up-direction switch 1, when actuated, completes a circuit for supplying voltage to the separately excited field winding GF, which extends from line conductor L1, through conductors 50, 51 and 52, contact members a on up-direction switch 1, conductors 53 and 54, separately excited field winding GF, conductors 55 and 56, contact members b on up-direction switch 1, conductor 57, resistor 58, contact member 59 on switching device 9, contact brush 60, and conductor 61. It will be observed that resistor 58 is divided into a plurality of sections each of which is connected in consecutive order to contact members on switching device 9, similar to contact member 59, and arranged to be engaged by contact brush 60 carried by switch arm 10.

The separately excited field winding GF will now be supplied with current corresponding to the value of resistance in the circuit, as determined by the size of resistor 58, and hence, the generator G will supply voltage to the elevator motor armature EM of a corresponding value, and the car C will start upwardly at a predetermined low speed.

It will be observed that current will traverse the calibrating coil 20 for the magnet 16 since this coil is connected in parallel relation to generator field winding GF, by way of conductor 63, the calibrating coil 20, conductors 64 and 65, contact members of relay 8 (now energized) and conductor 66, to line conductor L1. As previously described, voltage coil 19 is also energized by actuation of relay 8, by way of a circuit which extends from line conductor L1, through conductor 66, contact members of relay 8, conductor 65, voltage coil 19, adjustable resistor 67 and conductors 68 and 69, to line conductor L2.

If we assume that the load upon the elevator is such that the elevator motor is drawing power from the generator, we may say, for example, that current is flowing through the loop circuit formed by the connections between the generator and elevator motor armatures, by way of the armature G' of generator G, conductor 70, the armature EM' of elevator motor EM, conductor 71, coil 112' of latch member 112, conductor 111, the field winding 12' of torque motor 12, conductor 72, the coil 27 of reverse power relay 5, conductor 73, the series field winding GSF of generator G and conductor 75, back to the generator again. According, current will flow through the coil 28 of reverse-power relay 5, by way of conductors 70 and 76, the coil 28 and conductors 77 and 73, to the generator as described. In this case, then the fluxes of coils 27 and 28 will be additive, and reverse-power relay 5 will be actuated to close its normally open contact members, thereby completing a circuit for the coil of auxiliary direction switch 3, which circuit extends from line conductor L1, through conductors 50 and 78, contact members a of reverse-power relay 5, conductor 79, the coil of auxiliary direction switch 3, conductors 80 and 81, contact members of up-direction switch 1 (now closed) and conductors 82, 83 and 84, to line conductor L2.

When actuated, switch 3 closes its contact members a and b to complete a circuit to supply current in one direction to the armature of the motor 12, which circuit extends from line conductor L1, through conductors 50 and 51, and 85, contact members d of up-direction switch 1, conductors 86 and 87, contact mem-
bers b of auxiliary direction switch 3, conductor 88, the armature of motor 12, conductors 90 and 91, the contact members of relay 7, conductors 92, 93, and 89, contact members a of auxiliary reversing switch 3, conductors 94 and 95, contact members c of up-direction switch 1 and conductors 96 and 94, to line conductor 1. Since both the armature and field windings of motor 12 are now energized, the motor develops torque proportion to such energization and moves switch arm 10 of the accelerating device 9 in a clockwise direction against the opposing force of the spring 21, which movement continues until lug 22 on switch arm 10 encounters latching member 23.

As switch arm 10 moved in the clockwise direction, portions of resistor 58 were successively excluded from the separately excited field winding GF of generator G, and the current through, and the flux set up by, winding c was thus decreased. As a result, therefore, the voltage of generator G increased, and, accordingly, the speed of the hoisting motor EM increased proportionately.

Since a voltage is now developed across the terminals of generator G, a current will flow in the coil 112" of latching member 112.

Further, since the condition of positive load was assumed, the effect upon the armature of latching member 112 of its two coils 112' and 112" will be additive, and latching member 112 will therefore be retracted. It will be noted that, at any time that the load is positive, latching member 112 is retracted.

If it is desired to operate the car at its highest speed, the switch arm Cs may be moved to its extreme position in the counterclockwise direction. In so doing, the contact member 35 of the switch Cs will engage contact member 98 to complete a circuit for energizing the coil 24 of latch member 24, which circuit extends from line conductor L1, through conductor 33, contact members 34, 35 and 98 of the car switch Cs, conductors 99 and 100, the coil 24 of latching member 24 and conductors 101 and 69, to line conductor L2. Its coil being now energized, latch member 24 is moved to its extended position against the force of its restraining spring 30. This action, however, produces no effect during the acceleration of the car, but is effective during deceleration, as will be hereinafter described.

With the car switch in its extreme position, two additional circuits are completed, one for energizing relay 6, and one for retracting latch member 23. The former circuit extends from line conductor L1, through conductor 33, contact members 34, 35 and 98 of car switch Cs, conductors 103 and 104, the coil of relay 6 and conductors 105 and 40, to line conductor L2. Its coil, now being energized, relay 6 closes its contact members a, and opens its contact members b thereby transferring control of the circuit for the armature winding of the motor 12 from relay 7 to relay 6. It will be noted that the closing of contact members a is immediate, but that the opening of contact members b is retarded by any suitable retarding device. As illustrated, the retarding means comprise a spring 108 and a dash pot 107 adapted to retard the motion of contact members b in the opening direction. The purpose of so retarding the opening of contact members b is to insure the closing of contact members a before relay 7 is deenergized by the opening of contact members b. Thus, torque is maintained by the motor 12 throughout the transition period.

It will be noted, when relay 7 was deenergized as a result of the actuation of relay 6, the hook 31 formed at the end of the armature of switch 7 passed over, and was engaged by, the latch member 32 of latching magnet 7a. It is obvious that the circuit cannot be completed for the armature winding of the motor 12 through relay 7 until after latching magnet 7a is deenergized to retract the member 32, under the influence of its biasing spring 7a'.

The latter circuit, completed by the movement of car switch Cs to its extreme position, effected the energization of the coil of latch member 33, which circuit extends from line conductor L1, through conductor 33, the contact members 34, 35 and 102 of car switch Cs, conductors 103 and 106, the coil of latching members 23 and conductors 107 and 69, to line conductor L2. Being now energized, the coil of latching member 23 acts to retract latch member 23 from its extended position, thereby allowing the switch arm 10 to pass to its extreme position to thereby exclude additional portions of resistor 58 from the circuit of the separately excited field winding GF of generator F. Hence, hoisting motor EM accelerates to its high speed.

It will be observed that the rapidity with which the switch arm 10 moves to any of its positions is determined by the effect of the magnet 16 on the eddy-current disc 14. Since the voltage coil 19 is connected directly to the source of power, the force exerted by this coil will be constant through all movements of the switch arm 10. However, the calibrating coil 20, being connected in series relation with resistor 58, the force exerted by coil 20 will be dependent upon the value of resistance retained in the generator-field-winding circuit. Since the coils 19 and 20 are wound in opposition to each other, it follows that, during the initial movements of the switch arm 10, the eddy-current disc 14 will exert its greatest retarding effect, which effect is diminished as the arm 10 continues to rotate to assume new positions. That is, between the time that the arm 10 leaves the stop member 97 and the engagement of the lower por-
tion 22 of arm 10 with latch member 23, the movement of arm 10 will be slow, while the movement between latch 22 and the extreme position, defined by stop member 97, more rapid. It is the variable speed of movement of the arm 10 thus obtained to thereby exclude sections of the resistor R3 at increasing rates as the car switch Cs is moved to operate the motor EM at increasing speeds, which produces the most desirable acceleration curve for use with elevator operation.

It is well known that a limitation upon the rate of change of speed of an elevator car is imposed by the fixed rate at which the body of the passenger may be accelerated without discomfort. On the other hand, it has been observed that, if the acceleration can be started gradually, and increased thereafter, a much less discomforting effect is produced upon the passengers. I have illustrated, in Fig. 2, an acceleration curve 109 which represents the most rapid rate of acceleration which may be used without discomfort to passengers.

An inspection of this curve will illustrate the fact that, at the initial starting of the car from the point designated by legend “Start”, acceleration is at a comparatively slow rate, which increases as the car attains speed. It is obvious, therefore, that, with my system of control, utilizing different speeds of movement of the switch arm 10, this desired acceleration rate may be readily obtained.

Curve 109, illustrated in Fig. 2, represents a deceleration curve which is in all respects similar to the acceleration curve 108, and it has been observed that the rate of deceleration illustrated by curve 108 is the most rapid deceleration permissible for comfort for the passenger and also for accuracy in stopping the car level with a floor at which it is desired to stop.

It will be observed that, after the switch arm 10 has been moved to its high-speed position, that is, to a position at or near stop member 97, the arm 10 will thereafter act to maintain the speed of the motor EM constant, independent of variations of the load upon the car C. Since the total torque which will be exerted by the motor 12 is dependent upon the load upon the car C, it follows that, by arranging the spring 21 with a predetermined strength, the arm 10 will assume a position at which the torque exerted by the motor just balances the torque exerted by the spring.

The use of the series field winding GSF on the generator G, if properly designed, tends to impose a regulation on the speed of the motor to make the motor speed constant under variations in load. However, at high speeds, the effect of the series field winding GSF is insufficient to maintain constant-speed regulation within accurate limits. Therefore, in prior devices in which the Ward-Leonard or variable-voltage control is used, some means, in addition to the series field winding, must be provided if the car speed is to be regulated with accuracy at high speeds.

With my system, however, the additional necessary regulation is imposed by the accelerating device 9 since, when the motor is operating at high speed, the switch arm 10 will be positioned at some point intermediate the positions, defined by the dotted lines. If the load on the car is heavy, a greater torque will be exerted by the motor 12, and the arm 10 will be moved to a further position, cutting out one or more of the sections of the resistor R3 which are illustrated as bracketed under the reference character 110. As the load diminishes, less torque is exerted by the motor 12, the spring 21 will move arm 10 to a different position, including some of those sections of the resistor designated by the character 110. Thus, the full-speed position is variable in accordance with the load on the car. Hence, with the use of my accelerating device, the speed of the elevator motor EM will be maintained constant at high speeds without the necessity of any additional apparatus.

If it is now desired to decelerate the car to intermediate speed, the car switch Cs may be moved in the clockwise direction to disengage contact members 34 and 102, thereby breaking the circuit to relay 6 and to the coil of latching member 23.

The deenergization of relay 6 breaks the circuit for the armature winding of the torque motor 12, the torque of which is accordingly reduced to zero. As a result, therefore, the switch arm 10 is moved in the counter-clockwise direction, under the influence of the spring 21, until stopped by the latching member 24, now in its extended position. Deenergization of relay 6 completes the circuit for the coil of relay 7, which cannot close, however, due to the restraint imposed by latching magnet 7a.

In elevators arranged to operate at comparatively high speeds, such as from 500 to 800 feet per minute, it is desirable, in the stopping operation, to bring the car to a slow landing speed of about, for example, 20 to 50 feet per minute, a few feet from the floor at which it is desired to stop and to then interrupt the power supply and apply the brake at the same point each time. If the power supply was abruptly interrupted, with the car operating at high speed, the rate of deceleration would be so rapid as to cause discomfort to the passengers.

Therefore, in the assumed example, if it is now desired to stop the car, the car switch Cs may be moved in the clockwise direction to a point where contact member 34 is disen-
gaged from contact member 98 but still engages contact members 36, 41 and 45.

The disengagement of contact members 34 and 98 breaks the circuit to the coil of latching member 24, which thereby permits the latching member 24 to assume its normal retracted position under the influence of spring 30. Switch arm 10, therefore, under the influence of its spring 21, moves in a counterclockwise direction to its extreme or illustrated position, thereby slowing the elevator motor EM from intermediate speed to slow landing speed, as determined by the value of resistor 58. When the car C approaches within a predetermined distance of the floor at which it is to stop, the car switch Cs may be centered to disengage contact members 36, 41 and 45 from contact member 34. Disengagement of contact members 35 and 45 breaks the circuit for the up-direction switch 1 which, in turn, interrupts the circuit to the separately excited field winding of the generator and sets the brake (not shown) to bring the car to rest at the floor. The disengagement of contact members 35 and 41 breaks the circuit for the coil of latching magnets 7a, the core member 32 of which assumes its normal position. Between the time that the latching magnet 7a assumes its normal retracted position and the time that contact members 35 and 36 of the car switch Ca are disengaged, the circuit for switch 7 is completed, and no mechanical restraint is imposed upon it. However, its actuation is ineffective to supply power to the armature windings of motor 12, since this latter circuit has already been broken at the contact members c and d of up-direction switch 1. After the car switch is fully centered, relay 7, of course, is again deenergized, and the system, is returned to normal, ready for a subsequent cycle.

In describing the effect of the eddy-current disc 20 with respect to conditions during acceleration of the hoisting motor EM, it was pointed out that the amount of retardation exerted thereby upon the force of the motor 12 was directly proportional to the amount of resistor 58 included in the circuit of the coil 20. Stated otherwise, the degree by which the eddy-current disc 14 cooperated with spring 21 in restraining the movement of switch arm 10 was proportional to the amount of resistor 58 in the circuit of the coil 20. It will be apparent, therefore, that, on deceleration, the first part of the counterclockwise motion of switch arm 10 will be more rapid than the last part, as depicted by curve 109. Further, since, during deceleration, the torque of motor 12 is of zero value, the rate at which the switch arm 10 will move on deceleration is greater than the rate at which it will move on acceleration.

It will be also apparent that, by making independent adjustments of the torque of the motor 12, of the strength of the restraining spring 21 and of the retarding force of eddy-current disc 20, the rate of acceleration and deceleration of the hoisting motor EM may be varied over a considerable range.

In the present assumed operation, the action of the system was described in connection with a very slow advance and return of the car switch Cs. It will be apparent that such slow movement is unnecessary to effect the proper sequential relationship of the various parts, and that, in fact, such relationship is independent of the rate at which the car-switch handle is moved. With the type of control illustrated, it is, of course, necessary that the car switch be moved to the proper point to complete the proper circuits for the various rates of speed at which it is desired to operate the car.

Thus far, the description has been confined to upward travel with a positive load. If however, the load had been negative, or such as to drive the elevator motor as a generator to return power to the line, the situation would have been slightly different. Under such conditions, since the current in the loop circuit between the armatures of the generator and motor would have been reversed, the direction of current flow through coil 27 of reverse power relay 5 would have been reversed, whereas the direction of current flow through coil 28 of this relay would have remained the same. As a result, reverse-power relay 5 would not have been actuated to energize the coil of auxiliary direction switch 3.

However, under these conditions, the coil of auxiliary direction switch 4 would have been energized through the normally closed contacts of reverse-power relay 5 to complete a circuit for the armature of torque motor 12 to send current through said armature in the reverse direction. Hence, under these conditions, the direction of current flow through the field would have been reversed, such reversal would have been accompanied by a similar reversal of the armature current, and the direction of the developed torque would have remained unchanged.

It is well known that, with a given load on the car, an elevator motor will run at a higher rate when regenerating than when driving. The variation in speed from no-load to full-load regenerating may be five percent of the no-load speed of the system. Although there are other methods, one way to compensate for this speed difference is to reduce the generator excitation when the load is negative. Latching member 112 is illustrative of one method of accomplishing this result. As shown, under conditions of negative load, latching member 112 will extend into the path of the switch arm 10 and limit its motion in the clockwise direction. As a result, the generator excitation is limited to such value that the speed of motor EM is
the same as at no load or any value of positive load. If latching member 112 is designed to be effective at from one-half to full negative load, a normal regulation of five percent will obviously be reduced to two and one-half percent. If closer regulation is desired, additional latching members, as 112, may be designed to be responsive to different values of negative load. For purposes of simplification, one only is illustrated.

It is also apparent that a positive load in the upward direction is accompanied by the same direction of current flow through the loop circuit as is a negative load in the downward direction. However, it will be observed that, while a change from positive load to negative load in one direction will result in a change in direction of current flow through only the coil 27 of reverse-power relay, a change from positive or negative load in one direction to positive or negative load, respectively, in the other direction results in a reversal of direction of current flow in both coils 27 and 28 of relay 5. Under conditions of reversed travel with positive load then, relay 5 will be actuated to complete a circuit for auxiliary switch 3. Since the direction of current flow through the field 12 is reversed, however, it would appear that the direction of torque of motor 12 would be reversed. It will be remembered, though, that the circuit for the armature winding of torque motor 12 was led through contact members c and d of the direction switches. Thus it is that the direction switches 1 and 2 operate to keep the torque of motor 12 unidirectional, as affected by changes in direction of travel of the car, while auxiliary direction switches 3 and 4 operate to keep the torque of motor 12 unidirectional as affected by changes in the character of the load, as positive or negative.

It is apparent then, that travel in the down direction is in all respects similar to travel in the up direction except that down-direction switch 2 replaces up-direction switch 1.

For purposes of clarity of description, I have described my invention as applied to a manually controlled elevator. It will be apparent however, that it is equally applicable to any known system of automatic slow down and stoppage of the car by means of automatic devices set into operation by the centering of the car switch. Such a system is disclosed in a copending application of E. M. Bouton, Serial No. 731,921, filed August 14, 1934, and assigned to Westinghouse Electric and Manufacturing Company, in which the circuits set up by movement of the car switch are maintained through the normally-closed contact members of inductor relays carried by the car and adapted to cooperate with inductor plates mounted in the elevator shaft adjacent to the floor levels, to slow down and stop the car whenever the car switch is centered to energize the exciting coils of the inductor relays.

It will also be apparent that, while I have illustrated my system as applied to an elevator operable at a high speed, an intermediate speed, and a low landing speed, it is equally applicable to systems having any number of speeds, it being only necessary to add additional latching members, as 28 and 24, with suitable control means, to adapt my system to as many speeds as are desired.

The embodiment of my invention shown and described is a preferred form, but it is to be understood that my system is susceptible of many changes and modifications, and I, therefore, do not desire to be limited to any of the details shown and described herein except insofar as defined in the appended claims.

I claim as my invention:
1. In a motor-control system, a motor, a source of power, means for supplying voltage from said source to said motor, voltage-modifying means for varying the value of voltage so supplied comprising a switch arm movable over a fixed path between two extreme positions, means biasing said lever to a position representing lowest voltage and means for exerting a force proportional to the load on said motor to move said lever against the force of said bias and means for exerting a force inversely proportional to the degree of movement of said arm, to retard movements of said arm.
2. In an elevator-control system, a motor, means for supplying variable voltage to said motor, means for controlling the voltage so supplied to operate said motor at a plurality of different speeds between zero speed and a predetermined high speed, said controlling means including a switch arm movable to a plurality of positions, each corresponding to a different speed, voltage-modifying means controlled by movement of said arm and means for progressively increasing the rate of movement of said arm as said arm moves to positions of increasing speed.
3. In an elevator-control system, a motor, means for supplying variable voltage to said motor, means for controlling the voltage so supplied to operate said motor at a plurality of different speeds between zero speed and a predetermined high speed, said controlling means including a switch arm movable to a plurality of positions, each corresponding to a different speed, voltage-modifying means controlled by movements of said arm and means for progressively increasing the rate of movement of said arm as said arm moves to positions of increasing speed and progressively decreasing the rate of movement of said arm as said arm moves to positions of decreasing speed.
4. In a motor-control system, a motor, a generator having a separately excited field winding for supplying variable voltage to said motor, a source of power, means for sup-
plying exciting voltage to said generator including a plurality of voltage-modifying means, a switch arm movable over a predetermined path for rendering said voltage-modifying means ineffective in small increments to thereby accelerate said motor, means for moving said arm through distances proportional to the load on said motor, and a plurality of selectively operable means for limiting the movement of said arm at a plurality of different positions.

5. In a motor-control system, a motor, a generator having a separately excited field winding for supplying variable voltage to said motor, a source of power, means for supplying exciting voltage to said generator including a plurality of voltage-modifying means, a switch arm movable over a predetermined path for rendering said voltage-modifying means ineffective in small increments to thereby accelerate said motor, means for moving said arm through distances proportional to the load on said motor and means for decreasingly retarding the movements of said arm as said arm progressively renders increasing numbers of said increments ineffective.

6. In a motor-control system, a motor, a generator having a separately excited field winding for supplying variable voltage to said motor, a source of power, means for supplying exciting voltage to said generator including a plurality of voltage-modifying means, a switch arm movable over a predetermined path for rendering said voltage-modifying means ineffective in small increments to thereby accelerate said motor, means for moving said arm through distances proportional to the load on said motor, means for increasingly retarding the movements of said arm as said arm progressively renders increasing numbers of said increments ineffective, and means for variably adjusting said retarding means.

7. In a motor-control system, a motor, a generator having a separately excited field winding for supplying variable voltage to said motor, a source of power, means for supplying exciting voltage to said generator including a plurality of voltage-modifying means, means for rendering said voltage-modifying means ineffective in small increments to thereby accelerate said motor to a predetermined speed within a predetermined time, irrespective of load conditions.

8. In a motor-control system, a motor, a generator having a separately excited field winding for supplying variable voltage to said motor, a source of power, means for supplying exciting voltage to said generator including a plurality of voltage-modifying means, means for rendering said voltage-modifying means ineffective in small increments to thereby accelerate said motor, including a switch arm movable over a predetermined path between two extreme positions, means biasing said arm to one extreme position, a motor for moving said arm against the force of said biasing means, having its armature connected for constant-voltage energization and having its field winding connected to receive current in value proportional to the current supplied to said first named motor, retarding means for said arm including a magnet having opposed windings thereon, one connected for constant-voltage energization and the other connected in parallel with said generator field winding.

9. In a motor-control system, a motor to be controlled, a motor controlling member, means actuable by an operator to control said member for varying the speed of operation of said motor, and means comprising a load responsive device for automatically controlling said member to regulate the rate of speed variation to be according to a predetermined rate for all loads.

10. In a motor-control system, a motor to be controlled, load responsive means, means actuable by an operator for initiating the starting of said motor, and means operative thereafter for rendering said load responsive means effective, for automatically accelerating said motor to a predetermined speed in accordance with a predetermined rate of acceleration and for thereafter maintaining the speed constant at all loads.

11. In a motor-control system, a motor to be controlled, means actuable by an operator for initiating the starting of said motor, means rendered effective thereafter, for automatically accelerating said motor to bring it up to any one of a plurality of speeds as predetermined by said actuable means and for thereafter maintaining the speed constant, irrespective of the load, comprising a motor controller, and load responsive actuating means associated therewith.

12. In combination, an elevator car, a hoist motor associated therewith, a switch mounted on the car for actuation by the operator, means responsive thereto for initiating the starting of the hoist motor, and means comprising a load responsive device for automatically controlling the acceleration of the motor to a predetermined speed at a predetermined rate irrespective of the load.

13. In combination, an elevator car, a hoist motor associated therewith, a switch mounted on the car for actuation by the operator, and means responsive thereto for starting or stopping said motor including load responsive means and a motor controller actuated thereby for automatically controlling the rate of speed variation to be in accordance with a predetermined rate irrespective of the load.

In testimony whereof, I have hereunto subscribed my name this 22nd day of July 1929.

DANILO SANTINI.