No. 764,649. PATENTED JULY 12, 1904.

# G. H. WHITTINGHAM.

## AUTOMATIC MOTOR CONTROLLER.

APPLICATION FILED OCT. 20, 1902.

NO MODEL. 3 SHEETS—SHEET 1.

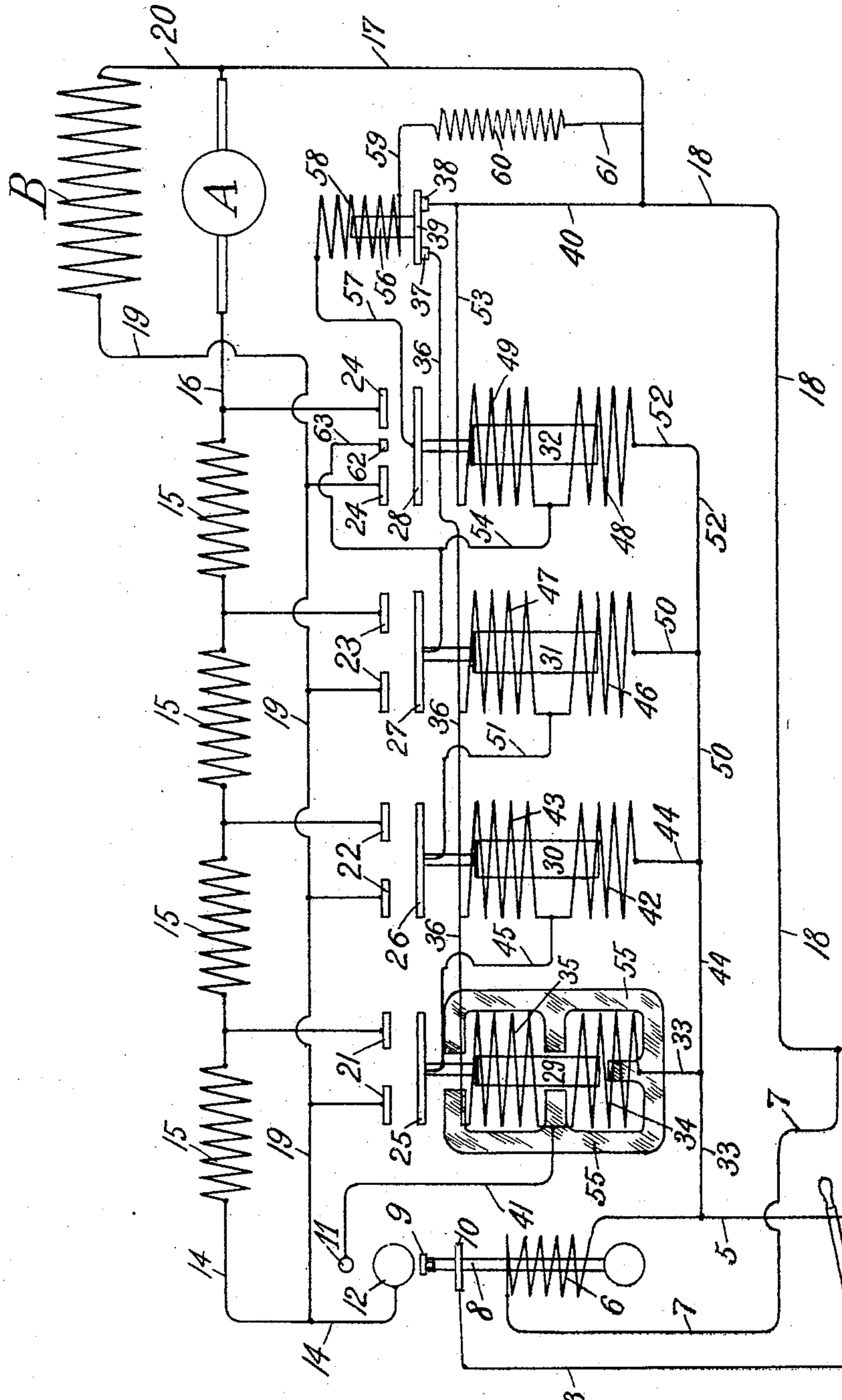


Fig. 1

Witnesses
Julian S. Wooster.
George N. Kerr.

George H. Whittingham Inventor
By his Attorney C. C. Edwards.

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NO MODEL. 3 SHEETS—SHEET 2.

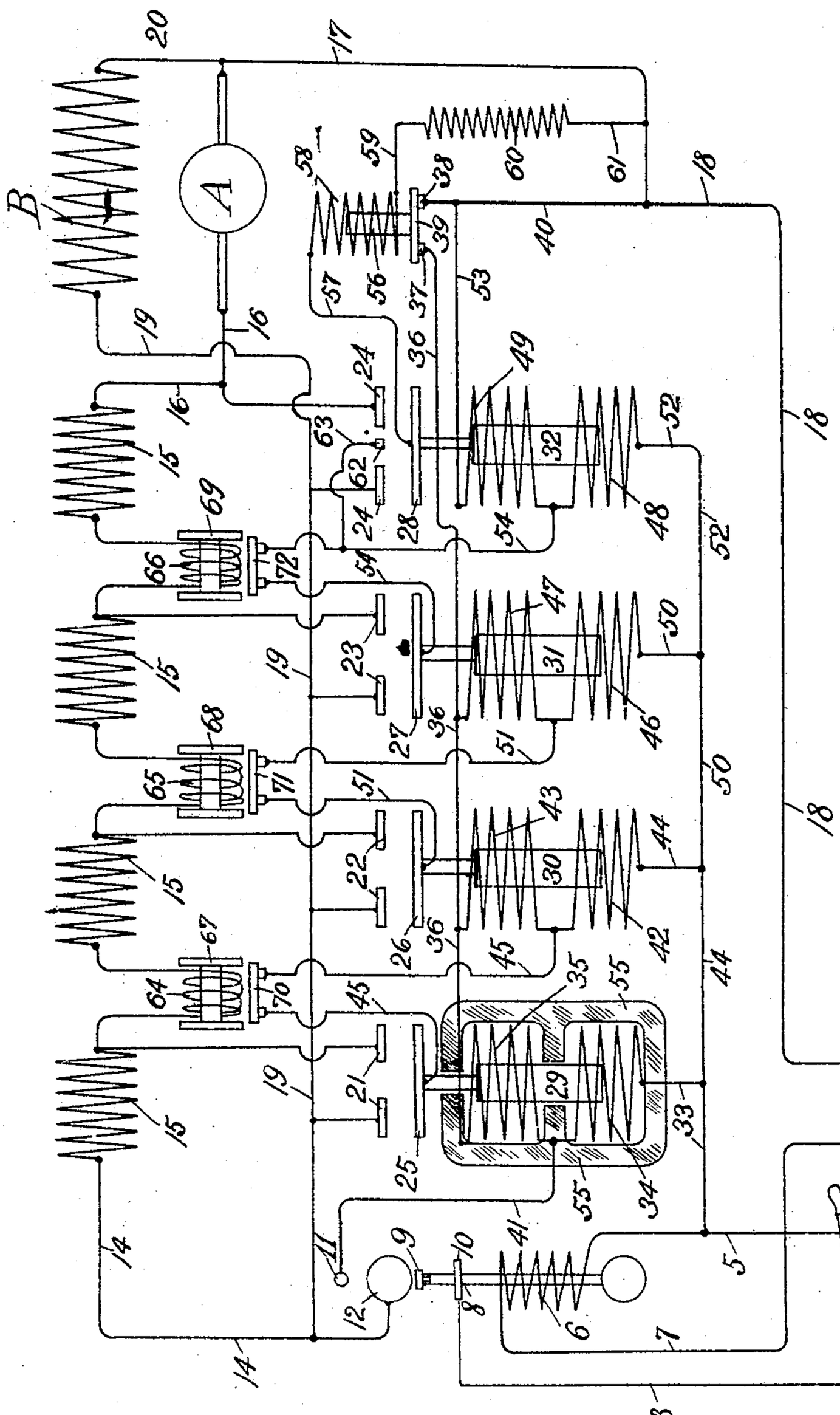


Fig. 2

Witnesses
Julian D. Brooks.
George N. Kent.

Inventor
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NO MODEL. 3 SHEETS—SHEET 3.

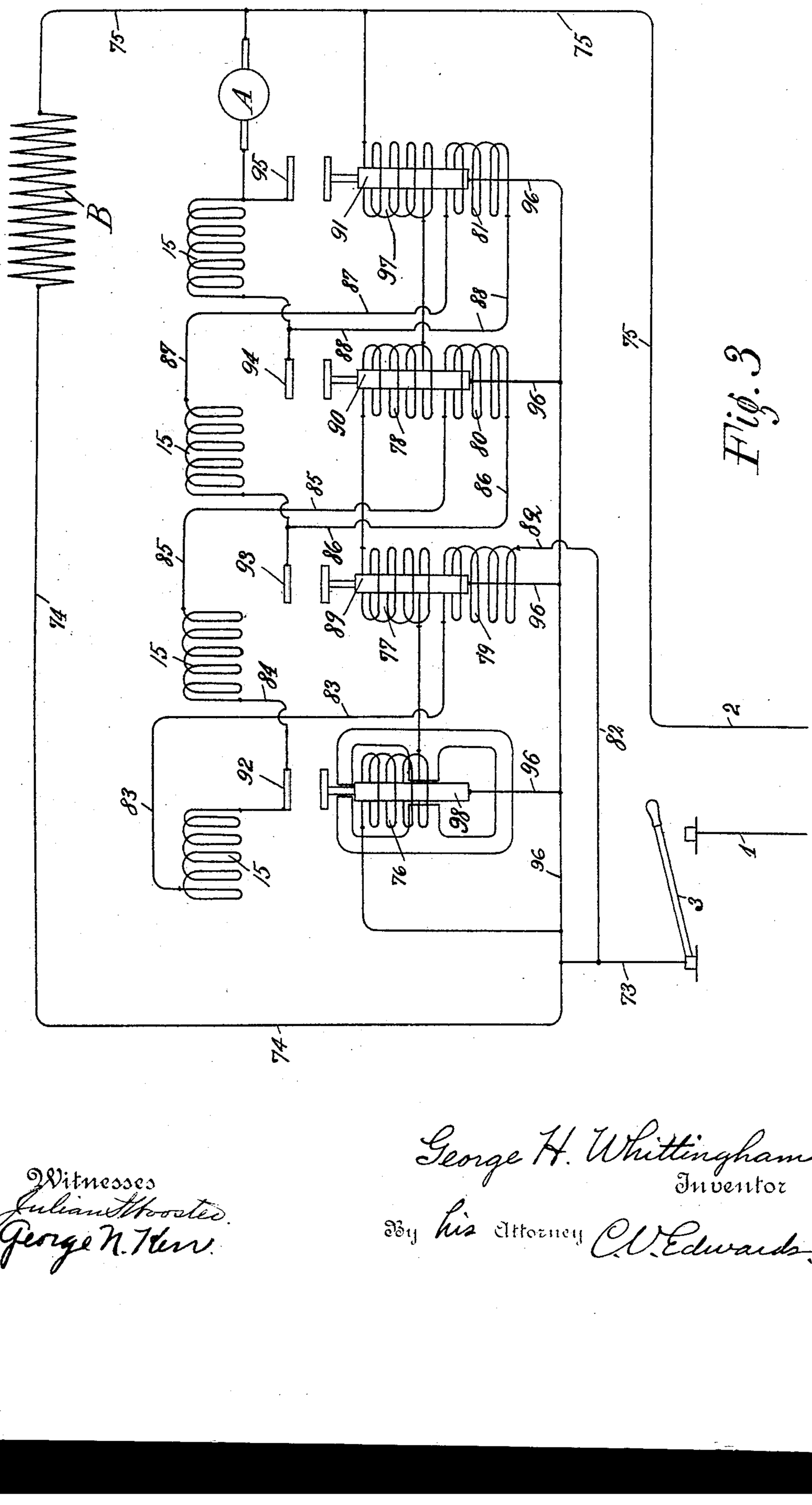


Fig. 3

Witnesses
Julian Thwaites.
George N. Kerr.

George H. Whittingham
Inventor
By his Attorney C. V. Edwards.

No. 764,649. Patented July 12, 1904.

# UNITED STATES PATENT OFFICE.

GEORGE H. WHITTINGHAM, OF NEW YORK, N. Y.

## AUTOMATIC MOTOR-CONTROLLER.

SPECIFICATION forming part of Letters Patent No. 764,649, dated July 12, 1904.

Application filed October 20, 1902. Serial No. 127,911. (No model.)

*To all whom it may concern:*

Be it known that I, GEORGE H. WHITTINGHAM, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Automatic Motor-Controllers, of which the following is a full, clear, and exact specification.

This invention relates to automatic motor-controllers designed to automatically remove from the circuit of the motor-armature successive portions of resistance, whereby following upon the simple throwing of a switch the motor will automatically be started in proper manner.

In such devices it is essential that the resistance be cut out gradually and at a rate of speed depending upon the desired acceleration of speed of the motor and consistent with safety to the motor-armature and that provision be made against too much resistance being cut out at once.

The present invention has for its object the provision of means whereby the speed at which the resistance-cutting-out devices are to operate may be regulated and whereby a definite time interval may be provided for between the cutting out of the successive resistance-coils.

Broadly speaking, the invention comprehends the magnetic retardation of the operation of the resistance-cutting-out device and the overcoming of said magnetic retardation by suitable means arranged to operate in a determined time.

The invention will be described more particularly with reference to the accompanying drawings, in which—

Figure 1 is a diagrammatic view of an automatic motor-starter embodying my invention, and Figs. 2 and 3 illustrate modifications of the apparatus.

In the drawings, A represents the armature of the motor to be controlled, and B the field of the motor.

1 and 2 represent the terminals of the main circuit. The operating-switch 3 is adapted to connect the terminal 1 with contact 4, from which wire 5 leads through the coil 6 to wire 7, which connects with terminal 2. The coil 6 embraces a suitable core 8, which is operated when the coil is energized, so that the contacts 9 and 10, which are carried by the core 8, are brought into contact with the contacts 11 and 12, the contact 9 first making contact with contact 12 and then with contact 11. Wire 13 connects terminal 1 to contacts 10 and 9, and wire 14 leads to the resistances 15 15 15, which are in series with each other and from which wire 16 leads to the armature A. From armature A wires 17 18 lead to terminal 2. From contact 12 or wire 14 the wire 19 leads to the field B, which is connected to terminal 2 by wires 20, 17, and 18. The resistances 15 15 are cut out of circuit by being successively short-circuited, and for this purpose pairs of contacts 21 21, 22 22, 23 23, 24 24 are provided. The contacts of each pair are respectively connected to wire 19 and between the resistance-coils. The contacts 21 21, 22 22, &c., of the respective pairs are adapted to be connected by the contact-bars 25 26 27 28, carried by the respective cores 29 30 31 32 of the operating-solenoids. Each of the cores is operated by a coil, which coils are successively made operative.

In the construction shown in the drawings the coils surrounding the cores 29 30 31, &c., are divided into two parts in series with each other, but wound in opposite directions, whereby the parts of each coil normally act in opposition to each other and prevent movement of the core, but when one coil is cut out of circuit permitting the other coil to move the core. The coils upon the respective cores are in multiple with each other. Thus from the contact 4 and wire 5 wire 33 leads to coil 34, which is in series with and oppositely wound with respect to coil 35. From coil 35 wire 36 leads to contact 37, which is normally connected to contact 38 by contact-bar 39, and from contact 38 the wire 40 leads to wire 18 and terminal 2. The wire 41 leads from contact 11 to the coils 34 and 35. In like manner the coil surrounding the core 30 is divided into coils 42 and 43, coil 42 being connected to wire 33 by wire 44 and coil 43 being connected to wire 36. Wire 45 connects the two coils with contact-bar 25 upon core 29. In similar manner the coils around cores 31 32 are divided into the coils 46, 47,

48, and 49, coils 46 and 47 being connected across wire 36 and wire 44 by the wire 50 and the two coils being connected to contact-bar 26 by wire 51. The coils 48 and 49 are connected to wire 50 by wire 52 and to wire 40 by wire 53. The two coils are connected to contact 27 by wire 54.

Inasmuch as the general operation of the apparatus is to successively cause the movement of the cores 29, 30, 31, and 32, it will be seen that the provision of a definite time interval between the cutting out of successive resistances may be obtained by magnetically retarding the operation of each of the solenoids for a definite period after one of the coils on that particular solenoid becomes operative. I accomplish this by interposing a definite reluctance in the magnetic circuit of the solenoid, and thus definitely retarding the movement of the solenoid-core. This reluctance may be arranged for either by properly selecting the material of the core or the magnet-frame or by any other known means to that end.

In the construction shown in the drawings owing to the differentially-wound coils it is obvious that the two coils of the solenoids will be acting in opposition to each other, thus tending to hold the core stationary. When one of the coils is short-circuited, the other coil tends to move the core; but in order to do so it must overcome the residual magnetism in that part of the core influenced by the other coil and establish a field the lines of force of which flow in the opposite direction. By calculating the strength of the respective coils, the magnetic density of the core, the relative mass of the core within the influence of the field, and similar conditions the movement of the core may be thus retarded for a definite time after the short-circuiting of one of the coils. In the drawings I have shown in connection with one of the solenoids a magnet-frame 55, which, if employed, may be of definite magnetic reluctance, and thus adjusted to offer a definite opposition to any change in the direction of the magnetic lines of force therein. In this construction when current passes through coils 34 and 35 in series two magnetic fields are established, one at each end of the core and tending to establish like polarities at opposite ends of the core. If now the coil 34 be short-circuited, it will be seen that coil 35 will then reverse the polarity of the extreme lower end of the core and establish one polarity at one end of the core and an opposite polarity at the opposite end of the core. To do this, however, it is necessary to reverse the direction of the lines of force in the lower field. The coil 35 therefore first overcomes the residual magnetism of coil 34, after which the coil 35 will raise the core 29. In the construction shown in the drawings the cores are arranged to drop by gravity, and therefore a greater mass of the core is located within coil 35 than within coil 34 in order that when coil 35 overcomes the residual magnetism of coil 34 it will more quickly raise the core. The length of the core, however, the size thereof, and, in fact, all such details will be arranged according to the time at which the solenoid-cores are intended to be operated and other individual conditions.

The operation of the apparatus is as follows: The operator first closes the switch 3 upon contact 4, whereupon a circuit is established by wire 5 through coil 6 to wire 7 and terminal 2. This brings the contact 9 into contact with contact 12 and immediately thereafter brings contact 9 into contact with contact 11 and contact 10 into contact with contact 12. When contact 9 makes contact with 12, the current is introduced into the field B through wire 19 and into the armature through wire 14 and the resistances 15. Both of these circuits will lead by wires 17 and 18 to terminal 2. As soon as contact 9 reaches contact 11 the coil 34 is short-circuited, the following circuit being established: from wire 13 through contacts 10 9 11 and wire 41 to coil 34 and from coil 34 through wires 33 and 5 to contact 4 and switch 3. As soon as coil 34 is short-circuited coil 35 overcomes the residual magnetism of coil 34 and raises the core 29, so that contact-bar 25 connects contacts 21 21. This short-circuits the first resistance-coil and also short-circuits the coil 42 upon the next solenoid, the latter short circuit being as follows: from wire 13 through contacts 10 12 and wires 14 and 19 to contacts 21 and 25, and by wire 45 to coil 42, from coil 42 by wires 44, 33, and 5 to contact 4 and switch 3. When coil 42 is short-circuited, coil 43 first overcomes its residual magnetism and then raises core 30, as before, thus connecting the contacts 22 22 and short-circuiting the next resistance-coil. This action continues until core 32 is raised and all of the resistance-coils are short-circuited.

In order that when all of the resistance-coils are short-circuited the various solenoids may be cut out of circuit, I provide a core 56, attached to the contact-bar 39 and adapted by gravity to hold the contact-bar in engagement with the contacts. The wire 57 leads from the contact-bar 28 through the coil 58, surrounding core 56, and from coil 58 and wire 59 leads to a resistance 60, from which wire 61 leads to wire 18. A contact 62 is adapted to be engaged by the contact-bar 28 when the latter is in engagement with the contacts 24 24, and from contact 62 a wire 63 leads to wire 54. Thus when the core 32 rises a circuit is established from wire 19 through bar 28 to contact 62, thence by wires 63 and 54 to the coil 49, and from coil 49 by wires 53, 40, and 18 to terminal 2, thus holding the contact 28 in engagement with the contacts 24 24. At the same time a circuit is established

from wire 57 through coil 58, wires 59, 61, and 18 and terminal 2, which circuit causes coil 58 to raise the contact 39 out of engagement with the contacts 37 and 38, and thus break the circuits through all of the solenoids except the last. In most instances the circuit from contact 62 will be unnecessary, for the reason that the core 32 when raised will be beyond the influence of coil 48, and thus will be held in raised position by coil 49 notwithstanding both coils 48 and 49 are left in circuit.

In order to protect the motor from too sudden rush of current notwithstanding the normal operation of the resistance-cutting-out devices and at the same time insure that too much resistance cannot be cut out at once, I provide the modification illustrated in Fig. 2, in which the coils 64 65 66 are in series with the respective resistance-coils 15 15 15. Coils 64 65 66 each control a magnet 67 68 69, which magnet operates a switch 70 71 72. Switches 70 71 72 are adapted to control the circuits through wires 45, 51, and 54, respectively. The coils 64 65 66 are so graduated that an abnormal current through the resistance to which it is adjacent causes the same to actuate its magnet and open the switch controlled thereby. If, for example, after the first two resistance-coils have been cut out a rush of current occurs, the coil 66 operates magnet 69 to open switch 72, whereupon the short circuit through the lower coil 48 will be opened and core 32 will drop, thus replacing the corresponding resistance-coil and arresting the operation of succeeding switches. If the rush of current is sufficiently great, all of the switches 70 71 72 will open, and thus replace all the resistance. When the current becomes normal, the resistance will be automatically cut out, as before described.

In Fig. 3 I have illustrated a modified form of apparatus, wherein the cutting out of the resistance under conditions of safety to the motor, such as no load, is permitted to be more rapidly effected. In this instance the field B of the motor is connected across the line through switch 3 and wires 73, 74, and 75. The upper coils 76 77 78 are also connected directly across the line and in series with each other. The resistance-coils 15 15 15 are in series with the lower coils 79 80 81 and with the motor-armature A, the circuit being from switch 3 and wire 73 by wire 82 to coil 79, wire 83, resistance-coil 15, wire 84, resistance-coil 15, wire 85, coil 80, wire 86, resistance-coil 15, wire 87, coil 81, wire 88, resistance-coil 15, armature A, and wire 75 to terminal 2. The respective lower coils are wound in opposite direction to the upper coils, as before described, but will ordinarily be adapted to carry the proper starting-current for a given motor. The resistance-coils are short-circuited by the cores 98 89 90 91 making contact with the contacts 92 93 94 95, the latter being connected to the respective resistance-coils and the cores or the magnet-frames being connected to wire 73 by wires 96. In the operation of the device when switch 3 is closed the field of the motor and the upper coils of the solenoids are energized, and at the same time current from the line passes through all the resistance-coils and the lower coils on the solenoids to the armature of the motor. As no lower coil is provided for the first solenoid, the upper coil 76 at once raises core 98 into contact with 92, thus short-circuiting the first resistance-coil 15 and coil 79, establishing a short circuit from wire 73 through wire 96, core 98, and contact 92. Coil 77 then becomes operative to raise core 89; but before it can do this it must first neutralize the residual magnetism of the short-circuited coil 79 and reverse the polarity of its field. The length of this retardation will be determined as before described. When core 89 is raised by coil 77, the next resistance-coil 15 and the lower coil 80 upon the next solenoid are short-circuited, as before described, and this action continues until all the resistance-coils are cut out, at which time the coil 97 upon the last solenoid having overcome the short-circuited coil 81 raises core 91 into engagement with contact 95 and establishes an uninterrupted circuit from terminal 1 through switch 3, wire 96, core 91, and contact 95 to the motor-armature, thence by wire 75 to terminal 2. If there be no load on the motor, so that the armature freely takes the current, the strength of the coils 79, 80, and 81 will correspondingly weaken, and thus the coils will be more readily overcome and the cutting out of resistance thus more rapidly effected.

It will be understood that the apparatus herein shown may be modified in various respects without departing from my invention. The magnetic retardation of the core may be arranged for in any well-known manner, and such magnetic retardation may be overcome in any suitable manner. Likewise the various other elements entering into the construction of the apparatus may be modified to meet individual conditions. I therefore desire it to be understood that I do not herein limit myself to the specific construction shown.

Having thus described my invention, I declare that what I claim as new, and desire to secure by Letters Patent, is—

1. The combination of a resistance-cutting-out device, a magnet normally retarding the operation of the same, and an electric circuit adapted to overcome said retardation, substantially as described.

2. The combination of a plurality of devices each of which is adapted to cutting out resistance, of a magnet adapted to retard each of said devices, and means for electrically overcoming the retardation of each of said magnets successively, substantially as described.

3. The combination of a resistance-cutting-

out device, a magnetic core for operating the same, two oppositely-acting coils surrounding said core, an electric circuit including said coils, and means for removing one of said coils from circuit, substantially as described.

4. The combination of a resistance-cutting-out device, a magnetic core for operating the same, means for creating a magnetic force normally preventing the operation of said core, and an electric circuit adapted to overcome said retardation, substantially as described.

5. The combination of a plurality of devices each of which is adapted to cut out resistance, of means for magnetically retarding the operation of each of said devices, and means for overcoming said retarding means, the operation of said overcoming means as to one device permitting similar operation as to the next succeeding device, substantially as described.

6. The combination of a resistance-cutting-out device and means for magnetically retarding the operation of the same for a determined length of time, substantially as described.

7. The combination of a resistance-cutting-out device, means for magnetically retarding the same, and means for electrically overcoming said retardation and operating said device, said electrical means requiring a determined time interval in which to overcome said retardation, substantially as described.

8. In a motor-controller, the combination of a solenoid, means for magnetically retarding the movement of the core thereof, and means for varying said retardation with the variation of current in the motor-armature, substantially as described.

9. In a motor-controller, the combination of a solenoid, and means for magnetically retarding the movement of the core thereof for a determined length of time after the coil of said solenoid has become operative, substantially as described.

10. In a motor-controller, the combination of a solenoid comprising a core and two oppositely-acting coils thereon, a determined reluctance in the magnetic circuit of said coils, and means for neutralizing one of said coils, substantially as described.

11. In a motor-controller, the combination of a solenoid comprising a core and two oppositely-acting coils thereon, and means whereby when one of said coils is neutralized, a definite time interval will occur before the other coil can actuate said core, substantially as described.

12. In a motor-controller, the combination of a solenoid comprising a core and two coils thereon, said coils each operating to establish opposite magnetic fields, and means whereby when one of said coils is neutralized the other coil will reverse the magnetic field of the first coil, substantially as described.

13. In a motor-controller, the combination of a plurality of solenoids each of which controls the cutting out of resistance, electric circuits adapted to normally establish oppositely-acting magnetic forces in said solenoids, and means for successively neutralizing a portion of the circuit of each of said solenoids, whereby one of said polarities is reversed, substantially as described.

14. In a motor-starter, the combination of a plurality of solenoids each of which controls a portion of the resistance in circuit with the motor-armature, a differentially-wound coil upon each of said solenoids, and means for successively neutralizing one of said coils upon each of said solenoids, substantially as described.

15. In a motor-starter, the combination of a plurality of solenoids each of which controls a portion of the resistance in circuit with the motor-armature, a differentially-wound coil upon each of said solenoids whereby oppositely-acting magnetic forces are developed in the solenoid-core, and means for successively short-circuiting a portion of each of said differential coils, whereby the other portion of said coil will reverse the polarity established by the first portion, substantially as described.

16. In a motor-starter, the combination of a plurality of solenoids each of which controls a portion of the resistance in circuit with the motor-armature, a differentially-wound coil upon each of said solenoids, means for successively neutralizing one of said coils upon each of said solenoids, and means for removing any determined number of said solenoids from circuit when a determined number of resistance-coils have been removed from the circuit of the motor-armature, substantially as described.

17. In a motor-controller, the combination of a solenoid, means for retarding the movement of the core thereof for a determined length of time after the coil of said solenoid has become operative, and means for varying said retardation with the variation of current in the motor-armature, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

GEORGE H. WHITTINGHAM.

Witnesses:

C. V. EDWARDS,

HENRY BEST.