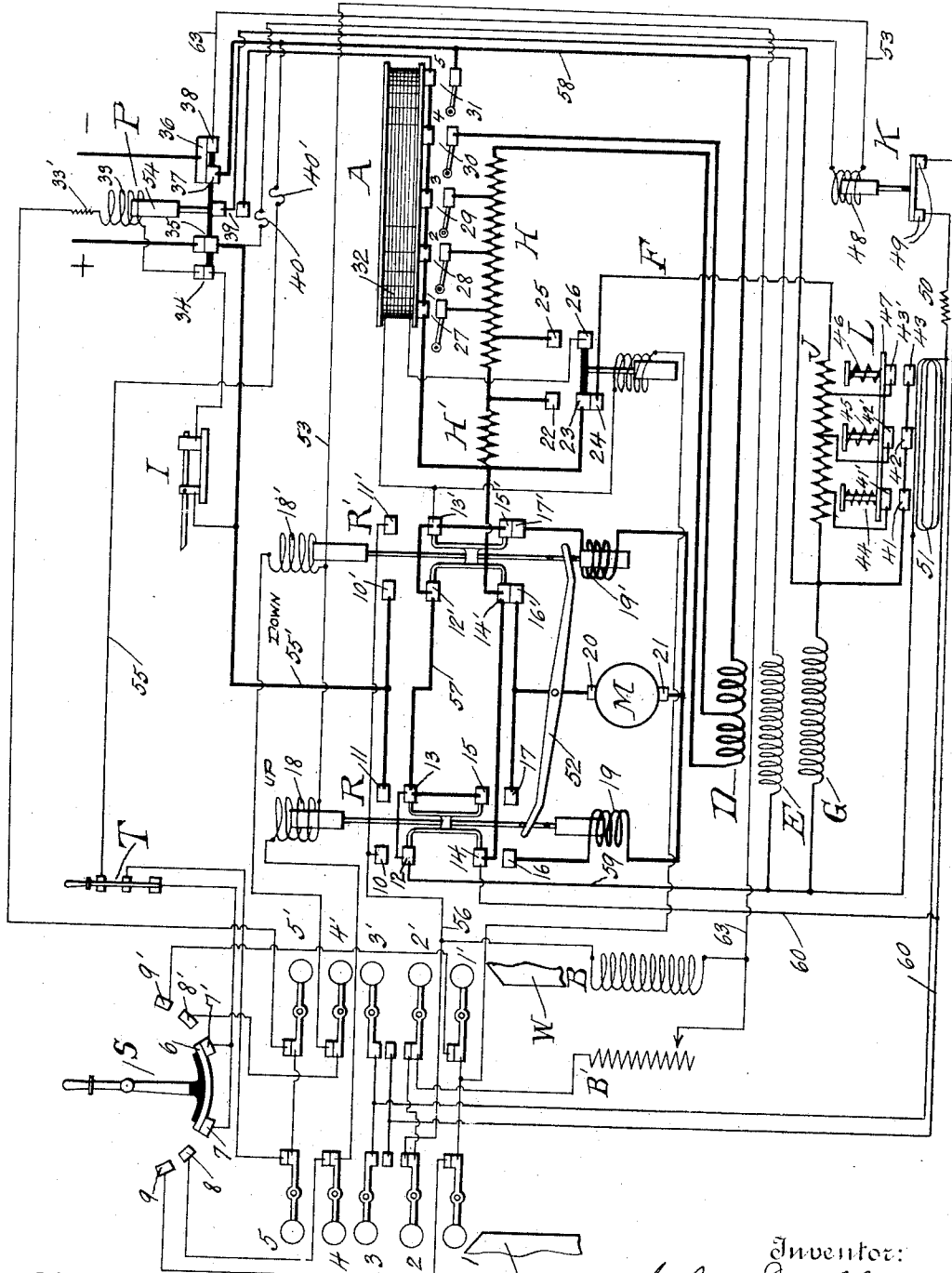


J. D. IHLDER.
MOTOR CONTROLLING MECHANISM.
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Patented June 10, 1913.



Witnesses:

Ernest L. Gale, Jr.
James G. Bethell.

Inventor:

John D. Ihlder
By J. F. Rule
Attorney

UNITED STATES PATENT OFFICE.

JOHN D. IHLDER, OF NEW YORK, N. Y., ASSIGNOR TO OTIS ELEVATOR COMPANY, OF JERSEY CITY, NEW JERSEY, A CORPORATION OF NEW JERSEY.

MOTOR-CONTROLLING MECHANISM.

1,064,224.

Specification of Letters Patent.

Patented June 10, 1913.

Application filed October 31, 1908. Serial No. 430,524.

To all whom it may concern:

Be it known that I, JOHN D. IHLDER, a citizen of the United States, residing in New York, in the county of New York and State of New York, have invented a new and useful Improvement in Motor-Controlling Mechanism, of which the following is a specification.

My invention relates in general to electrical controlling mechanism, and, while it is applicable to many classes of apparatus operated by electric power, it is particularly adapted for use in connection with hoisting mechanism, such as passenger and freight elevators and ammunition hoisting mechanism as used in fortifications and naval vessels.

One object of the invention is the provision of improved means for automatically controlling an electric motor to stop a car or carrier at predetermined points in its travel, regardless of the speed, load or friction.

Another object of the invention is the provision of automatic controlling mechanism for the motor, which will effect a gradual or gentle stop of the car or carrier at intermediate points in its travel and a rapid stop at the limits of travel.

A further object of the invention is to produce a motor and controlling mechanism therefor in which the automatic operation in stopping the motor at the limits of car travel differs from that effected manually, in accordance with the varying requirements and conditions for the different stops.

Other objects of my invention will appear hereinafter, the novel combinations of elements being pointed out in the claims annexed hereto.

Referring to the accompanying drawing which illustrates diagrammatically the motor controlling apparatus and electrical circuits therefor embodying my invention, S designates a switch by means of which an operator may start, stop and reverse the hoisting apparatus.

T designates a safety or emergency switch, and is preferably located close to the switch S so as to be within easy reach of the operator. Two sets of automatic stop switches 1, 2, 3, 4, 5 and 1', 2', 3', 4', 5' may be located adjacent the upper limit of car travel. The first-named set is adapted to be engaged by a cam C carried by the car as the latter

approaches its upper limit of travel, while the latter set is engaged by a similar cam W carried by the counterbalance weight or car when the car approaches its lower limit of travel, both cams being of sufficient length to be in engagement with all of the switches of a set at one time.

The automatic stop switches 1, 2, 3, 4, 5 and 1', 2', 3', 4', 5' may be arranged at varying distances from each other to suit various conditions met with in practice. Furthermore, these stop switches may be replaced by other switching means arranged to be automatically operated by any moving part of the hoisting apparatus, such as the winding drum shaft. The drawing shows separate switches operated directly by the car or counterbalance weight when the latter is used, merely for simplicity and clearness.

M designates a hoisting motor which is operatively connected to the car or carrier by means of suitable hoisting mechanism, the latter not being shown since it forms no part of the present invention and may be of any suitable construction.

R and R' are motor reversing switches, and, while the same may be of any suitable construction, I prefer the type of switches herein shown, the same being substantially like those shown in U. S. Patent No. 704,336, granted to me on July 8, 1902.

B designates the magnet coil of the usual spring or gravity actuated electrically released friction brake, while B' is a resistance normally in parallel therewith.

The motor illustrated herewith is of the direct current, compound wound type, this type of motor being particularly adapted for hoisting purposes in that it combines the powerful starting torque at low speeds of the series wound motor with the substantially constant speed characteristics of the shunt wound motor. The series and shunt field windings are designated by D and E, respectively.

G designates an extra field winding having in series with it a sectional resistance J, which latter is cut out of or into circuit by means of a load magnet L. A suitable resistance may be used in place of the extra field winding.

K is an electromagnetic switch which controls a circuit to the load magnet L.

A designates an accelerating magnet

which effects the short-circuiting of the motor starting resistance and series field winding as the motor is run up to speed.

F is a magnet switch, by means of which a fast or slow speed of the hoisting motor may be effected.

P designates a potential switch which under normal conditions connects the system of circuits to a suitable source of electrical supply through the conductors + and -.

I is a slack cable switch which operates to open the potential switch P and bring the hoisting motor to rest in case the hoisting cables should become slack from any cause.

Having briefly described the various parts of the apparatus embodying my invention, I will now go into a more detailed description of these parts and their coöperation, at the same time tracing out the various circuits.

The light lines represent the operating, brake and shunt field circuits and the circuit of the load magnet L, while the heavy lines denote the main or motor circuits, the extra field circuits being shown by lines of medium thickness.

The potential switch P comprises a magnet winding 33 and core 54, the latter being adapted when magnetized to hold a series of insulated contacts in electrical engagement with corresponding fixed contacts directly above. These contacts are designated by 34, 35, 36, 37 and 38. Other contacts 39 are in a similar manner normally held out of engagement with each other. The potential switch P under normal conditions has its magnet winding 33 energized, thereby maintaining its contacts closed, as shown. The circuit for this winding 33 is as follows,—from the positive main through the contacts 35, contacts of slack cable switch I, contacts 34, to and through the magnet winding 33 and resistance 33', through the automatic stop switches 5' and 5, emergency switch T, fuse 40', and contacts 37 and 36, to the negative main.

In order to illustrate the operation of the system, let the handle of the operating switch S be moved a short distance to the right until the segment 6 engages the fixed contact 8. This operation closes a circuit to the reversing switch R from the positive main through contacts 35 of the potential switch, fuse 40, through the magnet winding 48 of the switch K, wire 53, winding 18 of the reversing switch R, through the automatic stop switch 4, switch contacts 8, 6 and 7, emergency switch T, wire 55, fuse 40', contacts 37 and 36, of the potential switch P, and to the negative main. This circuit energizes the magnet switch K and reversing switch R and they will operate in a manner to be pointed out later.

The reversing switches R and R' each comprises a magnetic core or plunger to

which are fastened arms carrying contacts, such as 12, 13, 14 and 15. In the path of these movable contacts are fixed contacts, such as 10, 11, 16 and 17, which are adapted to be engaged by the movable contacts. The winding 18 of switch R, when energized, tends to lift its core to which are connected the contacts 12, 13, 14 and 15, causing the contacts 12 and 13 to engage the fixed contacts 10 and 11, respectively. The movable contacts 14 and 15 will at the same time be moved away from the fixed contacts 16 and 17, respectively. The winding 19, however, tends when energized to pull its core and connected contacts in a downward direction. A rocker arm 52 is operatively connected to the switches R and R' and prevents both switches being in their extreme upward or downward positions at the same time. This interlocking device is shown diagrammatically on the drawing, the precise construction being shown in Patent No. 704,336, granted to me on July 8, 1902, and entitled "Reversing switch motor."

As before pointed out, the circuit established by moving the operating switch S in a right-hand direction includes the magnet windings of the switches K and R. The switch K being thus energized, raises its core and connected contact plate, thereby open-circuiting the contacts 49. The winding 18 of switch R being also energized, raises its core, and by so doing brings the contacts 12 and 13 into electrical engagement with the fixed contacts 10 and 11, respectively. At the same time the rocker arm 52 allows the contacts 14 and 15 of the reversing switch R' to engage the contacts 16' and 17', respectively. The closing of these reversing switch contacts establishes circuits to the motor and brake magnet B. The motor circuit may be traced from the positive main through the potential switch contacts 35, wire 55', contacts 11 and 13 of the reversing switch R, wire 57, contacts 15' and 17' of the reversing switch R', winding 19', brush 21, through the armature of the motor M, brush 20, contacts 16' and 14' of the reversing switch R', to and through the sectional starting resistance H' and H, series field winding D, and by wire 58 and potential switch contacts 37 and 36 to the negative main. A circuit is at the same time closed to the brake magnet, which may be traced from the contact 11 to the contacts 13, 12 and 10, wire 56, to and through the brake magnet coil B, wire 63, contacts 38 and 36, to the negative main. The closing of the reversing switch R not only closes a circuit through the motor armature and brake magnet, but also a circuit through the shunt field and extra field windings, the armature circuit including the winding 19' which operates to pull its core in a downward direction, thereby maintaining the

contacts 14', 16' and 15', 17' in close electrical engagement. The shunt field circuit may be traced from the positive main through the contacts 35, wire 55', contacts 11, 13 and 12, wire 59, field winding E, wire 58, contacts 37 and 36, to the negative main. The extra field circuit is from the motor brush 21, winding 19', contacts 17', 15', wires 57 and 59, to and through the extra field G, resistance J, contacts 24 and 23 of magnet switch F, contacts 14' and 16' to the motor brush 20. The extra field is therefore connected as a shunt to the motor armature.

Under the present conditions the motor armature receives current limited in amount by the starting resistance H' and H, the series field, shunt field and extra field are energized, the current in the latter being limited in amount by the resistance J in series therewith. The brake is also released by the magnet B and the motor starts and runs at slow speed in a direction to lift the load. The next operation is to move the switch S farther toward the right until the contact segment 6 bridges the fixed contacts 7, 8 and 9. A circuit is thereby closed through the winding of magnet switch F, which may be traced from the positive main through contacts 35, wire 55', contacts 11 and 13, wire 57, contacts 12' and 13', to and through the winding of magnet switch F, automatic stop switch 1, contacts 9, 6 and 7 of switch S, emergency switch T, wire 55, fuse 40' and to the negative main 58. The magnet of switch F is now energized to raise its core and connected contacts 23 and 26 into electrical engagement with the fixed contacts 22 and 25, respectively, at the same time carrying the contact 23 out of engagement with the contact 24. By closing the contacts 22 and 23, the starting resistance H' is short-circuited, allowing more current to flow to the motor armature. At the same time a circuit to the winding 32 of the accelerating magnet A is established by way of the contacts 25 and 26. This circuit may be traced from the armature brush 21, through magnet coil 19', contacts 17', 15' and 13', to and through the winding 32, contacts 26 and 25 of switch F, through a portion of the starting resistance H (the resistance H' being short-circuited by the contacts 22 and 23 at this time), contacts 14' and 16', to the motor armature brush 20. The winding 32 is therefore connected across or in shunt to the motor armature and a portion of the starting resistance H, and its energization depends upon the counter-electro-motive force of the rotating armature. The winding 32 of the accelerating magnet when sufficiently energized operates to close a series of contacts 27, 28, 29, 30 and 31, which contacts may be arranged in any one of several well known ways so that they will always

operate in a certain predetermined order. The movable contacts are here shown as being at varying distances from their respective fixed contacts, and so arranged that the contacts 27 will close first, then the contacts 28, and so on until finally the contacts 31 will close. The contacts 27, 28 and 29 operate to short-circuit sections of the starting resistance H, the contacts 30 short-circuit a portion of the starting resistance, together with a portion of the series field D, and the last contacts 31 operate to short-circuit the remainder of the series field.

At the same time that the switch F operates to connect the contacts 23, 22 and 26, the contacts 23 and 24 are separated, and thus the circuit to the extra field winding G is broken at these contacts. The motor now accelerates to full speed, with all of the starting resistance cut out of the armature circuit, and, being excited by the shunt field alone, runs at substantially constant speed.

In order to stop the motor and thus arrest the upward movement of the car and load, the switch S is moved back to its initial or central position. The switch segment 6 first passes out of electrical engagement with the contact 9, thereby interrupting the circuit for the magnet coil of switch F and causing the separation of the contacts 22, 23 and 25, 26, the contacts 23 and 24 once more coming into engagement. The separation of the contacts 22 and 23 reinserts the resistance H' in the armature circuit, while the separation of the contacts 25 and 26 interrupts the circuit to the winding 32 of the accelerating magnet A and the latter operates to reinsert the resistance H and series field D in the armature circuit. The closing of the contacts 23 and 24 connects the extra field G and resistance J in series therewith across the armature brushes, producing a dynamic brake action, and by increasing the field strength of the motor, helps to reduce its speed. The switch S is next brought to its initial central position, the segment 6 passing off of the contact 8. Since the contact 8 is connected through the automatic stop switch 4 to one terminal of the reversing switch magnet 18, the latter is deenergized, allowing its core and connected contacts to drop, thus separating the contacts 10, 12 and 11, 13, respectively, of the reversing switch R, and thereby cutting off the current supply to the motor and brake magnet B. The brake magnet B contains a resistance B' connected in parallel with it, this parallel connection including the automatic stop switches 2 and 2' which are normally closed as shown. The function of this resistance B' is to furnish a path for the brake magnet discharge which occurs when the supply circuit to the brake magnet is broken at the reversing switch con-

tacts 10 or 11'. By reason of this discharge through the resistance B', the de-magnetization of the brake magnet is not instantaneous, but requires a certain interval of time. The period of time required to de-energize the brake magnet an amount sufficient to allow the brake mechanism to stop the motor may be varied considerably, as it depends largely upon the amount of resistance B' in circuit, and also upon the construction of the brake magnet itself. For this reason the resistance B' is so arranged that more or less of it may be connected in circuit, and this adjustable feature is indicated on the drawing in the usual manner.

As soon as the switch S is brought back to center, the circuit to the winding 48 of magnet switch K, which is connected in series with the reversing switch magnets 18, 18', is broken and the contacts 49 are electrically connected together. This connection closes a circuit from the armature brushes to the winding 51 of the load magnet L, including the resistance 50 in series therewith. This circuit may be traced from the brush 20, through contacts 16', 14' and 14, wire 60, contacts 49 of switch K, resistance 50, winding 51, wire 59, contacts 12, 13, 12', 13', 15', 17', winding 19', and to the brush 21. The winding 51 of the load magnet L in series with the resistance 50 is thus connected directly across the motor brushes and is therefore subjected to the varying potential of the armature. The load magnet L having its winding 51 energized by virtue of its connection across the motor armature, will close more or less of its contacts to short-circuit the resistance J in series with the extra field G according to the counter-electro-motive force of the armature. Since this counter-electro-motive force will depend upon the speed and load upon the car or carrier, the amount of resistance J automatically cut out of the extra field circuit by the magnet L will also depend upon the speed and load on the car. Thus it follows that the reduction in speed of the motor armature, due to the dynamic brake action produced by the extra field G, will be proportional to the speed and load on the car. At about this time the brake magnet B has become sufficiently deenergized to allow the brake apparatus to be gradually applied and the motor and connected car or carrier come gently to rest.

The operation just described is the normal operation when the car is started and stopped by the manipulation of the switch S, such operation taking place at any position of the car between the upper and lower normal limits.

In order to illustrate the operation of stopping by means of the automatic stop switches 1, 2, 3, 4, 5, etc., we will assume

that the switch S is maintained in its extreme right-hand position with the motor running at full speed, the shunt field alone being excited. As the car approaches at full speed the upper limit of its travel, the cam C carried by the car will first engage and open the automatic stop switch 1. Since this switch includes the circuit to the magnet switch F, the latter will become deenergized, thereby opening its contacts and energizing the extra field G. This operation is the same in effect as when the switch segment 6 was moved away from the contact 9 by manual means, as before described; that is, the starting resistance and series field are cut into circuit and the extra field, having in series with it the resistance J, is connected across the armature brushes. The speed of the motor is thus reduced. The next operation is when the cam carried by the upwardly traveling car engages and opens the automatic stop switch 2. The opening of this switch 2 opens the parallel circuit to the brake magnet B which includes the resistance B'. This operation does not at the present time produce any effect on the existing speed conditions, it being merely a preparatory operation. The automatic stop switch 3 is next engaged and in this case the contacts of this switch will be closed, thereby closing a circuit to the winding 51 of the load magnet L connected across the armature brushes. This circuit may be traced from the wire 59 which is connected through the contacts of the reversing switch R' to the armature brush 21 as before pointed out, through the winding 51, automatic stop switch 3, wire 60, through the contacts 14, 14', 16', to the armature brush 20. The winding 51 is thus connected directly across the armature brushes, the resistance 50 and contacts 49 of the switch K being left out of circuit.

When the automatic switch 3 is operated, the speed of the motor and its counter-electro-motive force have been reduced and the winding 51 of the load magnet is therefore subjected to a reduced potential. When the load magnet is brought into operation by operating the switch S with the car in an intermediate position, this magnet will in most cases be subjected to substantially the full line potential, since the operator will usually center the operating switch S rapidly to stop the car, allowing little or no time for a reduction in motor speed before the load magnet circuit is completed. Consequently, if the resistance in the load magnet circuit remains constant, the dynamic brake retardation will always be at a maximum, which is not desirable at intermediate stops as produced by the operator, since these stops should be gentle. It is desirable, however, to have the dynamic retardation at a maximum when the stop is

produced automatically at the limits of car travel, and in order to effect this distinction between intermediate stops and automatic stops I vary the resistance of the circuits including the winding 51 of the load magnet L.

It sometimes happens that shortly after the motor has been reduced in speed by the action of the automatic stop switches preparatory to stopping, the load conditions on the motor are altered. This change of load may be caused by additional friction or by reason of the counterbalance weight having bottomed, or by other causes which tend to vary the load on the motor. In some cases, such as double cage ammunition hoists, the final stop position of the upper carrier may be varied to correspond to the different elevations of the gun. If, under the above conditions, the dynamic brake remains active to the full extent for which it has been adjusted to operate while the car was running under normal conditions of load, any variation in load at this time would tend to place an additional duty on the motor which it could not properly perform with the full dynamic braking power, and consequently the final stop position would not be correct. It is with special reference to the above conditions that the load magnet L is arranged to open more or less of its contacts and thus reinsert in the extra field circuit the sectional resistance J or a portion thereof, depending upon the reduction in potential of the motor armature as the latter slows down, thereby increasing the power of the motor again in proportion to the existing load conditions so that when the friction brake is finally applied to stop the motor the car will automatically come to rest exactly at the required landing. In this manner the load magnet L automatically controls the sectional resistance J for all variations of speed and load, either cutting out or reinserting the proper amount of resistance in series with the extra field winding and always short-circuiting or open-circuiting the different resistance sections in predetermined order or sequence as before described.

While the load magnet L may be constructed substantially like the accelerating magnet A, that is, a single winding operating any desired number of contacts to cut out or short-circuit a sectional resistance, there is this distinction: The magnet A is arranged as before described to close a series of contacts in a predetermined order or sequence of operation; the magnet L is so arranged that it not only closes its contacts in a predetermined order, but also causes them to open again in a predetermined order as well. This operation may be brought about in any one of several ways. As illustrated on the diagram, a series of movable contacts,

such as 41', 42', 43', form the armatures for the stationary contacts or pole pieces 41, 42, 43 of the load magnet L. Graduated springs 44, 45 and 46 surrounding the stems carried by the movable contacts hold the latter normally up against a stationary supporting piece 47. When the magnet coil 51 is excited, the weakest spring 44 permits the contact 41' to be pulled down into engagement with the contact 41 first, thereby short-circuiting a section of the resistance J. The contact 42' is next pulled down to short-circuit another section of the resistance, and finally the contact 43' will be operated against the upward pressure of the strongest spring 46, and thereby short-circuit another section of the resistance, leaving only a small portion of the resistance J in the circuit. It will be understood that the current through the magnet coil 51 may at times be strong enough to operate only a portion of the movable contacts, and also that the number of contacts and sections of resistance controlled thereby may be varied to obtain any desired degree of refinement in operation. Should the strength of load magnet L be reduced, part or all of the movable contacts will be operated to open position in the inverse order of their initial operation, the strength of the springs determining the order in which they will overcome the weakened pull of the magnet and lift their contacts. The amount of resistance J short-circuited is therefore varied in accordance with the variations in the strength of the load magnet L.

While I consider the above method of varying the resistance J an important feature of the invention, I wish not to be limited to the precise construction of the load magnet L as just described, as I am well aware that there are many other ways in which the desired results could be accomplished. The present construction as shown and described is merely illustrative of a simple way in which the desired operation may be obtained. The multiple magnets A and L could be replaced by a series of separate magnets suitably connected and arranged to operate a series of contacts, and by varying the windings of these magnets or their magnetic circuits similar results could be obtained. As the car continues to move upwardly at reduced speed, the cam C next engages the automatic stop switch 4 whose normally closed contacts include the winding 18 of the reversing switch R. These contacts are now opened, thereby breaking the circuit to the reversing switch magnet 18 which becomes deenergized and allows the contacts 10, 12 and 11, 13, respectively, to separate, thereby cutting off the current supply to the motor and brake magnet B. Since the parallel circuit to the brake magnet including the resistance B' has already been open-cir-

cued by the automatic stop switch 2, the brake magnet will become deenergized substantially instantaneously and the brake will therefore be at once applied with full power to stop the motor.

From the foregoing it is readily seen that the brake is applied rapidly when the car is stopped automatically at either of the limits of its travel, while the application of the brake at all other positions of the car is more gradual with a corresponding gentle stop of the car.

Should the car for any reason continue to move upwardly after the automatic stop switch 4 has been opened, the switch 5 will be engaged by the cam and have its contacts opened, thereby interrupting the circuit to the potential switch P, causing the latter to drop its core and connected contacts, thereby disconnecting the entire system from the source of electrical supply and at the same time connecting the extra field G through the contacts 39 directly across the motor armature, the dynamic braking action being at its maximum. The stop switch 5 is only opened in case of emergency, as when the other switches 1, 2, 3 and 4 refuse to perform their proper functions, and, under ordinary conditions, it is never brought into operation, the operation of the switch 4 being all that is necessary to stop the car automatically at the proper position. The operation of the emergency switch T or the slack cable switch I at any point of the car travel opens the circuit of the potential switch magnet 33 and stops the car with maximum dynamic braking power, and in some cases I contemplate including the emergency switch T and slack cable switch I in the circuit through the automatic stop switches 2 and 2' so as to have the friction brake applied instantaneously with maximum power, as well as the dynamic brake action.

The operation of the entire system when the car is descending is similar to its operation when the car is ascending. In the former case the manually operated switch S is moved to the left, thereby energizing the reversing switch R' which operates to start the motor in an opposite direction corresponding to a descending car. As the car approaches its lower limit of travel the counterweight, or rather the cam W carried thereon, operates the automatic stop switches 1', 2', 3', 4' and 5' in succession to slow down and finally stop the car at the desired lower limit of its travel in a manner similar to that before described in connection with an upwardly moving car.

From the foregoing description it is readily seen that the desired distinction or refinement between the manually effected stop and the automatic stop at limits is ac-

complished in a simple and effective manner without the use of a complicated system of electrical circuits or mechanical devices which are liable to disarrangement and uncertain operation at critical moments.

While the principles involved in my invention are clearly set forth in this application for Letters Patent, and the illustration accompanying the same shows a preferred arrangement of electrical circuits and apparatus embodying my invention, the same admits of wide variation in the construction and arrangement of parts and of electrical circuits without departing from the spirit and scope of my invention as herein set forth, and I desire not to be limited to the precise arrangement of parts as here shown.

What I claim as new and desire to secure by Letters Patent of the United States is:—

1. In a controlling system, the combination with an electric motor, of retarding mechanism therefor, automatic means for effecting the operation of said mechanism, and manually controlled means for effecting the operation of said mechanism with a different degree of power.

2. In a controlling system, the combination with an electric motor, of a retarding device therefor, automatic and manual means for effecting the operation of said device, and means for reducing the operative power of said device when controlled manually.

3. In a system of motor control, the combination of an electric motor, resistance in a circuit in parallel to the motor, an electroresponsive device for varying said resistance, and a plurality of means for effecting the operation of said device to an extent depending on which of said means is operated.

4. In a system of motor control, the combination with an electric motor, of resistance in a circuit in parallel to the motor, electromagnetic apparatus for varying said resistance, a plurality of circuits for said apparatus, and means for impeding the current in one of said circuits and thereby controlling the extent of operation of said electromagnetic apparatus.

5. In a system of motor control, the combination with an electric motor, of resistance in a circuit of the motor, an electro-responsive device for effecting a variation in said resistance, a plurality of circuits for said electro-responsive device each arranged to receive current proportional to the voltage of the motor armature, resistance in one of said last-named circuits, and devices for opening and closing the circuits.

6. In a system of motor control, the combination with an electric motor, of a sectional

resistance in a circuit of the motor, an electro-magnetic device for short-circuiting one or more sections of the resistance, a plurality of circuits for said electro-magnetic device each adapted to receive current proportional to the voltage at the terminals of the motor armature, means for reducing the current strength in one of said last-named circuits below that of the other for a predetermined voltage of the motor armature, and devices for opening and closing the circuits.

7. In a system of motor control, the combination with an electric motor, of a dynamic brake circuit, including resistance means for effecting a variation in said resistance substantially proportional to the speed of the motor, and a second means for effecting a different variation in said resistance also substantially proportional to the speed of the motor.

8. In a system of motor control, the combination with an electric motor, of a dynamic brake circuit therefor, resistance in said circuit, automatic means for reducing the resistance to amounts varying inversely with the speed of the motor, and manual means for effecting a similar reduction of the resistance but to a different extent for any given speed of the motor.

9. In a system of motor control, the combination with an electric motor, of a dynamic brake circuit therefor, sectional resistance in said circuit, an electromagnet, switches controlled thereby for successively short-circuiting sections of said resistance, a plurality of circuits for the electromagnet, a switch in each of said last-named circuits, automatic means for opening and closing one of said switches, a manual device for effecting the opening and closing of the other switch, and a resistance in the manually controlled circuit.

10. In a system of motor control, the combination with a motor, of an electro-dynamic brake therefor, mechanism for varying the power of said brake as the speed of the motor varies, automatic means for bringing said mechanism into operation, manual means for bringing said mechanism into operation, and a device for rendering said mechanism less effective when controlled by the manual means.

11. In a system of motor control, the combination with an electric motor, of a dynamic brake circuit including resistance in parallel to the armature of the motor, and automatic means for increasing and decreasing said resistance substantially in in-

verse proportion to increase and decrease in the speed of the motor.

12. In a system of motor control, the combination with an electric motor, of a sectional resistance in a dynamic circuit across the motor armature, a plurality of switches controlling short circuits across sections of the resistance, and means for opening and closing said switches in a predetermined order and at predetermined speeds of the motor and thereby maintaining a short circuit across an amount of said resistance varying directly as the speed of the motor.

13. In a system of motor control, the combination with an electric motor, of a sectional resistance in a dynamic circuit of the motor, a plurality of switches controlling short circuits across sections of the resistance, and a device for opening and closing one or more of said switches in unison with fluctuations in the speed of the motor and thereby increasing the resistance in said circuit as the speed is reduced and reducing the resistance when the speed is increased.

14. In a system of motor control, the combination with an electric motor, of an electro-dynamic brake circuit connected across the armature and normally open when the motor is running, sectional resistance in said circuit, means for closing the dynamic circuit, and mechanism for short-circuiting a number of sections of resistance proportional to the speed of the motor and again introducing said sections of resistance successively as the speed of the motor falls below predetermined limits.

15. In electrical controlling mechanism, the combination with an electric motor, of an electromagnetic brake coil, a resistance in a circuit in parallel therewith, circuits and connections for supplying current to said parts, a series of switches, means for successively operating said switches at a predetermined period in the operation of the motor, means controlled by the first switch for effecting a reduction in the speed of the motor, a succeeding switch of the series effecting the opening of the resistance circuit, and means controlled by a third switch of the series for cutting off the supply of current to the motor and brake coil.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN D. IHLDER.

Witnesses:

C. BLINN,
JOHN R. EVERS.