No. 772,277. PATENTED OCT. 11, 1904.

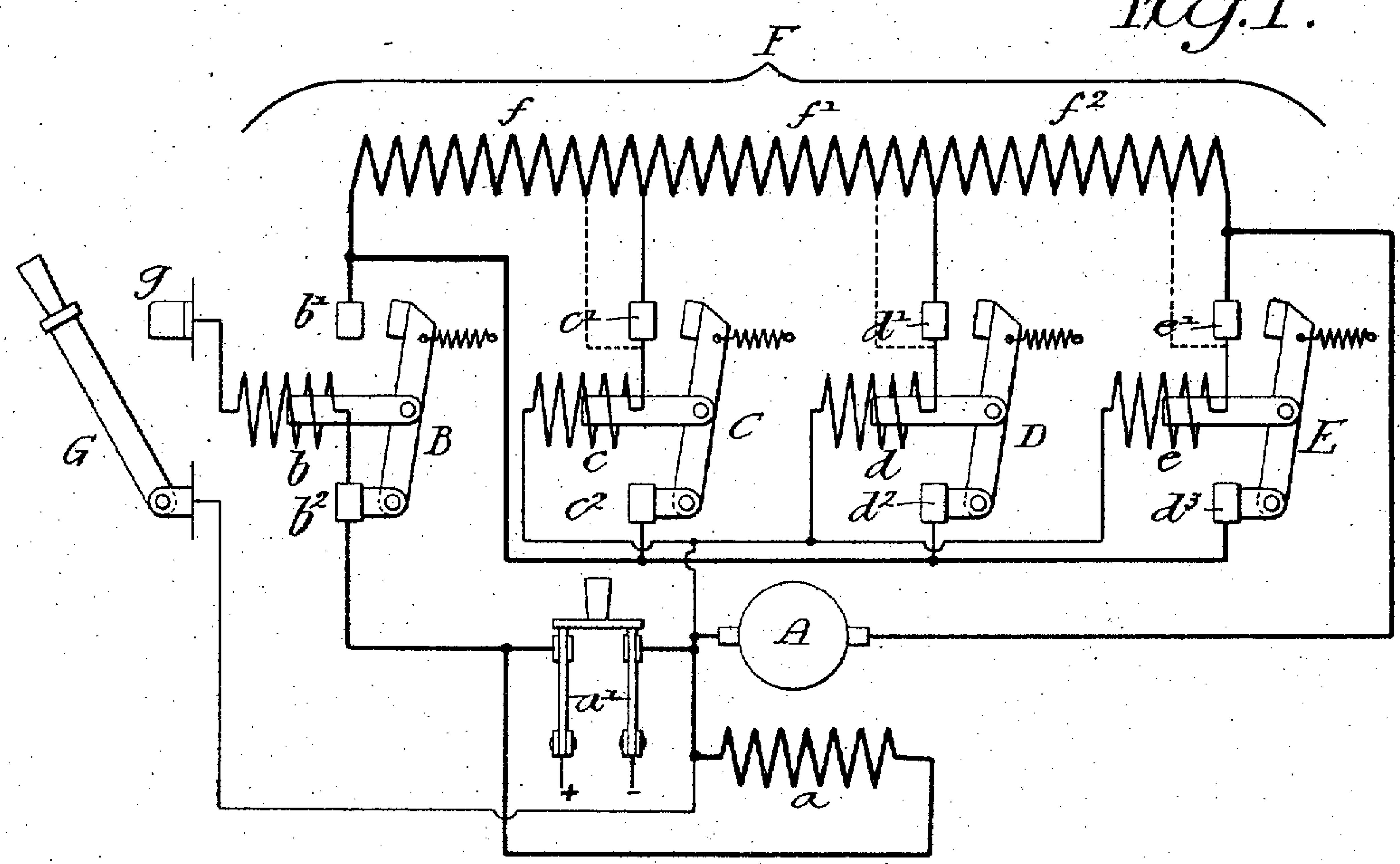
A. C. EASTWOOD.

CURRENT CONTROLLING SYSTEM.

APPLICATION FILED JUNE 4, 1904.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
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Titus H. Irons.

Inventor:
Arthur C. Eastwood,
by his Attorneys
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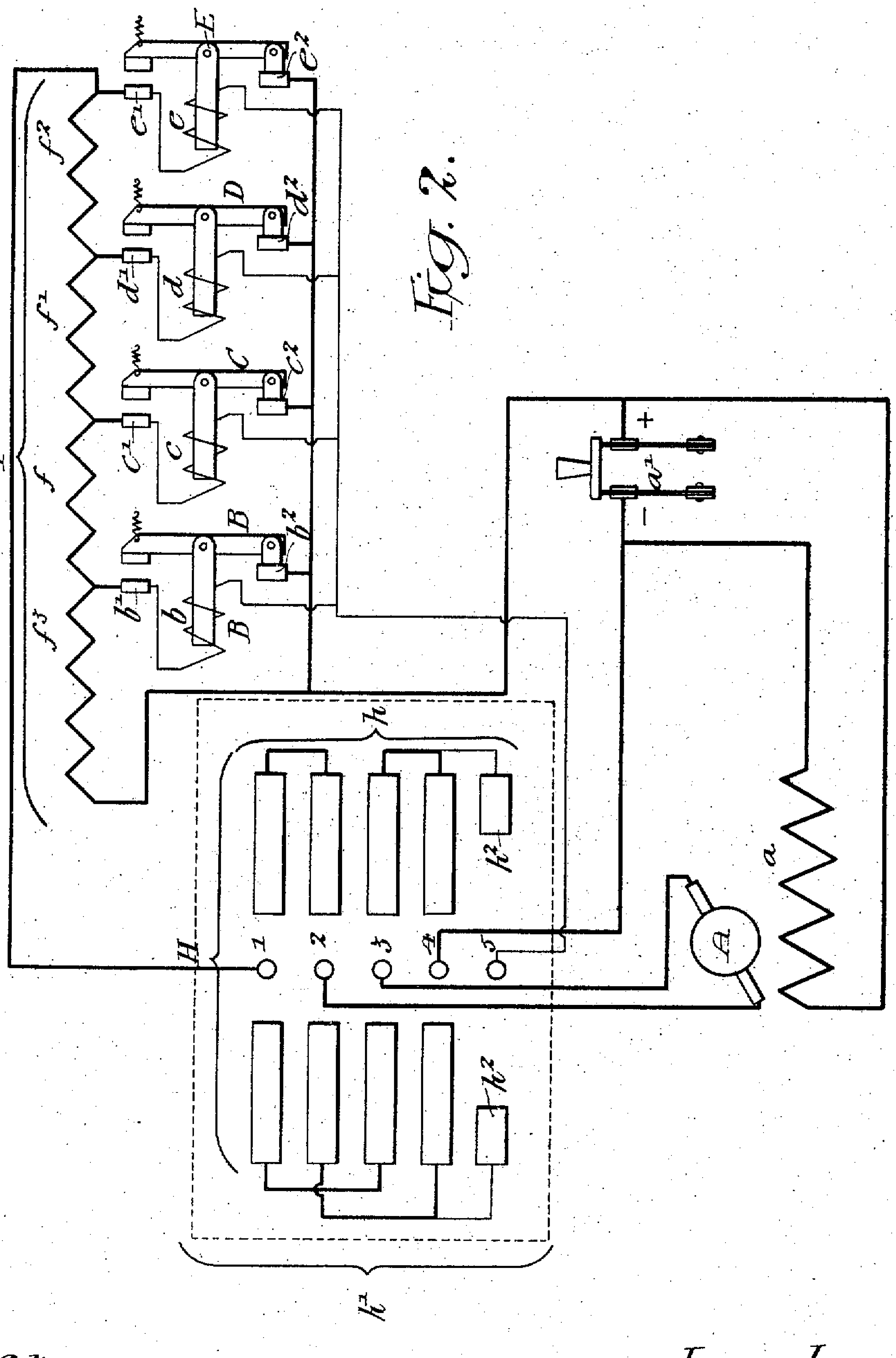

Fig. 2.

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No. 772,277. Patented October 11, 1904.

UNITED STATES PATENT OFFICE.

ARTHUR C. EASTWOOD, OF CLEVELAND, OHIO.

CURRENT-CONTROLLING SYSTEM.

SPECIFICATION forming part of Letters Patent No. 772,277, dated October 11, 1904.

Application filed June 4, 1904. Serial No. 211,210. (No model.)

To all whom it may concern:

Be it known that I, ARTHUR C. EASTWOOD, a citizen of the United States, residing in Cleveland, Ohio, have invented certain Improvements in Current-Controlling Systems, of which the following is a specification.

One object of my invention is to so connect the automatic switches for governing the operation of an electric motor that the same voltage shall be applied successively to their coils to cause said switches to operate.

An additional object of my improved system is to control the cutting of resistance into and out of circuit by automatic switches, all of substantially the same mechanical and electrical construction and adjustment.

I also desire to provide a system for controlling the flow of current to an electric motor by which it shall be possible to utilize a number of electromagnetic switches of substantially the same mechanical and electrical construction and adjustment to successively short-circuit banks of resistance in order to accelerate the speed of the motor, it being further desired to so arrange the apparatus that under operating conditions the same voltage shall be applied to the coils of the switches to cause their operation.

These objects I attain as hereinafter set forth, reference being had to the accompanying drawings, in which—

Figure 1 is a diagrammatic view illustrating the connections of a system including resistance and an electric motor arranged according to my invention, there being a single switch employed to start and operate the motor. Fig. 2 is a diagrammatic view illustrating the connections of an electric motor and the starting resistance for the same arranged in accordance with my invention, the whole being designed to be operated by a reversing-controller.

In the above drawings, A is the armature of a shunt-wound motor, whose field is indicated at *a* as being connected directly across the terminals of a double-pole main switch a'.

B, C, D, and E are respectively electromagnetic switches provided with means for normally retaining them in their open positions and having solenoids *b*, *c*, *d*, and *e*, all wound with the same number of turns of the same-sized wire and operative upon plungers connected to the blades of their respective switches.

F is a bank of resistance divided in three sections f, f', and f^2, connected to each other in series, as shown. The section f is connected at one end to the terminal b' of the switch B, while its opposite end is connected to the terminal c' of the switch C, to which is also connected one end of the section f', whose opposite end is in turn connected to the terminal d' of the switch D. Similarly the section f^2 has one end connected to the terminal d' of switch D and its opposite end connected to the terminal e' of the switch E.

The terminals c^2, d^2, and d^3 of the switches C, D, and E are all connected together and to the terminal b' of the switch B, whose terminal b^2 is connected to the positive side of the main switch a'. One of the armature-terminals is connected to the negative side of said main switch, while the second armature-terminal is connected to the wire joining the resistance-section f^2 with the switch-terminal e' of the switch E. One end of the coil *b* of switch B is connected to the terminal b^2 of said switch, while its opposite end is connected to the terminal *g* of a knife-switch G, whose second terminal is connected to the negative terminal of the main switch. One end of each of the coils *c*, *d*, and *e* is connected to the negative terminal of the main switch, while the opposite ends of said coils are respectively attached to those terminals of their respective switches which are permanently connected to the bank of resistance F.

Under operating conditions if it be assumed that the voltage of the supply-circuit is two hundred and ten and that the resistance of each of the sections f, f', and f^2 is .7 of an ohm then the total resistance of the bank F will be 2.1 ohms, so that when the switch B is closed, as by the closing of the main switch a' and the excitation of the coil *b* by the closing of the switch G, a current of one hundred amperes will flow to the armature A. If it be assumed, further, that the said armature is attached to a load which requires a current of ninety amperes to drive it, the above-noted current of one hundred amperes will start the armature, and as this accelerates the counter electromotive force generated will cause said current to fall to ninety amperes. Under these conditions the voltage applied to the coil c of switch C will be $210-(90\times.7)=147$ volts. If this switch be designed to operate at one hundred and forty-seven volts, it will now close, short-circuiting the section f of the resistance and practically transferring the positive side of the supply-circuit to the terminal c' of the switch C. By this means the motor is further accelerated, its counter electromotive force gradually rising until the current-flow has again been cut down to ninety amperes, at which time current at one hundred and forty-seven volts will be applied to the winding d of the switch D. Since it was originally assumed that this switch was mechanically and electrically similar to the other switches used, this latter will now close, cutting out the resistance f', and after the current has for the third time fallen to ninety amperes one hundred and forty-seven volts will be applied to the coil e of the switch E, causing it to operate to cut out the last section of the resistance f^2.

Hitherto in order to cause automatic acceleration of the motor one end of each of the various switch-coils has been connected to the negative side of the main switch a, while the opposite ends of these coils have been connected to the point of junction of one of the armature-terminals and the end of the resistance-terminals f^2. With such an arrangement the coils must be wound to close at different voltages. For example, one must close at an applied voltage of twenty-one, another at eighty-four volts, and another at one hundred and forty-seven volts. It will be evident that when the armature of the motor has reached full speed the coils of all the switches are subjected to the full line voltage of two hundred and ten. Since one coil, c^3, must close at an applied voltage of twenty-one and later be subject to current at a pressure of two hundred and ten volts after the motor is up to speed, the construction of said coil is rendered costly and its maintenance in good condition is apt to be difficult. The same is true of the other coils, which must operate their switches at relatively low voltages and later be subjected to the full line voltages.

With the arrangement of connections shown all of the coils are wound to operate on the same voltage, which is relatively nearly the same as that to which they are subjected after the operation of their switches. Consequently all of the switches may be uniform both as regards their adjustment and coils, and, moreover, with the connections shown in Fig. 1 it is possible to adjust the coils c, d, and e so that they will cause operation of their respective switches when the counter electromotive force of the armature has risen to any desired point. In order to do this, the ends of these coils which are shown as connected to the terminals c', d', and e' may be tapped onto the various resistance-sections, as indicated in dotted lines, so that the various switches will be operated before the current flowing has fallen to the ninety amperes, which was assumed as the current required to operate the motor. In any case the points of the connection between the ends of the various coils and the resistance can be so adjusted that all of the switches will operate when the same voltage is applied to their terminals.

In Fig. 2 I have illustrated my system of control as used in connection with a reversing-controller H. In this figure the barrel of the controller is illustrated as developed, there being upon it two sets of segments h and h', connected in the well-known manner. In addition there are five contact-fingers 1, 2, 3, 4, and 5, of which finger 5 serves the same function as the switch G in Fig. 1. The two segments h^2 on the controller-barrel which are placed to engage this finger are shorter in length than the remainder of the segments, so that the fingers 1 to 4, inclusive, are in engagement with their respective segments before the finger 5 engages the segments h^2. By this means the armature connections of the motor are properly reversed to operate said motor in either direction before current is supplied to the coil of the switch B to permit current to actually flow to said armature and current is cut off from the various coils of the automatic switches, so as to cause their opening before any connections are broken at the fingers 1 to 4, inclusive. It will be further noted that in the form of my invention shown in Fig. 2 I provide a shunt for the switch B, including a body of resistance f^3, which in practice is substantially equal in amount to the total resistance of the sections f, f', and f^2. If when the motor is operating with such an arrangement of connections and with the fingers of the controller H in engagement with the segments h the barrel of said controller is turned so that the said fingers are brought into engagement with the segments h', a current of almost double the normal voltage will be applied to the motor—that is to say, if current from the supply-mains be at a voltage of two hundred and ten upon the sudden reversal of the motor the voltage available to force current through the armature will be two hundred and ten plus the counter electromotive force of the motor, or almost four hundred volts. It will be noted, however, that as the barrel of the controller H is moved from one position to another, as above noted, all of the switches are permitted to open, so that when the segments h' are brought into engagement with the controller-fingers the circuit is completed through all of the resistance in the bank F', which resistance, as above noted, is substantially double that in circuit when the motor is started with current at normal voltage. With such a condition the current forced through the motor by the high voltage will be substantially equal to that ordinarily flowing when the motor is started from rest, and when the armature has finally come to rest and started to turn in a reverse direction the counter electromotive force of the motor begins to act against the current from the mains. When the voltage applied to the coil of the switch B is substantially equal to the voltage existing between the supply-mains, said switch will close and cut out the section of resistance f^3, after which the operation of the system would continue as described. From the above it will be seen that by the use of the extra section of resistance proportioned and connected as described all danger of burning out or straining the motor by sudden or oft-repeated reversals is avoided. In addition it is possible to accomplish the reversal of the motor in a much shorter time than has hitherto been considered practicable.

I claim as my invention—

1. A current-controlling system including a motor, a bank of resistance and a plurality of electromagnetic switches for cutting out portions of said resistance, the coils of the switches being connected so that the voltage of the current applied to them depends on the counter electromotive force of the motor, current at the same voltage being successively applied to operate each of the said coils as the motor is accelerated, substantially as described.

2. A current-controlling system including a motor, a bank of resistance, a series of electromagnetic switches for short-circuiting portions of said resistance and means for energizing, at will, the coil of one of the switches, the coils of the other switches being connected to various points of the resistance so as to have the same voltage successively applied to them to cause their automatic operation, the connections of said coils being such that the time of operation of the switches depends upon the counter electromotive force of the motor, substantially as described.

3. A current-controlling system including a bank of resistance, a motor in series therewith, with a number of automatic switches placed to short-circuit parts of said resistance, the coils of said switches being of substantially equal resistance and being connected to various points of the resistance so that they operate automatically to accelerate the motor after current is once applied thereto, their time of operation depending on the counter electromotive force of the motor, substantially as described.

4. A current-controlling system including a motor, a bank of resistance, and electromagnetic switches for controlling the amount of said resistance in circuit with said motor, the coils of said switches each having one end connected between a motor-terminal and a supply-main and their second ends respectively connected to different points of the bank of resistance, substantially as described.

5. A current-controlling system including a motor having in series with it a bank of resistance and switches each having one terminal connected to a supply-main and their second terminals respectively connected to different points of the resistance, with coils for operating said switches, said coils being connected at one end to different points of the resistance and having their second ends connected to one of the motor-terminals, substantially as described.

6. A current-controlling system including a bank of resistance with a shunt thereto, a series of electromagnetic switches respectively having one terminal connected to some point of the resistance and the other terminal connected to the shunt, with a current-actuated device having one terminal connected to the resistance, the coils of said switches each having one end connected to the second terminal of said device and their opposite ends respectively connected to different points of the resistance, substantially as described.

7. A current-controlling system including a bank of resistance having one end connected to a supply-main, a motor connected to the second end of said resistance and to a second supply-main, a series of switches each having one terminal connected to the first supply-main and their second terminals respectively connected to different points of the resistance, with coils for actuating the switches, each coil having one end connected to the resistance-terminal of its switch and its second end connected to the second supply-main, substantially as described.

8. A current-controlling system including a controller, a motor, a bank of resistance, switches for controlling the amount of said resistance in circuit, coils for operating said switches and a contact on the controller connected to one end of all the coils, the opposite ends of said coils being connected to different points of the resistance, substantially as described.

9. A current-controlling system including a controller, a motor, a bank of resistance, switches for controlling the amount of resistance in circuit, and coils for operating said switches, one set of the ends of the coils being connected to different points on the resistance and the other set of ends of the coils being connected to a finger on the controller, the segment or segments for said finger being placed to engage the same after the other segments have engaged their respective fingers, substantially as described.

10. A current-controlling system including a motor, a reversing-controller therefor, a bank of resistance, and a series of electro-

magnetic switches connected to cut out sections of said resistance, the coils of said switches being connected to have the same voltage successively applied to operate each of them as the motor is accelerated, substantially as described.

11. A current-controlling system including a motor, means for reversing the same, a series of sections of resistance of which the first is substantially equal to the sum of the other sections and a series of electromagnetic switches connected to short-circuit said sections, the coils of said switches being connected so that they will operate automatically and successively, substantially as described.

12. A current-controlling system including a motor, means for reversing the same, means for controlling the flow of current to the motor, including a bank of resistance composed of a number of sections, and a series of automatic switches connected to short-circuit said resistance, the coils of the switches being connected so that the same voltage is applied to them in succession when current is supplied to the motor, and the section of resistance first cut out when the motor is accelerated being substantially one-half of the total resistance, substantially as described.

13. A current-controlling system including a current-actuated device, a bank of resistance and a plurality of automatic switches for varying the amount of said resistance in circuit with said device, the windings of the switches being connected to different points of the resistance so that the voltage of the current applied to them depends on the amount of current flowing through the resistance, current at the same voltage being successively applied to operate certain of the said windings as the device is set in operation, substantially as described.

14. The combination of a motor, a body of resistance and a switch or switches connected to cut said resistance in and out of circuit with the motor, with means for operating a switch to cut out a portion of said resistance as the electromotive force of the motor acting temporarily as a generator, falls, substantially as described.

15. The combination of a motor, a body of resistance and an electromagnetic switch connected to short-circuit said resistance, said switch being constructed to operate as the electromotive force of the motor acting temporarily as a generator, falls, substantially as described.

16. The combination of a motor, a body of resistance, a series of automatic switches for cutting said resistance into and out of circuit with the motor and means for reversing the motor, the operating mechanism of the switches being arranged to cut out a portion of the resistance between the time when the motor connections are reversed and the time when the armature reverses its direction of rotation, substantially as described.

17. The combination of a motor, a body of resistance, a series of electromagnetic switches for short-circuiting successive portions of the resistance, and a reversing-switch for the motor, one of the switches having its actuating-coil connected to cause its operation after each operation of the reversing-switch and before the armature reverses its direction of rotation, substantially as described.

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

ARTHUR C. EASTWOOD.

Witnesses:
C. W. Comstock,
J. E. Wellman.