No. 793,768. PATENTED JULY 4, 1905.

E. R. CARICHOFF.

MOTOR CONTROL.

APPLICATION FILED DEC. 8, 1903.

2 SHEETS—SHEET 1.

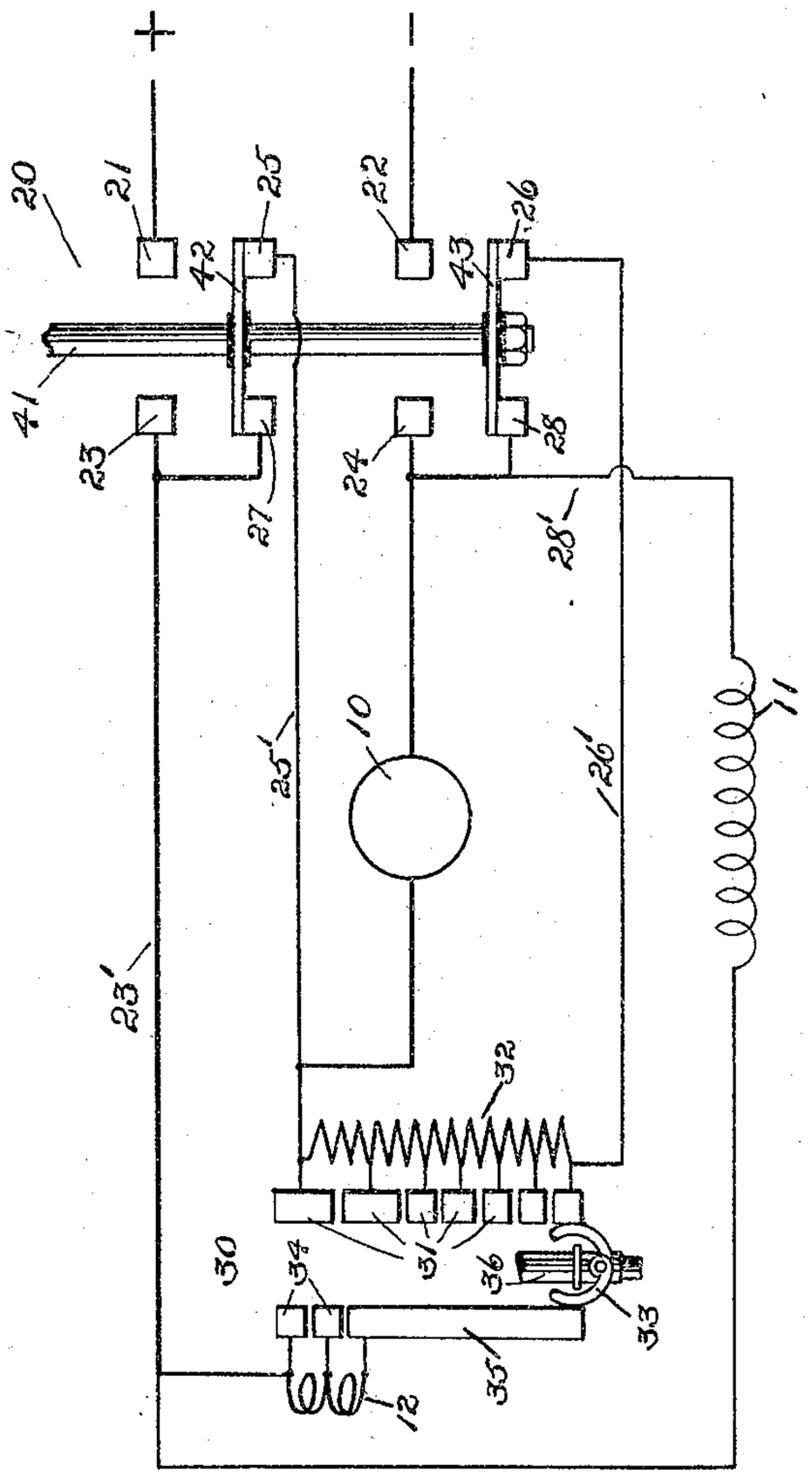

Fig. 1

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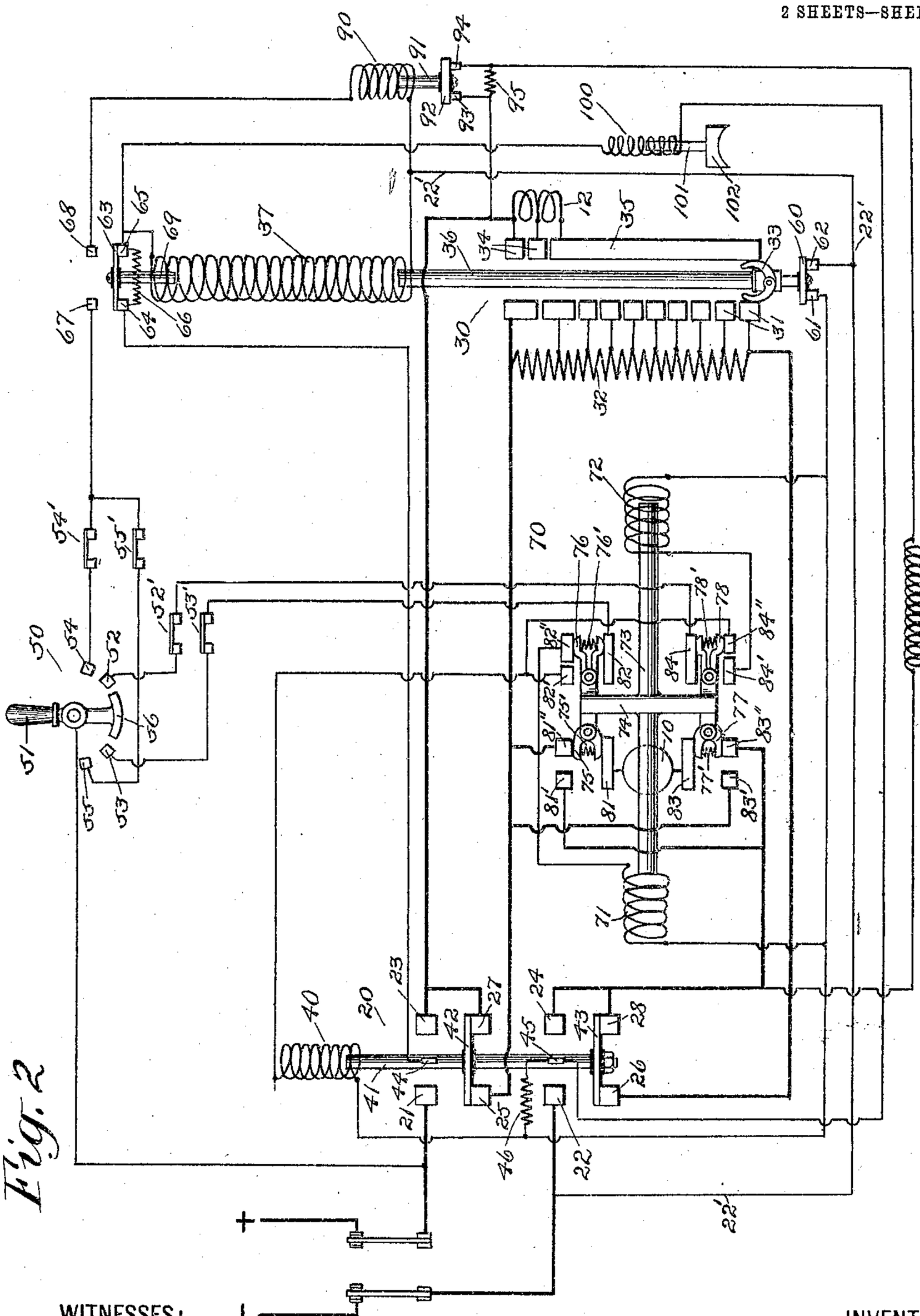

Fig. 2

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UNITED STATES PATENT OFFICE.

EUGENE R. CARICHOFF, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO OTIS ELEVATOR COMPANY, OF EAST ORANGE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

MOTOR CONTROL.

SPECIFICATION forming part of Letters Patent No. 793,768, dated July 4, 1905.

Application filed December 8, 1903. Serial No. 184,258.

To all whom it may concern:

Be it known that I, EUGENE R. CARICHOFF, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented new and useful Improvements in Motor Control, of which the following is a specification.

My invention relates to a system of motor control; and it consists in the novel arrangement of apparatus and circuits fully explained in the following specification and specifically pointed out in claims.

Referring to the drawings, Figure 1 is a wiring diagram and parts of certain apparatus embodying my invention in a simple form. Fig. 2 is a more complete diagram showing my invention and including a reversing-switch and other apparatus.

Similar figures of reference indicate corresponding parts in both of the figures.

10 represents the motor-armature, and 11 the shunt-field, of the motor.

20 is a main-line or double-acting circuit-closing switch. Its contacts 21 and 22 are connected, respectively, to the positive and negative mains from a source of electrical supply indicated by + and —. The contact 23 of this main switch is connected to the series fields 12 of the motor, and the contact 24 is connected to the motor-armature. The contacts 27 and 28 are also connected to the series fields 12 and the motor-armature, respectively. The contact 25 is connected to the top of the starting resistance-coils 32 and to the armature, and the contact 26 is connected to the bottom of the starting resistance-coils 32.

30 is a device for automatically controlling the resistance in the armature-circuit and comprises stationary contacts 31, 34, and 35 and brushes 33, provided with means for moving the brushes over the contacts.

11 is the shunt-field of the motor and is connected to the contacts 23 and 24.

42 and 43 are movable contacts attached to the rod 41, but insulated from it. When these movable contacts 42 and 43 are down, they bridge the stationary contacts 25 27 and 26 28, respectively, and when they are raised by the rod 41 they bridge the stationary contacts 21 23 and 22 24, respectively.

So far this description applies to both figures. Referring now to Fig. 2, I will describe the additional features shown therein. 50 represents a manually-operated switch, in which 56 is a movable contact, which can be operated by the insulated handle 51 to make electrical contact with the stationary contact-points 52 and 54 or 53 and 55. 52′, 53′, 54′, and 55′ are cut-out switches the purpose of which will be shown later. The main-line switch has already been described. Fig. 2, however, shows the following additional features: the small contacts 44 and 45 and the coil 40. The small contacts 44 and 45 are adapted to be connected, respectively, to the positive and negative mains by the movable contacts 42 and 43 when the latter are in their raised positions. 40 is the coil of a solenoid, and the rod 41 is the core of this solenoid. When the coil 40 is energized by an electric current passing through it, it will attract the rod 41 and raise it until the movable contacts 42 and 43 bridge the stationary contacts 21 23 22 24, as above described. The resistance-controlling device 30 has also been described; but Fig. 2 shows several additional features. 37 is the coil of a solenoid, and 36 is its core. The brushes 33 are attached to this core, and when the coil 37 is energized these brushes will be moved up over the stationary contacts 31, 34, and 35. It is usual to provide some retarding device for the core 36, so that its movement will not be too rapid—as, for example, by making the core a close fit in the spool of the solenoid and closing the end of the spool. This is not shown on the drawings, as it constitutes no part of the present invention and would only tend to complicate the drawings. The small stationary contacts 61 and 62 are placed under the resistance-controlling device and are connected by the bridging-piece 60, which is attached to the solenoid 36 when the latter is down, but are disconnected as soon as the core begins to rise. Above the resistance-controlling device 30 are

four small stationary contacts 64, 65, 67, and 68. The lower ones, 64 and 65, are connected by the resistance 66 and when the core 36 is down are connected by the bridging-piece 63. When the core 36 approaches the upper limit of its travel, it strikes the stem 69 of the bridging-piece 63 and raises it from the contacts 64 and 65 and pushes it up against the contacts 67 and 68, thus connecting them electrically. 70 is a reversing-switch of novel arrangement. 71 and 72 are solenoid-coils for drawing the core 73 to the left or right. The core 73 carries a cross-arm 74, to which are attached brushes 75 76 77 78. These brushes are each made in two parts pivoted, as shown, and pushed apart by the springs 75′, 76′, 77′, and 78′. These brushes bear against and are in electrical contact with stationary contact-pieces 81, 82, 83, 84, 81′, 81″, 82′, 82″, 83′, 83″, 84′, and 84″. 90 is a solenoid-coil arranged when it is energized to lift a core 91 and a contact 92, which bridges the stationary contacts 93 and 94 when it is down. These contacts are also connected by a resistance 95. 100 is another solenoid arranged when energized to lift a core 101, to which is attached a brake-shoe 102, which is adapted and arranged to coact with the motor-armature to stop the latter rotating when the brake-shoe is not raised by the solenoid 100. This brake arrangement is actually placed near the motor-armature, but in the diagram is shown where it is for the sake of simplifying the drawings.

Referring again to Fig. 1, I will trace the circuits and describe the operation of the parts shown therein. When the main-line switch is closed by the rod 41 being pulled up, two circuits are closed—one through the shunt-field and one through the series fields and armature. The shunt-field circuit is closed directly across the mains at the stationary contacts 21 and 23, which will now be bridged by the movable contact 42, and at the stationary contacts 26 and 28, bridged by the movable contact 43. The shunt-field 11 is directly connected to the contacts 23 and 28 by the conductors 23′ and 28′. I will now trace the armature-circuit. The positive main is connected from the stationary contact 21 through the movable contact 42 to 23. Thence the circuit goes through a conductor 32′ to the series fields 12, through them, and through the contact 35, brushes 33, and resistance-coils 32 to the left-hand side of the armature 10. The other side of the armature is connected to the stationary contact 24, which is now connected to the negative main by contacts 43 and 22. Thus the armature 10 is connected to the mains through the series fields 12 and the resistance-coils 32 and will begin to rotate. Now as the brushes 33 are moved up over the contacts 35, 31, and 34 the resistance-coils will be cut out of circuit step by step and so will the series fields, thus increasing the speed of the armature rotation, and when the brushes have reached the upper limit of their travel the armature will be connected directly across the main line and will have attained its full speed. This, then, is the operation for starting the motor. When it is desired to stop the motor, the rod 41 is dropped, and the movable contacts 42 43 now bridge the stationary contacts 25 27 and 26 28, respectively. The rotation of the armature will generate an electromotive force which will supply an energizing-current to the shunt-fields. The diagram shows that the right-hand side of the motor-armature 10 is now connected to the right-hand side of the shunt-field 11 by the conductor 28′ and that the left-hand side of the armature is connected to the left-hand side of the shunt-field by the conductor 25′, the contacts 25, 42, and 27, and the conductor 23′. At the same time another path for the armature-current is established through the resistance-coils 32, as the upper of these coils is connected to the left-hand side of the armature and the lower of these coils is to the right-hand side of the armature through the conductor 26′ and the contacts 26, 43, and 28. The left-hand side of the armature is also connected to the upper side of the series fields 12 by the conductor 25′, the contacts 25, 42, and 27, and the conductor 23′. The brushes 33 I have described as at the upper limit of their travel. While in this position all of the resistance-coils 32 are in series with the motor-armature when the movable contacts 42 43 of the main-line switch are down, so that the amount of current generated by the armature will be comparatively small. This will produce a braking effect and tend to stop the armature rotating. As the brushes 33 move downward the series fields are put into the armature-circuit and the resistance-coils 32 short-circuited through the series fields step by step. This will have a tendency to increase the current which is being generated by the armature, and thus increase its braking effect. When the brushes 33 have reached the lower limit of their travel, all the resistance-coils 32 have been short-circuited, and the armature itself is short-circuited through the series fields alone. While this short-circuiting of the resistance-coils is taking place the armature is slowing down and so generating less and less electromotive force until it comes to rest. In this way an easy and gradual stopping of the motor is accomplished, using for this purpose the same resistances and the same apparatus which was used for starting the motor. From this operation it is apparent that the circuit of the shunt-field is not broken abruptly; but its current-supply is kept up by the rotation of the armature and gradually dies down as the armature slows down. In this way the high disruptive discharge, which is usually present when the circuit of a shunt-field of a motor is broken, is obviated. The current generated by the rotation of the motor-arma-

ture will flow in the same direction through the shunt and series fields as it did when they received their current from the line.

I will now describe the function and operation of the additional features shown in Fig. 2. The reversing-switch 70 is of novel construction. It is a magnetic reversing-switch, but is so arranged that its operating-current is used but momentarily and is then cut off automatically. The core 73 is placed in a horizontal position, so that after it has been drawn to one side or the other by the solenoid-coils 71 or 72 it has no tendency to move until it is drawn to the opposite side by the other solenoid-coil. As shown in Fig. 2, it has been drawn over to the right. If it is desired to move it over to the left, the movable contact 56 of the manually-operated switch 50 is brought into contact with contact-point 53. The positive main is directly connected to this movable contact 56, and now a circuit will be established through contact-point 53, cut-out switch 53′, stationary contact-piece 82, brushes 76, contact-piece 82″, solenoid-coil 71, contacts 61, 60, and 62 to the negative main. This will cause the solenoid-coil 71 to be energized, and it will draw the core 73 and the brushes 75, 76, 77, and 78 over to the left. As soon as the brushes 76 have moved off from contact 82″ the circuit through solenoid-coil 71 will be broken; but at the same time the brushes will establish another circuit through contact 82′ through solenoid-coil 40 of the main-line switch, for this solenoid-coil 40 is connected to the contact 82′ and to the negative main through contacts 61, 60, and 62. A current will then flow through the solenoid 40, which will attract its core 41 and raise the main-line switch. When this has been done, another path for the current from the positive main through solenoid 40 has been established through the resistance 46 and the small contact 45 to the negative main by the movable contact 43. The main-line switch may be dropped by bringing the movable contact back to the center or by opening the cut-out switch 53′. The raising and lowering of the main-line switch 20 starts or stops the motor, as has been described. The motor may be started, stopped, and started again in the same direction indefinitely without moving the reversing-switch 70; but if it is desired to start the motor rotating in the opposite direction the movable contact 56 is brought into contact with 52, and a circuit is thereby established through cut-out switch 52′, contact 84, brush 78, contact 84′, solenoid-coil 72, contacts 61, 60, and 62 to the negative main. This will cause the core 73 and its connected brushes to move to the right, and this movement in turn will cause the circuit through the solenoid-coil 72 to be broken and another circuit through solenoid-coil 40 to be established in a manner similar to that already described. The operation of the main-line switch in starting and stopping the motor was described in connection with Fig. 1. It is the same in this case, only now the positive main after passing through the resistance-controlling device 30 is connected to contacts 81″ and 83′, and the negative main is connected to contacts 83″ and 81′. If the reversing-switch is in its right-hand position, its brushes 75 connect the positive main at 81′ to contact 81, and thus to the upper side of the armature, and its brushes 77 connect the negative main at 83″ to contact 83, and thus to the lower side of the armature. This will cause the latter to rotate in one direction. If the reversing-switch is in its left-hand position, its brushes 77 connect the positive main at 83′ to contact 83, and thus to the lower side of the armature, and its brushes 75 connect the negative main at 81′ to contact 81, and thus to the upper side of the armature. This will cause the latter to rotate in the opposite direction. When the main-line switch 20 is raised, it causes the small contact 44 to be connected to the positive main through the movable contact 42. This small contact 44 is connected to the solenoid-coil 37 through the contacts 64, 63, and 65. The other side of the solenoid-coil 37 is connected to the negative main by the conductor 22′. Thus the solenoid-coil 37 will become energized whenever the main-line switch is raised. This will attract the core 36 and cause the upward movement of the brushes 33. In addition to the operation of this resistance-controlling device 30, already described, it will raise the bridging-piece 60 from the contacts 61 and 62, and so break one of the paths of the current through solenoid-coil 40. The other path for this current through the resistance 46 remains so that the solenoid continues to get current, but it is reduced by the resistance 46. This is a desirable feature, as less current is required to maintain the main-line switch in its raised position than is required to raise it in the first place. If the main-line switch 20 is dropped while the contacts 61 and 62 are disconnected, it cannot be raised again until these contacts 61 and 62 are connected, because the path of the circuit from the car-switch to the solenoid-coil 40 must pass from 61 to 62 through the bridging-piece 60. This insures the resistance-coils 32 all being in the armature-circuit when the latter is closed. When the core 36 nears the upper limit of its travel, it engages the stem 69 of the bridging-piece 63, lifts it from the contacts 64 and 65, and pushes it up against the contacts 67 and 68. When the contact between 64 and 65 is thus broken, the current no longer passes directly from the positive main to the solenoid-coil 37, but it will flow to solenoid-coil 37 through the resistance 66. This will reduce it in amount; but, as explained in the case of solenoid 40, less current is needed to hold the core up than was required to pull it up. The circuit to the brake solenoid-coil 100 is closed at 44 and 45

when the main-line switch is raised. This circuit also passes through the contacts 64 65 and their bridging-piece 63 when the latter is down or through the resistance 64 when it is up. This solenoid-coil 100 lifts its core 101 and releases the brake-shoe 102, which, as has been explained, is adapted and arranged to coact with the motor-armature. This brake is not necessary with this system of motor control; but it may be used, if desired, and if it is used it may be connected in the way just described. The device shown at 90-95 is a high-speed arrangement. It comprises a solenoid-coil 90 so arranged that when not energized it is down and short-circuits a resistance 95. The shunt field-circuit passes through this contact 92 when it is down; but when it is raised the resistance 95 is inserted into the shunt field-circuit, thus weakening it and causing the motor to run faster. The circuit through the solenoid-coil 90 is completed by moving the movable contact 56 of the manually-operated switch onto contact-points 54 or 55, provided the cut-out switches 54′ and 55′ are closed and the contacts 67 and 68 are bridged by the bridging-piece 63. This only occurs when the core 36 is at the upper limit of its travel, so that it is not possible to speed the motor by weakening its shunt-field until all the resistance-coils and the series fields have been cut out of the armature-circuit. The resistance 95 may be again short-circuited whenever it is desired to run the motor slower again.

The double-acting circuit-closer above described has no intermediate position. When it is raised, power is applied to the motor. When it is down, it has a braking effect upon the motor. This makes it particularly adaptable to elevator service, as the usual arrangements for elevators always have the power on or the brake on the motor. This system is also particularly adaptable to elevator service on account of its simplicity and the easy and gradual stop and start which it gives to the motor. When it is used for this or similar purposes, the automatic cut-out switches 52′, 53′, 54′, and 55′ may be provided. These are operated by the motor when it has run a predetermined number of revolutions—as, for example, when it has driven an elevator-car to the ends of its travel. First, one of the cut-out switches 54′ or 55′ is opened. This will cause the solenoid 90 to be deënergized and will short-circuit the shunt-field resistance 95 and slow down the motor. Then 52′ or 53′ will be opened, which will cut off the current-supply from the solenoid-coil 40, cause the main-line switch to be dropped and the motor to stop. The direction of the rotation of the motor determines whether 54′ and 52′ or 55′ and 53′ will be operated, and whichever pair of cut-out switches is operated the other pair will remain closed, so that the operator may start up the motor in the opposite direction at will.

The construction of the apparatus itself forms no part of my invention. So I do not wish to confine myself to that here shown, for obviously I can use any of the various forms of electrical switches and other devices now in use which are adapted to make the connections and changes in the circuits above described.

What I claim as new, and desire to cover by Letters Patent, is—

1. In a motor-control system, the combination of a motor, a source of electrical supply, a resistance, a double-acting circuit-closer adapted when in one position to connect the motor to the source of electrical supply through the resistance, and when in another position to connect the motor to the resistance, and means for preventing the circuit-closer from connecting the motor to the electrical supply until the resistance is placed in the circuit.

2. In a motor-control system, the combination of a motor, a source of electrical supply, a resistance, a double-acting magnetically-operated circuit-closer adapted when in one position to connect the motor to the source of electrical supply through the resistance, and when in another position to connect the motor to the resistance, and means for preventing the circuit-closer from connecting the motor to the electrical supply until the resistance is placed in the circuit.

3. In a motor-control system the combination of a motor, having an armature and a series field, a variable resistance, a source of electrical supply, a double-acting circuit-closer adapted when in one position to connect the armature, the series field and the variable resistance to the source of electrical supply, and when in another position to connect the series field and variable resistance to the armature in such a way that the current generated by the rotation of the armature will flow through the series field in the same direction as it did when it was connected to the source of electrical supply.

4. In a motor-control system the combination of a motor, having an armature, a series field and a shunt-field, a variable resistance, a source of electrical supply, a double-acting circuit-closer adapted when in one position to connect the armature, the series field, the shunt-field and the variable resistance to the source of electrical supply, and when in another position to connect the series field, the shunt-field and variable resistance to the armature in such a way that the current generated by the rotation of the armature will flow through the series field and the shunt-field in the same direction as it did when it was connected to the source of electrical supply.

5. In a motor-control system, the combination of a motor, a source of electrical supply, a resistance, a double-acting magnetically-operated circuit-closer adapted when in one po-

sition to connect the motor to the source of electrical supply through the resistance, and when in another position to connect the motor to the resistance, a solenoid arranged to vary the resistance, means for preventing the circuit-closer from connecting the motor to the electrical supply until the resistance is placed in the circuit, and a manually-operated switch for controlling the system.

6. In a motor-control system the combination of a motor, a reversing-switch, an automatic resistance-varying device, a source of electrical supply, a double-acting, magnetically-operated circuit-closer adapted when in one position to connect the motor to the source of electrical supply through the reversing-switch and the resistance-varying device and when in another position to connect the motor to the resistance-varying device, and a manually-operated switch for controlling the system.

7. In a motor-control system the combination of a motor, a reversing-switch, an automatic resistance-varying device, a source of electrical supply, a double-acting, magnetically-operated circuit-closer adapted when in one position to connect the motor to the source of electrical supply through the reversing-switch and the resistance-varying device and when in another position to connect the motor to the resistance-varying device, a manually-operated switch for controlling the system and cut-out switches for stopping the motor after it has run a predetermined number of revolutions in either direction.

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

EUGENE R. CARICHOFF.

Witnesses:

WALTER C. STRONG,

ERNEST W. MARSHALL.