E. R. CARICHOFF.

ELECTRICALLY CONTROLLED SWITCH.

APPLICATION FILED DEC. 2, 1908.

953,369. Patented Mar. 29, 1910.

4 SHEETS—SHEET 1.

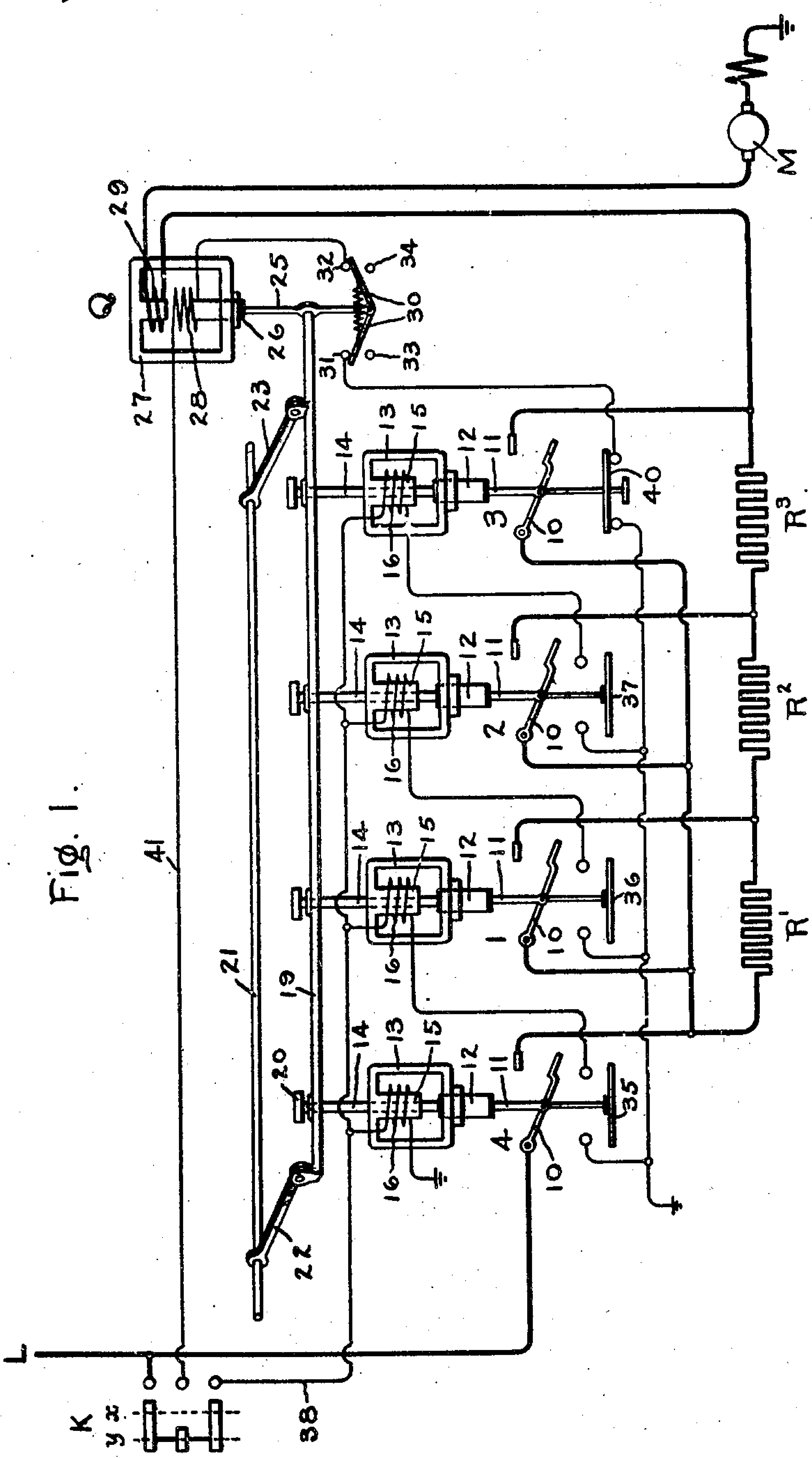

Fig. 1.

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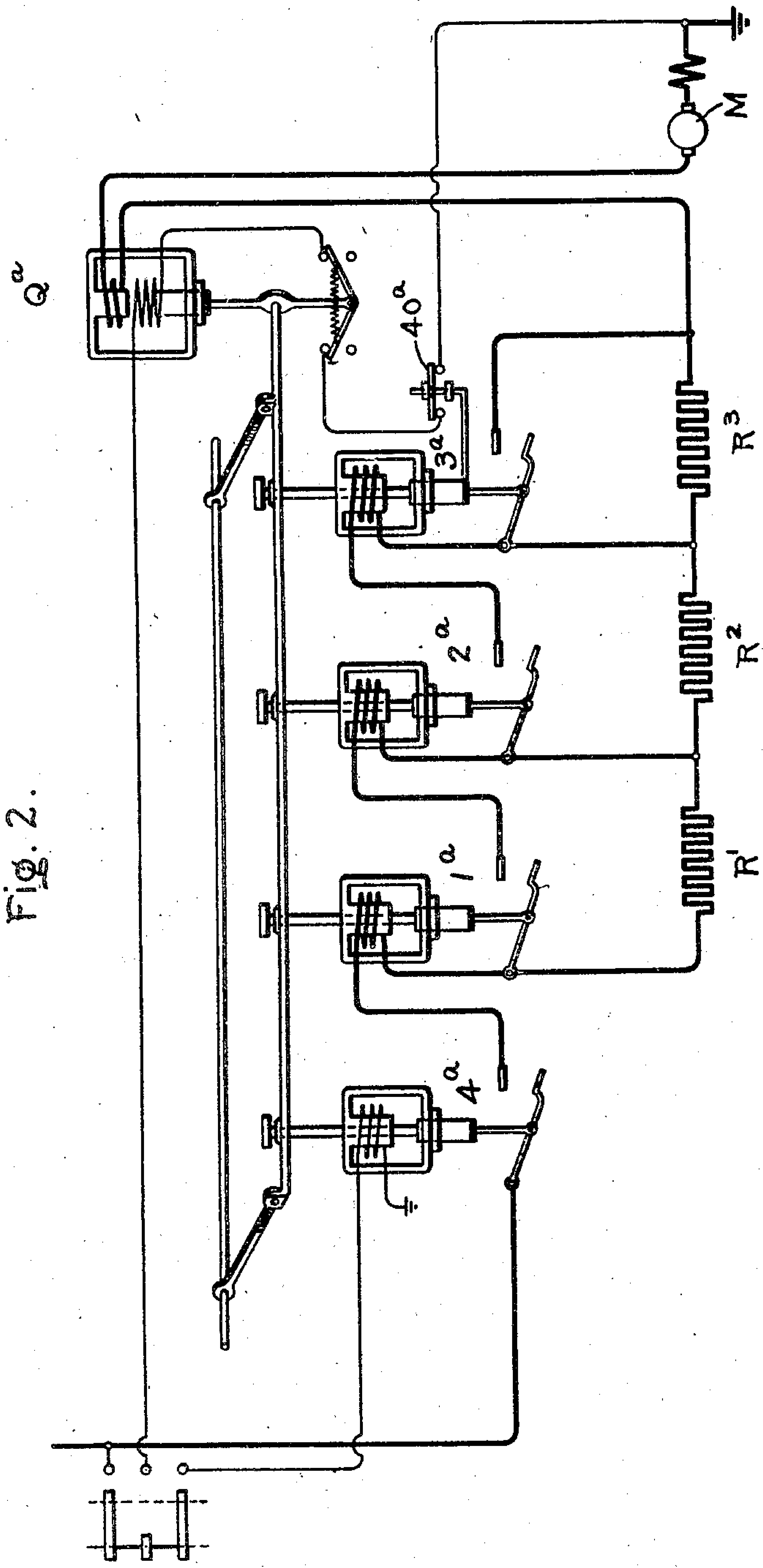

Fig. 2.

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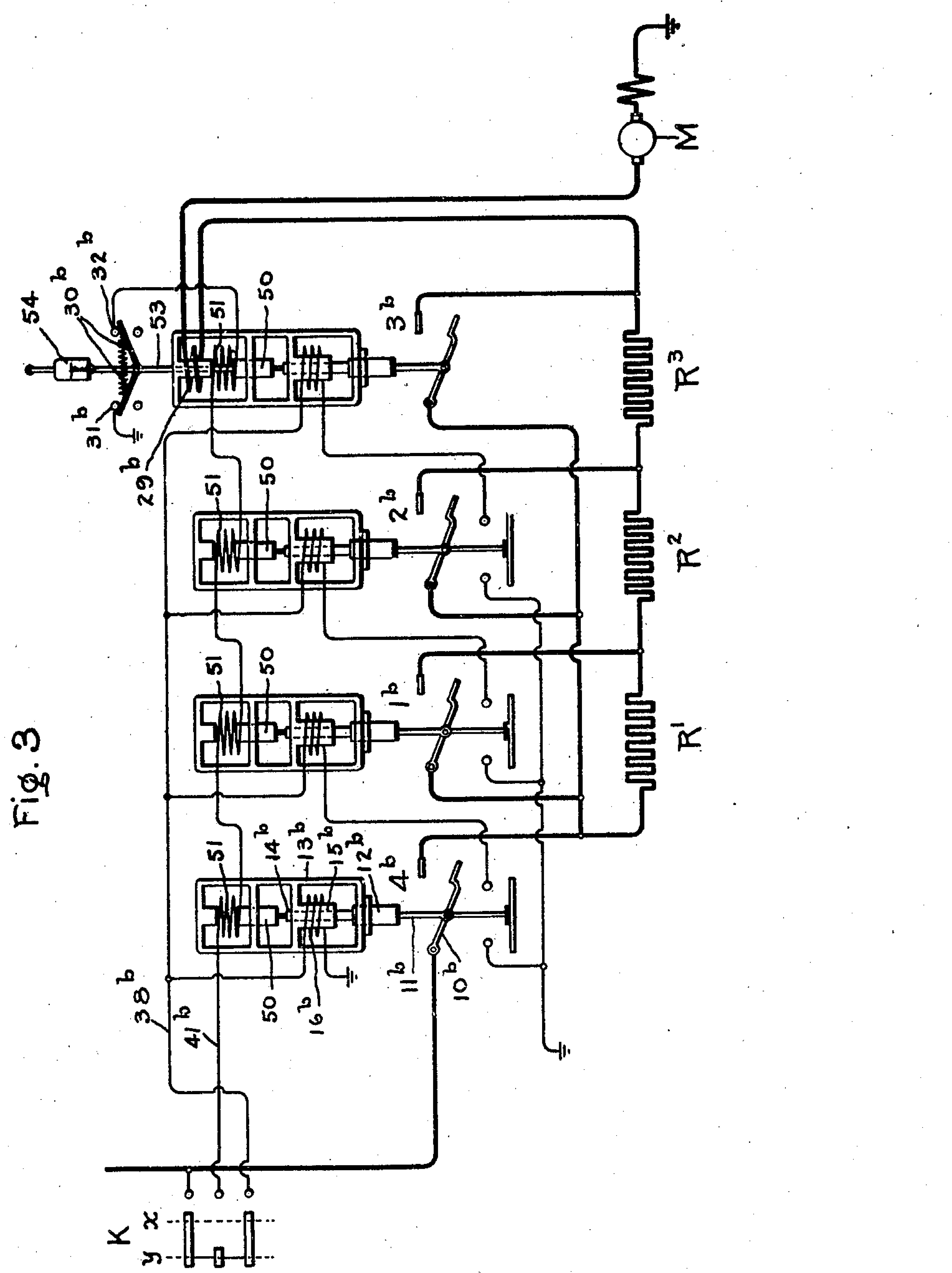

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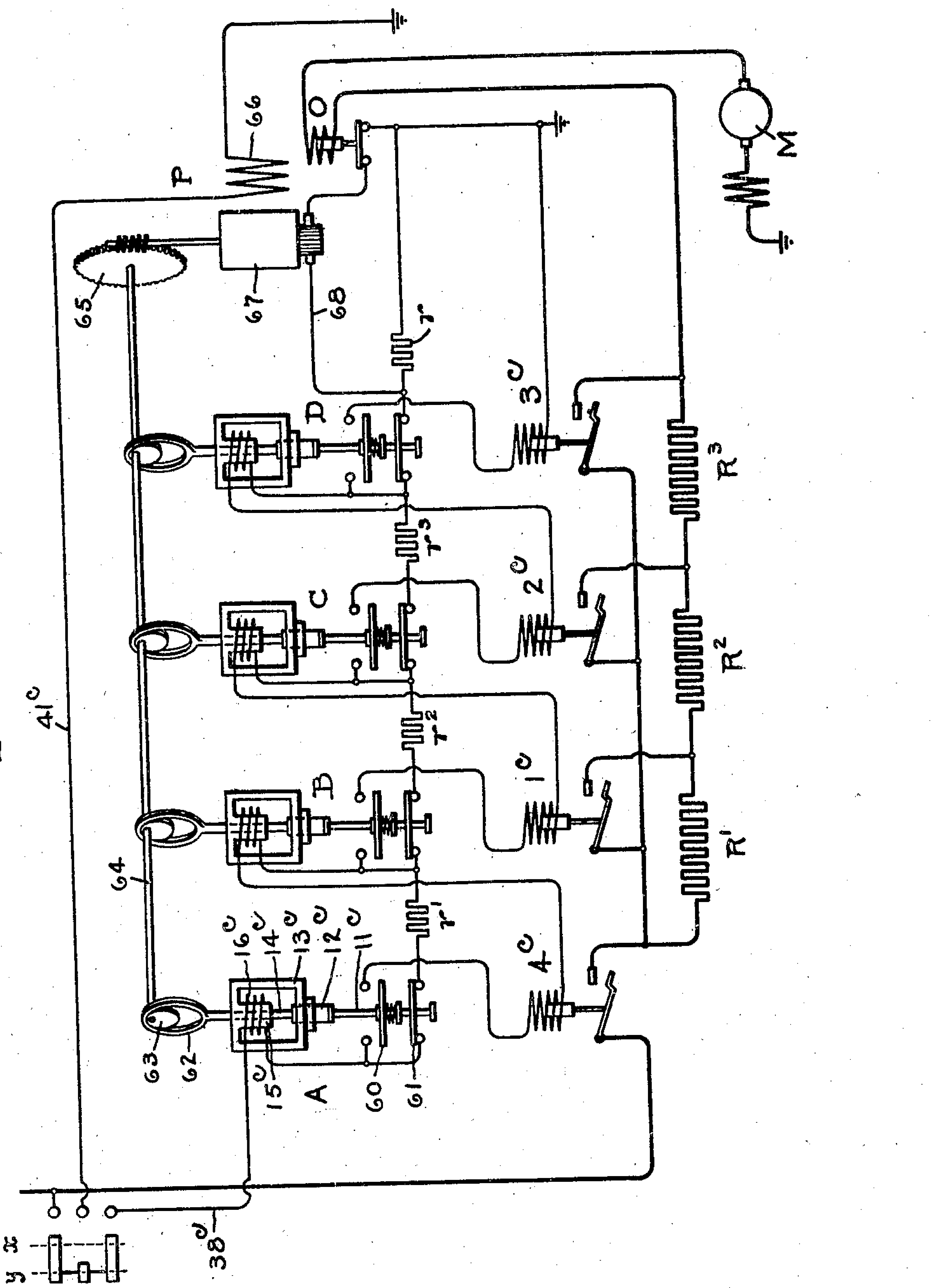

Fig. 4.

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UNITED STATES PATENT OFFICE.

EUGENE R. CARICHOFF, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRICALLY-CONTROLLED SWITCH.

953,369. Specification of Letters Patent. Patented Mar. 29, 1910.

Application filed December 2, 1908. Serial No. 465,745.

To all whom it may concern:

Be it known that I, EUGENE R. CARICHOFF, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Electrically-Controlled Switches, of which the following is a specification.

My invention relates to electrically controlled switches, and particularly to an arrangement of a plurality of such switches designed for operation in succession.

In systems of motor control of the separately-actuated contact type, it is the custom to employ a plurality of electrically controlled switches or contactors for regulating the amount of resistance in the motor circuit. When a plurality of contactors are employed for this purpose it is usual to arrange them so that they will close in regular succession with a certain interval of time between their operation, this interval often being controlled by the current in the motor circuit. The successive operation of the contactors in such arrangements has been provided for in many different ways, one of the best known being by the use of interlocking switches operated by the contactors and arranged to complete the control circuits in the required order, a so-called "notching relay" being employed for the purpose of insuring a certain interval of time between the operation of successive switches, depending, to a certain extent, upon the current in the motor circuit. In such systems of motor control, particularly those in which a plurality of motors are controlled according to the well-known series parallel method, now almost universally used in the operation of electrically driven cars, a large number of interlocking switches are necessary and the control circuits are quite numerous and intricate.

The general object of my invention is to provide a new and improved construction and arrangement of successively operated switches in which few interlocking switches are required and which will be simple in construction and efficient and reliable in operation. To this end, I have devised certain arrangements and constructions which will be understood from the following description taken in connection with the accompanying drawings.

For the sake of simplicity I have shown my invention as embodied in certain simple systems of motor control, but these are merely illustrative and, as will be obvious to those skilled in this art, it is equally applicable to other systems of control for dynamo-electric machinery. In fact, my invention is adapted for use in any connection where it is desirable to close a plurality of switches in succession.

Referring to the drawings, Figure 1 illustrates, in a diagrammatic way, one form of my invention embodied in a simple system of motor control; Fig. 2 is a modified form of the arrangement shown in Fig. 1; Fig. 3 shows still another modification of the system of Fig. 1; and Fig. 4 shows another arrangement in which my invention may be embodied.

Referring to Fig. 1, M indicates a motor to be controlled. R^1, R^2 and R^3 are sections of resistance located in the motor circuit and arranged to be short-circuited by switches 1, 2 and 3. A line switch 4 in closing connects the motor circuit to the source as will be clear from the diagram. A master switch K, shown in the usual conventional way and having an "off" position and two "on" positions x and y, controls the operation of the switches 1 to 4, as hereinafter explained.

Each of the switches 1 to 4 comprises a movable contact member 10 to which is secured, by means of a rod 11, a core of magnetic material 12 arranged for sliding movement in a frame 13 of magnetic material of a form clear from the drawing. Extending through a hole in the upper part of the frame 13 is an actuating member consisting of a rod or core 14 of magnetic material, the lower end of which normally rests upon the top of the core 12. This rod 14 passes through an extension 15 of the frame 13 surrounded by a coil 16 which when energized produces a magnetic field through the frame 13, the rod 14 and the core 12, as hereinafter explained. In order to insure the rod 14 and the core 12 sliding freely in the frame 13 without sticking, the holes through which these parts pass may be lined with tubes of brass or other non-magnetic material. The rods 14 pass freely through holes in a bar 19 which forms one side of a quadrilateral frame and are provided with heads 20 by which the rods may be lifted when the bar 19 is raised. The quadrilateral frame consists of a shaft 21, mounted for partial rotation, to which are secured arms 22 and 23 in the outer ends of which is pivoted the bar 19, as shown in the drawing. One end or, in fact, any portion of the bar 19, is engaged by a rod 25 extending from the core 26 of a relay Q. This relay Q may be of any suitable design, and, as shown, comprises a frame 27 within which are mounted an actuating coil 28 and a holding overload coil 29, within the fields of which the movable core 26 moves. The lower end of the rod 25 is provided with snap contact members 30, of a well-known form, which, when the relay is in the position shown, make electrical connection between the fixed contact studs 31 and 32 connected in series with the actuating coil 28 of the relay. When the core 26 of the relay moves up the snap contact members 30 are thrown out of engagement with the studs 31 and 32 and against the stops 33 and 34, thereby interrupting the current through the coil 28. The coil 29 is arranged in the motor circuit and is so designed that if the current in the latter is higher than a certain safe value a field will be produced in the relay Q sufficient to hold the core 26 in its raised position. If, however, the current in the coil 29 does not rise to this value, the core 26 will drop and when in its lower position the snap contact members 30 will return to the position shown and will again complete the circuit through the coil 28, thereby causing the relay to pull up again. In this way the relay Q serves as means for reciprocating the bar 19 in an approximately vertical plane, thereby raising and lowering the rods 14.

The field structure of the switches 1 to 4 and the proportions of the coils 16 are such that these coils when energized each produce a magnetic field through its frame 13, rod 14 and core 12 which causes magnetic adhesion between the rod 14 and the core 12, thereby causing the core 12 to be raised when the rod 14 is lifted. The coils 16 have a further function of producing a magnetic field from the extensions 15, through the cores 12 such that when the latter have been brought to their raised position they will be firmly held there as long as the coils are energized. The circuits through the coils 16 on the switches 1, 2 and 3 are completed, respectively, through interlocking switches 35, 36 and 37 closed by the switches 4, 1 and 2 in closing. Current for these coils is furnished from the source through the master controller K and the wire 38 in a manner clear from the diagram. The circuit through the actuating coil 28 of the reciprocating relay Q passes through an interlocking switch 40 opened by the switch 3 in closing, and this circuit is furnished with current from the source through the master switch K and the wire 41 as clearly shown.

The operation of the system of Fig. 1 is as follows: When the master switch is thrown to its first position *x*, the circuit from the source L, through the wire 38 and the coil 16 on the line switch 4, is completed, but this switch will not close since the field produced by this coil is insufficient to pull up the core 12. When, however, the master switch is moved to its second position *y*, a circuit is completed through the wire 41 and the actuating coil 28 on the relay Q and this relay pulls up lifting the bar 19 and raising all the rods 14. The magnetizing coil 16 of the switch 4 being energized the core 12 adheres to the rod 14 and is raised by the latter, thereby closing the switch 4. In its raised position the core 12 engages with extension 15 of the frame 13 and is held in that position by the magnetizing effect of the coil 16, independently of the rod 14. Closing of the switch 4 completes the connection of the motor to the source through all of the resistance R^1, R^2 and R^3. The interlocking switch 35 is closed at the same time and completes the circuit through the magnetizing coil 16 of the switch 1. The relay Q in pulling up interrupts its circuit through the actuating coil 28 by the snapping over of the contact members 30 away from the contacts 31 and 32 and into engagement with the stops 33 and 34, and the core of this relay drops at once unless an excessive current in the motor circuit energizes the holding coil 29 sufficiently to hold the relay up. When the core of the relay Q drops, the bar 19 falls with it and lowers the rods 14 into re-ëngagement with their respective cores 12. The relay Q in dropping completes the circuit through its actuating coil 28 and goes up again, thereby again lifting the bar 19 and the rods 14. Since the coil 16 of the switch 1 is energized, the core 12 of this switch will now adhere to the rod 14 and this switch will be closed in the same manner as in the case of the switch 4. The switch 1 in closing short-circuits the section of resistance R^1 and increases the potential applied to the motor. The interlocking switch 36 being closed, a circuit is completed through the magnetizing coil on the switch 2, and operation of this switch takes place on the next upward movement of the bar 19. In this way the switches 4, 1, 2 and 3 are closed in succession, under the control of the current in the motor circuit passing through the holding coil 29 on the relay Q, as long as the master switch K is held in its position *y*. If at any time the operator desires to stop the successive closing of the switches he can do so by throwing his master switch back to the position *x*, whereupon the circuit through the wire 41 and the actuating coil 28 of the relay Q will be interrupted and reciprocation of this relay stopped. The circuit through the wire 38, however, will be maintained and those of the switches 4, 1, 2 and 3 which have closed will be held in that condition. Upon throwing the master switch back to the "off" position all the switches 4, 1, 2 and 3 will, of course, open. The switch 3 in closing opens the interlocking switch 40 in the circuit through the actuating coil 28 of the relay, and further needless operation of the reciprocating relay is prevented.

The system of Fig. 2 is very similar to that of Fig. 1, the difference being that, in the system of Fig. 1, the magnetizing coils of the resistance controlling switches are supplied with current from a control circuit passing through the master switch, while in the system of Fig. 2 the magnetizing coils of the resistance controlling switches are each connected directly in the motor circuit by the closing of the preceding switch. That this is the case will be apparent from the diagram, it being clear that, when the line switch 4^a closes, a circuit to the motor is completed through the magnetizing coil of the resistance controlling switch 1^a. It is obvious, also, that closing of switch 1^a causes the motor current to pass through the magnetizing coil of switch 2^a, and that closing of switch 2^a changes the path of motor current to the coil of the switch 3^a. The switches in the system of Fig. 2 will close in succession under the control of the reciprocating relay Q^a in the same manner as above described in connection with the system of Fig. 1. Closing of the last resistance switch 3^a opens an interlocking switch 40^a which interrupts the actuating coil of the reciprocating relay Q^a as in the case of the system of Fig. 1. It is evident that with the system of Fig. 2 the number of interlocking switches necessary is reduced to one and the system is thus rendered very simple.

The system of Fig. 3 also resembles that of Fig. 1, the difference residing in the mechanism by which certain parts are given a reciprocating motion and close the switches one after another. Instead of the pivoted quadrilateral frame illustrated in Figs. 1 and 2, I have shown in Fig. 3 an individual electromagnetic reciprocating device for each of the switches. As in the case of the switches of Fig. 1, each switch 4^b, 1^b, 2^b and 3^b of Fig. 3, comprises a movable contact member 10^b to which is secured, by means of a rod 11^b, a core 12^b of magnetic material arranged for sliding movement in a frame 13^b. As in the system of Fig. 1, the core 12^b is lifted by the magnetic adhesion between it and a rod or core 14^b of magnetic material and is held in its raised position magnetically by adhesion to the end of the extension 15^b. A coil 16^b serves, when energized, to produce the necessary magnetic field for these operations as in the systems of Figs. 1 and 2. In the switches of Fig. 3, the frame 13^b is extended upward and made of the form shown, and within it is mounted a core 50 of magnetic material arranged for movement into and out of the field produced by a coil 51. The core 50 is mechanically connected with the rod 14^b, preferably by a non-magnetic connection, in order that the field produced by the coil 51 may not interfere with that produced by the coil 16^b. The coils 51 are all connected in series and means is provided for periodically interrupting and completing the circuit through them in order to cause the reciprocation of the cores 50 and the consequent rising and falling of the rods 14^b. This circuit interrupting means may be of any suitable form, and, as shown, comprises snap action contact members 30^b which coöperate with fixed contacts 31^b and 32^b and are thrown into and out of engagement with these contacts by the movement of the core 50 of the switch 3^b. In the construction shown these snap contact members 30^b are carried by a rod 53 extending upward from the core 50 of the switch 3^b, to which rod is secured one of the members of a dash pot 54 which serves to retard the downward movement of these reciprocating parts and thus gives a time limit to the operation of the switches. The switch 3^b may be provided with a coil 29^b, connected in the motor circuit, which serves to hold the reciprocating parts of the switch in their upward position, thereby maintaining the circuit through the coils 51 interrupted, as long as an overload exists, thus retarding the successive closing of the switches. With this arrangement it is clear that when the master switch K is thrown to its position *y*, the wires 38^b and 41^b are energized and the reciprocation of the cores 50 and rods 14^b of each switch will commence. As in the case of the system of Fig. 1, the coils 16^b of the switches are energized successively and closing of the switches one after another, therefore, takes place. The dash pot 54 insures a certain time interval between closing of the switches and the overload coil 29^b increases this interval if at any time the current in the motor circuit exceeds a certain safe value. When the switch 3^b has closed, its core 50 and the rod 53 are held in their upper position and the circuit through the coils 51 is permanently interrupted at the snap contacts.

In the embodiment of my invention illustrated in Fig. 4, the switches which it is desired to close in succession are not actuated directly by the reciprocating members. Instead, the reciprocating members form the actuating members of relays which close and open the control circuits for the switches and thereby cause the latter to operate in the desired order. In the system of Fig. 4, also, I have shown a different arrangement of reciprocating mechanism, namely,—a pilot motor arranged to rotate a shaft upon which are cams coöperating with the reciprocating members of the various relays. In this system the motor to be controlled is indicated at M, the starting resistances at R^1, R^2 and R^3, these being short-circuited by electromagnetically operated switches or contactors 1^c, 2^c and 3^c, respectively. A contactor 4^c serves as a line switch, and a master controller K regulates the operation of the switches, as hereinafter explained. Above the switches 4^c, 1^c, 2^c and 3^c are diagrammatically shown relays A, B, C and D which, in their construction and principle of operation, resemble the switches of the system of Fig. 1. Each relay comprises a field frame 13^c through a hole in which a core 12^c of magnetic material is arranged for movement. A rod 11^c extends downwardly from each core 12^c and carries contact disks, of any suitable form, shown in the usual conventional manner. In the arrangement shown, when the core 12^c is raised, the upper disk 60 comes into engagement with its coöperating fixed contacts and the lower disk 61 is directly afterward lifted from its coöperating contacts. Each relay has a magnetizing coil 16^c which, when energized, acts in the same manner as in the switches of Figs. 1, 2 and 3 to cause magnetic adhesion between the rods or cores 14^c and the cores 12^c, and also to hold the cores 12^c in their raised positions in engagement with the extensions 15^c of the frames 13^c. The rods 14^c are provided at their upper ends with rings 62, within which rotate cams 63 secured to a shaft 64 driven by a motor P through gearing 65, or in any other suitable way. With this arrangement it is clear that rotation of the shaft 64 will cause vertical reciprocation of the rods 14^c unless the latter are held in their raised position by their coöperating cores 12^c having been raised, under which condition the cams 63 will rotate freely within the rings 62. The field 66 of the motor P is excited through a wire 41^c connected to the source through the master controller K as shown. The armature 67 may receive its current through a circuit 68 by which it is connected in shunt to a resistance r, this circuit being interrupted by an overload relay O if the current in the motor circuit exceeds a certain value. The arrangement of control circuits will be easily understood from the diagram and from the following description of the operation of the system.

When the switch K of Fig. 4 is thrown to its position y, a circuit from the source is completed through the wire 41^c and the field 66 of the pilot motor P. At the same time a circuit is made through the wire 38^c, the magnetizing coil 16^c of the relay A, and through the lower contacts 61 on all the relays and resistances r^1, r^2, r^3 and r, to ground. The armature of the motor P, being connected in shunt to the resistance r, is supplied with current and the pilot motor P begins to run thereby reciprocating the rods 14^c. The magnetizing coil 16^c of the relay A being energized the core 12^c of this relay magnetically adheres to the rod 14^c and is raised with it thereby closing the contact 60 and opening the contact 61 of this relay. The magnetizing coils 16^c of the relays B, C and D not being initially energized, the rods 14^c of these relays will at first rise without raising their coöperating cores 12^c. Closing of the contact 60 and opening of the contact 61 inserts the actuating coil of the switch 4^c and magnetizing coil 16^c of the relay B in the control circuit in place of the resistance r^1. The switch 4^c thereupon closes and connects the motor M to the source through all of the resistance R^1, R^2 and R^3. Energization of the coil 16^c of the relay B will, however, have no effect upon the operation of this relay until its rod 14^c has been lowered into engagement with its coöperating core 12^c, since, as in the systems of Figs. 1, 2 and 3, the field produced by this coil is insufficient to pull up the core 12^c. When, however, the pilot motor P has lowered the rods 14^c again, the core 12^c of the relay B will magnetically adhere to the rod 14^c and will be raised by the next upward movement of this rod. Raising of the contact disks on the relay B will shift the control circuit from the resistance r^2 to the coil of the contactor 1^c and the magnetizing coil of the relay C as in the case of the relay A and the switch 4^c. In this way the contactors will close in succession as long as the master switch is held in its position y, unless the current in the motor circuit rises to a value sufficient to open the contacts of the overload relay O, thereby interrupting the circuit through the armature of the pilot motor P and stopping it. When the last relay D has pulled up the circuit through the resistance r will be interrupted and the armature of the pilot motor will no longer be supplied with current and will, therefore, cease to rotate. It is to be observed that when all the relays have pulled up and the contactors are all closed, the magnetizing coils 16^c of the relays and the actuating coils of the contactors will all be connected to the source in series and the compensating resistances r^1, r^2 and r^3 will be eliminated from the circuit. If at any time during the closing of the switches the master switch K is thrown back to its position x the pilot motor will stop and further closing of the contactors will be prevented, while those contactors which have already closed will remain in that position. When the master switch is thrown back to its "off" position the relays will, of course, all drop and the contactors all open.

The particular systems of control above described are to be understood as being merely illustrative of the principles of my invention.

It will be obvious to those skilled in the art that my invention may be embodied in many other constructions and arrangements without departing from the spirit thereof. For example, many different arrangements may be employed for giving a reciprocating motion to the actuating members. It is my intention to cover all such arrangements in the following claims.

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

1. In a switch, a movable member of magnetic material, an actuating member of magnetic material arranged for movement into and out of engagement with said movable member, and a magnetizing coil which when energized produces magnetic adhesion between said actuating member and said movable member and retains said movable member in the position to which it is moved by said actuating member.

2. A switch comprising a fixed contact member, a movable contact member coöperating therewith, an actuating member coöperating with said movable contact member, and a magnetizing coil for producing magnetic adhesion between said actuating member and said movable contact member and for magnetically retaining the latter in one extreme position of movement.

3. A switch comprising a fixed contact member, a movable contact member coöperating therewith, a core of magnetic material secured to said movable contact member, a frame of magnetic material within which said core is arranged for movement, an actuating core of magnetic material arranged for movement within said frame and in coöperative relation to said first named core, means for moving said actuating core, and a magnetizing coil mounted in said frame and arranged to produce magnetic adhesion between said cores and serving to magnetically retain the first named core in one extreme position of movement.

4. A plurality of switches, each having a movable member, a core of magnetic material forming a part thereof, a second core of magnetic material arranged for movement into and out of engagement with said first named core, and a coil for producing magnetic adhesion between said cores, in combination with means for reciprocating said second mentioned cores, and means for causing energization of said magnetizing coils on the switches in succession, whereby the movable members of said switches are operated in succession.

5. A plurality of switches, each having a movable member of magnetic material, an actuating member of magnetic material arranged for movement into and out of engagement with said movable member, and a magnetizing coil for producing magnetic adhesion between said actuating member and said movable member, in combination with means for reciprocating said actuating members, and means for causing energization of said magnetizing coils in succession, whereby the movable members of said switches are moved in succession by said actuating members.

6. A plurality of switches, each having a movable member of magnetic material, an actuating member of magnetic material arranged for movement into and out of engagement with said movable member, and a magnetizing coil arranged when energized to produce a magnetic adhesion between said actuating member and said movable member and to magnetically hold said movable member in one of its extreme positions of movement after the same has been moved by said actuating member, in combination with means for reciprocating said actuating members, and means for causing energization of said magnetizing coils in succession.

7. A plurality of switches, each having a movable member of magnetic material, an actuating member of magnetic material arranged for movement into and out of engagement with said movable member, and a magnetizing coil arranged when energized to produce magnetic adhesion between said actuating member and said movable member, in combination with electrically operated means for reciprocating said actuating members, and means for causing energization of said magnetizing coils in succession.

8. A plurality of switches, each having a movable member of magnetic material, an actuating member of magnetic material arranged for movement into and out of engagement with said movable member, and a magnetizing coil arranged when energized to produce magnetic adhesion between said actuating member and said movable member, in combination with electromagnetically operated means for reciprocating said actuating members, and means for causing energization of said magnetizing coils in succession.

9. A plurality of switches, each having a movable member of magnetic material, an actuating member of magnetic material arranged for movement into and out of engagement with said movable member, and a magnetizing coil arranged when energized to produce magnetic adhesion between said actuating member and said movable member and to magnetically hold said movable member in the position to which it is moved by said actuating member, in combination with electromagnetically operated means for

reciprocating said actuating members, and means for causing energization of said magnetizing coils in succession.

10. In a system of motor control, a motor, a starting resistance therefor, a plurality of contactors arranged to regulate the amount of resistance in the motor circuit, relays coöperating with said contactors and controlling the operation of the same, each having a movable member of magnetic material, an actuating member of magnetic material arranged for movement into and out of engagement with said movable member, and a magnetizing coil arranged when energized to produce magnetic adhesion between said actuating member and said movable member, in combination with means for reciprocating said actuating members, and means for causing energization of said magnetizing coils in succession.

11. In a system of motor control, a motor, a starting resistance therefor, a plurality of contactors arranged to regulate the amount of resistance in the motor circuit, relays coöperating with said contactors and controlling the operation of the same, each having a movable member of magnetic material, an actuating member of magnetic material arranged for movement into and out of engagement with said movable member, a magnetizing coil arranged when energized to produce magnetic adhesion between said actuating member and said movable member, in combination with means for reciprocating said actuating members, means for causing energization of said magnetizing coils in succession, and an overload responsive means for regulating the operation of said reciprocating means.

12. In a system of motor control, a motor, a starting resistance therefor, a plurality of contactors arranged to regulate the amount of resistance in the motor circuit, relays coöperating with said contactors, each having a movable member of magnetic material, an actuating member of magnetic material arranged for movement into and out of engagement with said movable member, a magnetizing coil arranged when energized to produce magnetic adhesion between said actuating member and said movable member, and contacts controlled by said relays for completing the circuit through the actuating coil of a corresponding contactor, through the magnetizing coil of the succeeding relay, in combination with means for reciprocating said actuating members.

In witness whereof, I have hereunto set my hand this 30th day of November, 1908.

EUGENE R. CARICHOFF.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.