No. 778,242. PATENTED DEC. 27, 1904.

G. H. HILL.

ELECTRICAL CONTROLLING APPARATUS.

APPLICATION FILED JUNE 27, 1902.

3 SHEETS—SHEET 1.

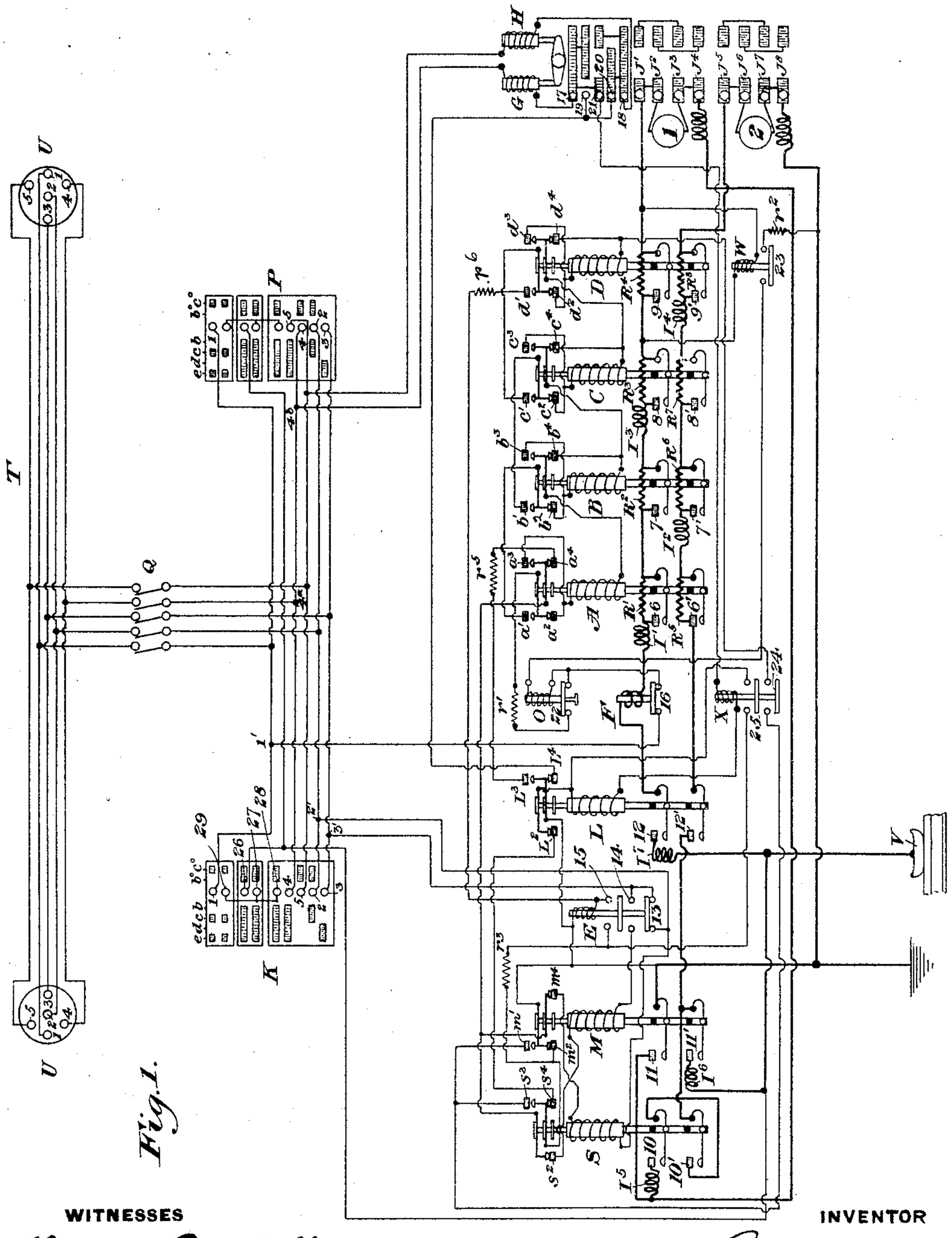

Fig. 1.

WITNESSES

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3 SHEETS—SHEET 2.

Fig. 2.

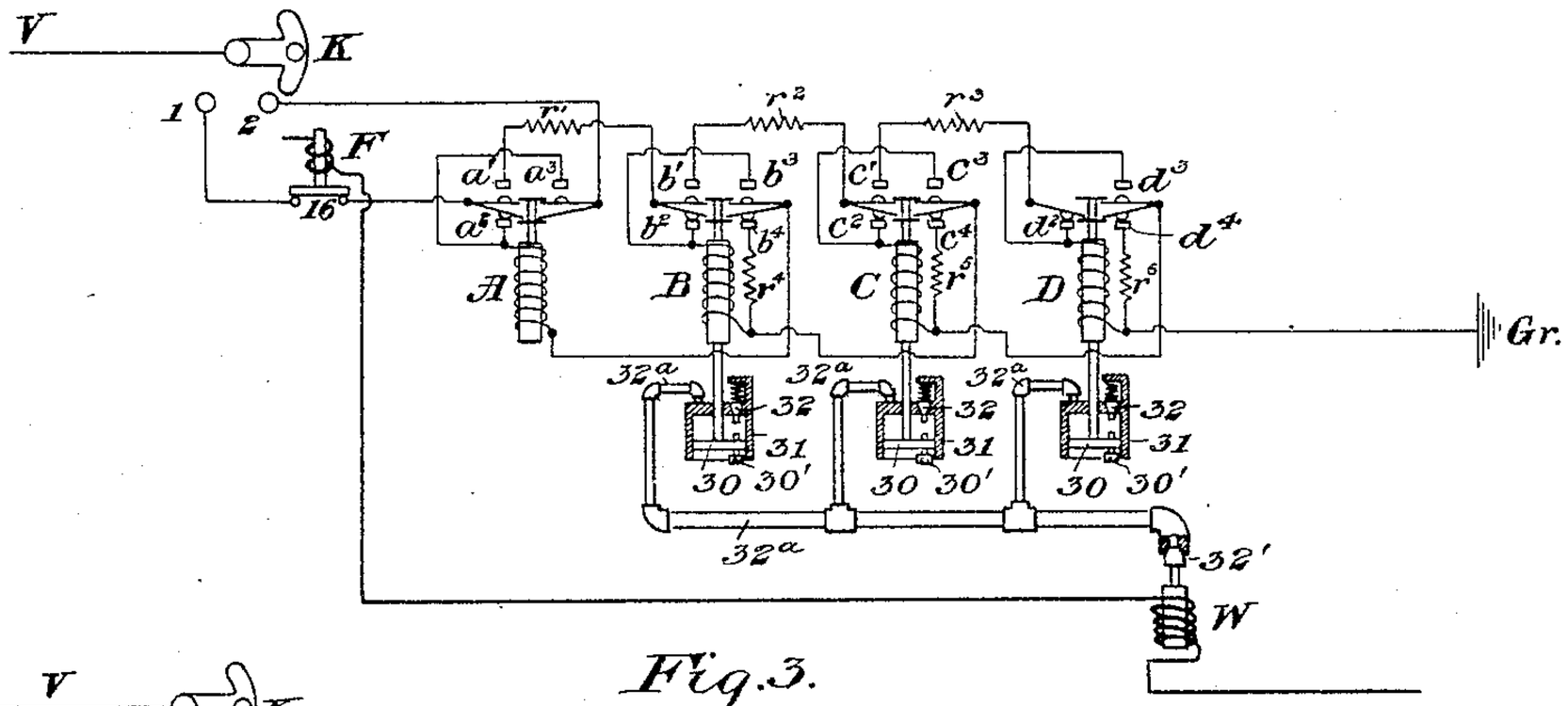


Fig. 3.

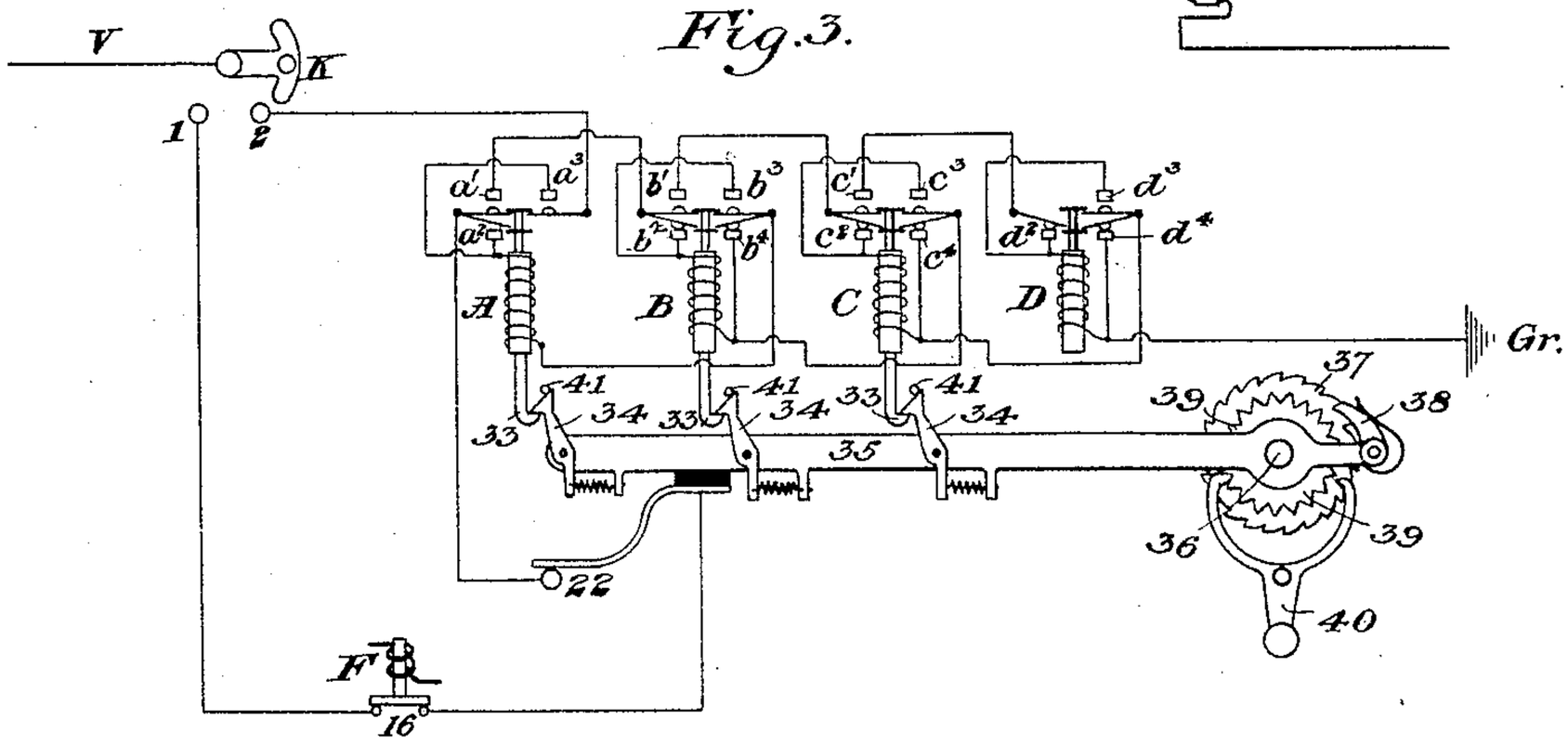
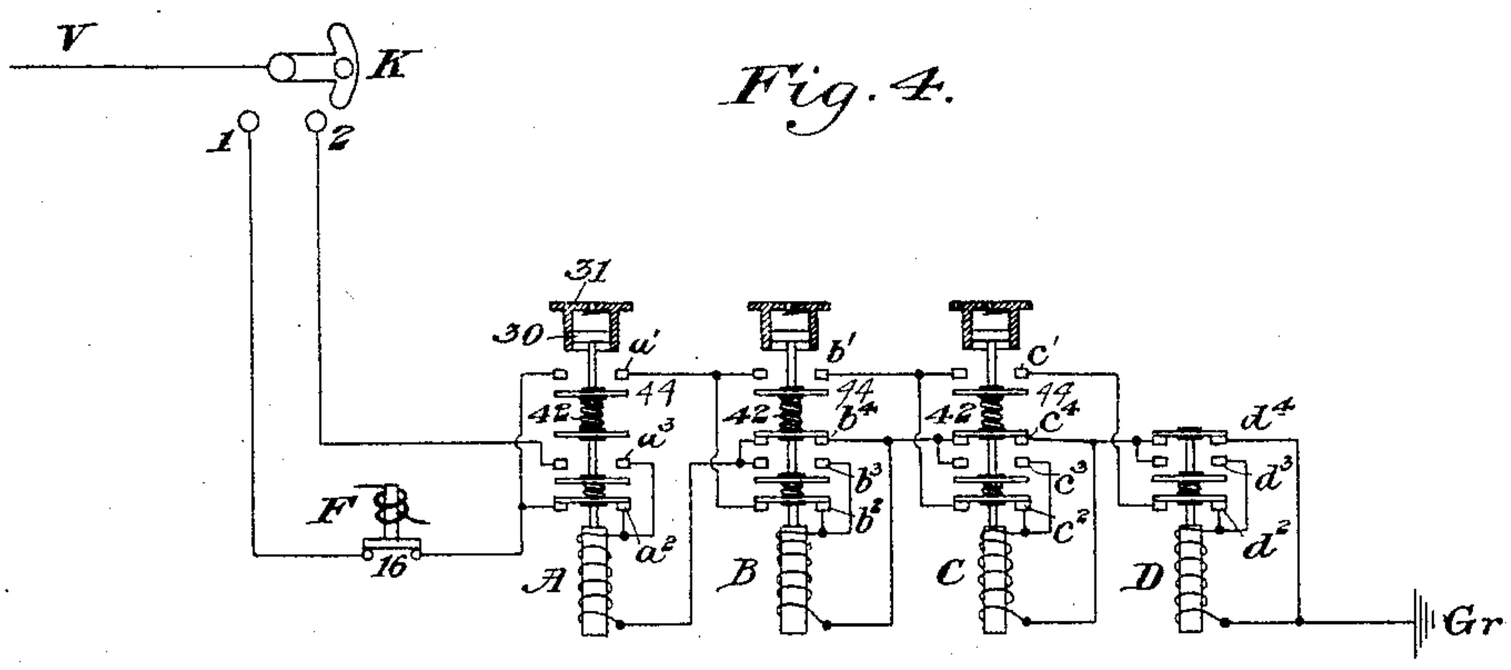


Fig. 4.



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3 SHEETS—SHEET 3.

Fig. 5.

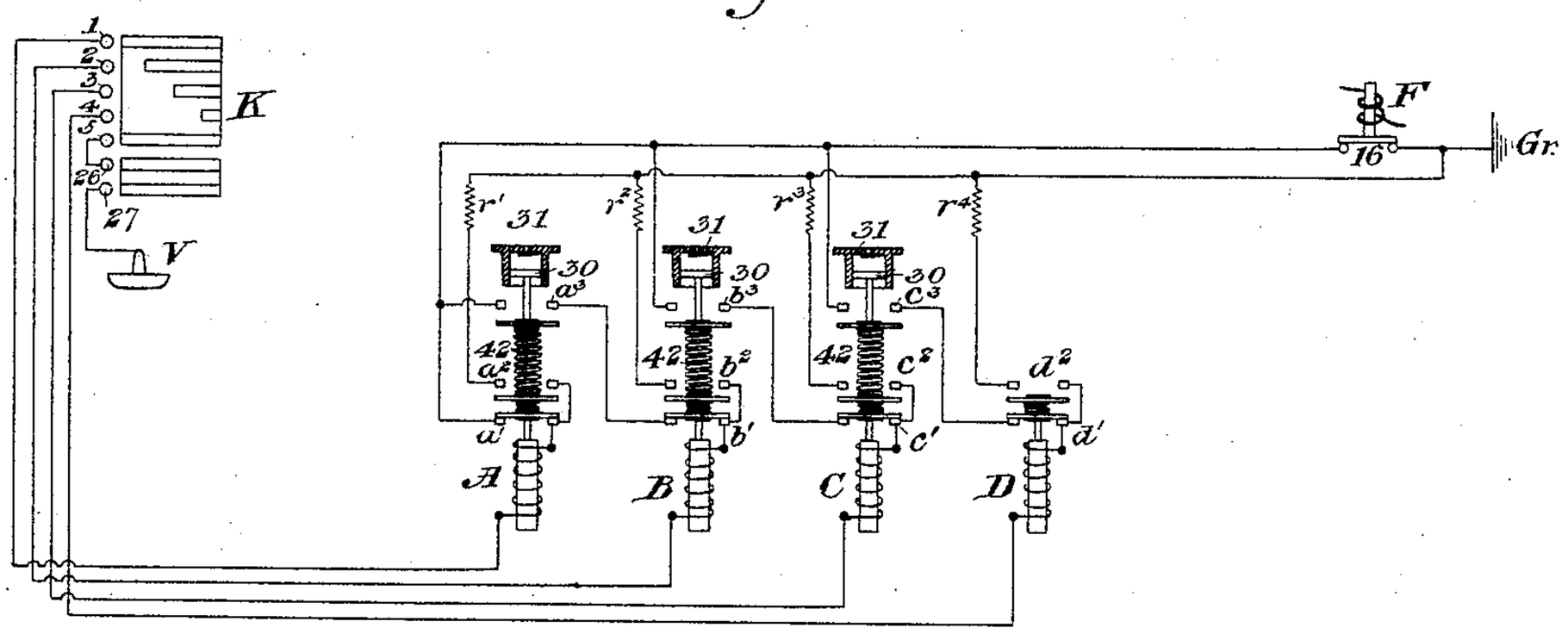
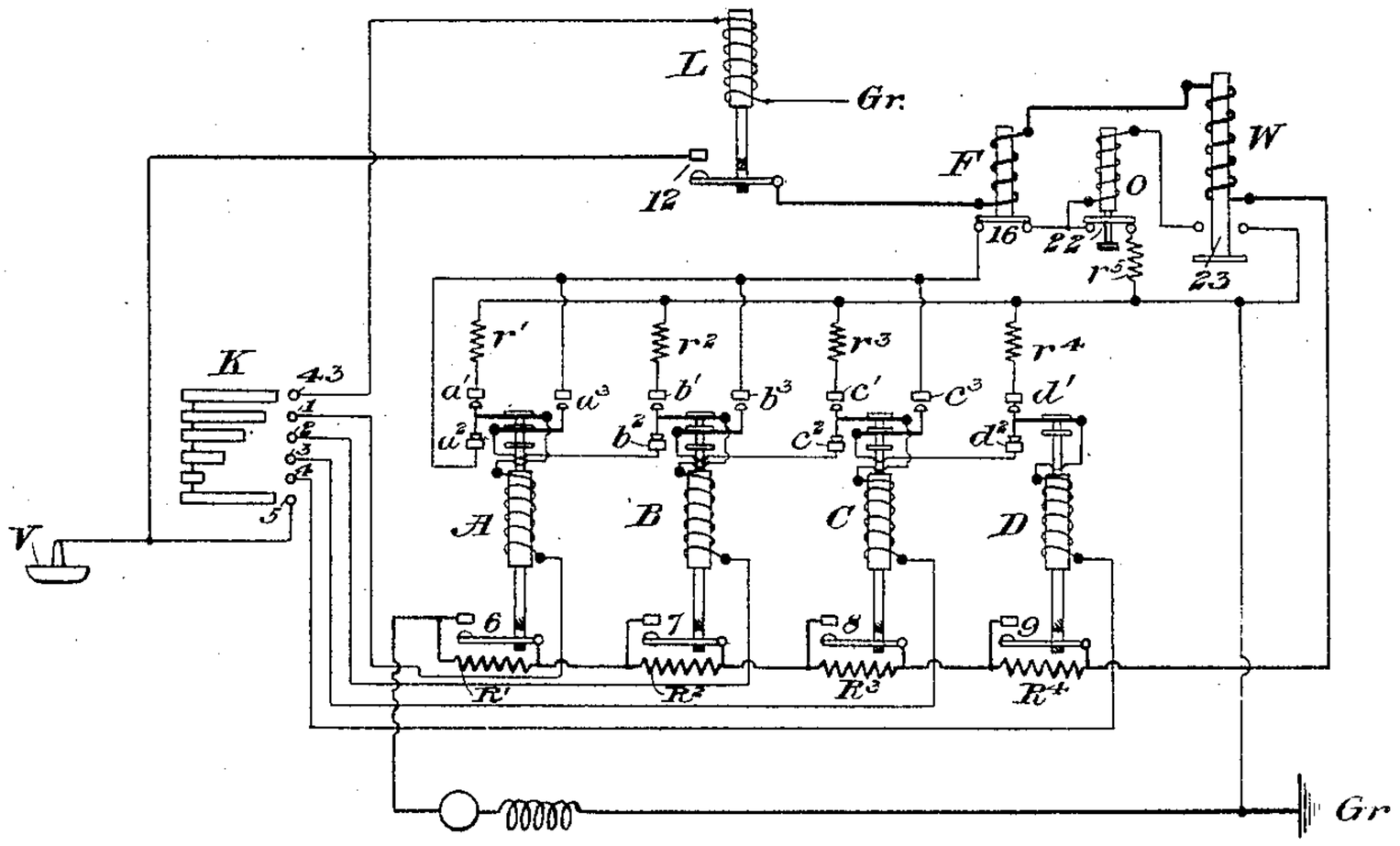


Fig. 6.



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No. 778,242. Patented December 27, 1904.

UNITED STATES PATENT OFFICE.

GEORGE H. HILL, OF GLENRIDGE, NEW JERSEY, ASSIGNOR TO SPRAGUE ELECTRIC COMPANY, A CORPORATION OF NEW JERSEY.

ELECTRICAL CONTROLLING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 778,242, dated December 27, 1904.

Application filed June 27, 1902. Serial No. 113,454.

To all whom it may concern:

Be it known that I, GEORGE H. HILL, of Glenridge, in the county of Essex and State of New Jersey, have invented an Electrical Controlling Apparatus, of which the following is a specification, reference being had to the accompanying drawings, in which—

Figure 1 is a diagram of an apparatus embodying my invention, and Figs. 2, 3, 4, 5, and 6 are diagrams showing modifications thereof.

This invention relates to improvements in electric controlling apparatus for motors, particularly that form of controlling apparatus in which the control is accomplished by a series of individually-actuated contacts so arranged that they can be governed by a manually-operated switch or controlling device or by any one of a number of such switches or controlling devices placed where desired. In such controllers, particularly where used on railway-cars, it is desirable that the contact devices be arranged *seriatim* and that the action of the magnets or other means which operate such contacts while primarily under the control of the master-switch or controlling device be rendered automatic as to their sequence and rate of action.

In my prior application, Serial No. 113,067, filed March 24, 1902, I have shown and described a motor-control system in which the contacts are automatically operated in succession and in which the progression may be stopped at any desired point. An actuating-circuit and a maintaining-circuit are provided for the magnets which actuate said contacts, and the master-switch is so constructed and arranged that the actuating-circuit may be opened to arrest the progressive operation of said contacts without opening the maintaining-circuit. Provision is thus made for checking the cutting out of the motor-circuit resistance at any point by the movement of the master-switch, and the motorman can operate at any speed he desires independently of the automatic progression. Furthermore, the automatic progression is checked by an automatic throttle whenever the current in the motor-circuit is too high, the progression continuing when the current in the motor-circuit falls below a predetermined value.

In such a system as above described there is great liability that the successive action of the contacts will be so rapid that when it is desired to check their progression by the master-switch a very prompt opening of the said actuating-circuit at the master-switch will be necessary in order to prevent several or all of the contacts from being actuated. Also with such an arrangement the action of the automatic throttle must be very prompt to check the progression of the magnets at the proper point. The necessity for such prompt action is very undesirable, inasmuch as a slow movement or delayed action, respectively, may result in the cutting out of too much resistance, thereby causing too great flow of current through the motors.

In the system hereinafter described I provide means for preventing a too rapid progression of the contacts in a system of electric control, said means comprising a checking device acting with the successive contact devices and adapted to check, at least temporarily, the operation of the succeeding contact device, thereby securing, by means of the master-switch or master controlling device or by means operated by the current in the controlled circuit, control of the extent and rate of progression of the contacts.

The checking device may be constructed in various ways, some of which I have illustrated in the accompanying drawings. In an electrically-operated system it may consist of a time-interval magnet in the control or actuating circuit which operates with the successive controlling-magnets and as each magnet is actuated checks the operation of the succeeding magnets, preferably by interrupting their actuating-circuit. When the operation of the succeeding magnets is checked in this manner, they cannot be operated until the actuating-circuit is again interrupted and established at the master-switch or by the operation of an automatic device controlled by the current in the motor-circuit.

To effect the progression of the controlling-

contact devices, which are arranged *seriatim*, the operator can successively close and interrupt the circuit at the master-switch or other master controlling device by moving the operating-handle back and forth. Each motion will cause one of the magnets to be energized and will operate the system by operations which correspond to the notching up of the ordinary street-car controller, or the operator may close the contact at the master-switch and keeping it closed may cause the checking and throttle magnets to effect the progression of the magnets by their automatic action in alternately interrupting and closing the actuating-circuit as the acceleration of the car and the cutting out of resistance alternately decrease and increase the flow of current through the motor-circuit. The checking device may also consist in retarding mechanism, a variety of forms of which I have shown in the drawings, which retards the successive contact devices, so that, the actuation of each contact device being dependent upon the complete operation of the preceding contact device, the retardation of the preceding contact device will introduce a time interval between their automatic operation sufficient to enable the motorman without the exercise of special skill or fitness to stop the progression at any stage by interrupting the circuit of the master-switch and sufficient also to enable the throttle-magnet, even if sluggish in its action, to stop the progression automatically at the proper point in case the current through the motor should be too great.

My invention also comprises a governing device or underload-magnet for the checking device which will automatically put the latter out of operation in case the conditions of current become such as to render it unnecessary or undesirable. The said governing device also operates under certain current conditions to release the checking device during the "notching-up" process in a manner which will be hereinafter fully described.

Other features of my invention will be described and stated in the claims.

In Fig. 1 of the drawings I have illustrated my invention as applied to a control system for railway-car motors employing an actuating-circuit and a maintaining-circuit, and while I intend to claim this combination specifically my invention as stated in other claims is not limited thereto.

In Fig. 1, A, B, C, and D are electromagnets operating switches or contacts 6 6′ 7 7′ 8 8′ 9 9′, each bridging a resistance R′ R^2 R^3 R^4, &c., in the motor-circuit.

S and M are magnets operating main contacts 10 10′ 11 11′, which effect, respectively, the series and parallel connections of the motors.

L is a magnet whose contacts 12 and 12′ open and close the motor-circuit.

E is an automatic multiple governing-magnet which controls the contacts 13, 14, and 15 in the circuits of the controlling-magnets. Besides controlling the main contacts above noted the magnets A, B, C, D, S, M, and L also control the small contacts a' a^2 a^3 a^4 b' b^2, &c., in the circuits of the controlling-magnets. Resistances r r are provided in the controlling-magnet circuits.

F is a throttle-magnet or overload-relay whose coil is in the controlled motor-circuit and which controls a contact 16 in the actuating-circuit of the controlling-magnets. Its function is to interrupt the actuating-circuit automatically when the current in the motor-circuit exceeds a predetermined value.

I′ I^2 I^3, &c., are blow-out magnets.

G and H are magnets operating the reverser-contacts J′, J^2, J^3, J^4, J^5, J^6, J^7, and J^8, which connect the motors for forward or backward movement.

17, 18, 19, 20, and 21 are contacts in the circuit of the controlling-magnets operated by the reverser-magnets G and H.

K and P are master-switches at the ends of the car, either one of which may be used to control the operation of the system.

Q is a cut-out switch connecting the circuits of the master-switch with the train-line T, which terminates at the ends of the car with the couplers U U. By connecting the couplers of successive cars by suitable jumpers a number of cars can be operated from any master-switch on any car.

O is the checking-magnet, which is in the actuating-circuit of the magnets A, B, C, and D and controls said circuit by means of its contact 22.

W is an underload-magnet which serves as a governor for the checking-magnet O. It operates contact 23, which is in circuit with the checking-magnet, and its coil is in shunt relation to a portion of the main motor resistance R^4.

X is a cut-out magnet controlling contacts 24 and 25. Its coil is in series with the line-magnet L.

The operation is as follows: Suppose the handle of the master-switch K is moved so that its contacts are in the first forward position, (marked *b*.) Current will then flow from the trolley-contact V to contact 26 on the master-switch through contacts 27 and 28 and out contact 4, branching at 4^a, part going through Q and the train-line to other cars and part through 4^b to the coil G of the reverser. The reverser is shown in position for forward operation of the motors. If it were in the position for backward movement, the current would pass through the coil G, contact 17, out 19 to contact L^4 of magnet L, to ground and by energizing the coil G would move the reverser to its forward position. Moving the reverser opens the contact 19 and makes the contact 21. Current then passes from 17 out 21 through magnet-coil X, mag-

net-coil L, contact L^2, contacts s^4 m^2, to ground. This energizes the magnet X, which closes its contacts 24 and 25, and also energizes the coil L, which closes its contacts 12 12′ and L^3 and opens L^2 and L^4. Current then passes from the line-contacts 26 and 27 of master-switch through the contact 28 and out contact 2, branching at 2′, part going to other cars and part out 2′ to magnet S, contact m^4, contact a^4, resistance r^5, contact L^3, to ground. This energizes the series magnet S, which closes its contacts 10, 10′, and s^3 and opens s^2 and s^4. Main circuit through the motors is now established from the trolley or rail contact V, blow-out I^7, contact 12, throttle-coil F, blow-out I′, resistances R′ R^2, blow-out I^3, resistance R^3, resistance R^4 and coil W in shunt therewith, reverser-contacts J′ and J^2, armature of motor No. 1, contacts J^3 J^4, field of motor No. 1, blow-out I^5, contacts 10 10′ 12′, resistance R^5, blow-out I^2, resistances R^6 R^7, blow-out I^4, resistance R^8, contacts J^5 J^6, armature of motor No. 2, contacts J^7 and J^8, field of motor No 2, to ground. If now the master-switch contacts be moved to position *c*, another circuit as follows is established: from line-contacts 26, 27, and 29 out 1, branching at 1′, part going to other cars and part through the throttle-contact 16, branching, part going through contact 22, resistance *r*′, contact a^2, magnet A, contacts b^4 c^4 d^4 24 s^3 m^2, to ground, part also going through the checking-magnet O, contact 23, and resistance r^2 to ground. Magnet W has been previously energized by current passing through its coil in shunt to the resistance R^4. The magnets O and A are thus simultaneously energized. Magnet O has its contact arranged loosely upon the stem of the plunger, so that the latter is capable of a limited loose motion, or it is otherwise arranged so that the plunger must move a certain distance before opening the contact. During the time that this contact is being opened the magnet A is closing its contacts 6 6′ *a*′ a^3 and is opening a^2 and a^4. When the contact a^2 is broken, the actuating-circuit from the contact 1 of the master-switch is cut off from the magnet A. When a^4 is opened, the maintaining-circuit through the magnet S is cut off from the resistance r^5 and contact L^3 and is shifted through the contact a^3, coil A, contacts b^4, c^4, d^4, 24, s^3, and m^2 to ground. The magnet A is thus maintained in its closed position. Closing the contact *a*′ of the magnet A shifts the actuating-circuit to contact b^2, coil B, and contacts c^4, d^4, 24, s^3, and m^2 to ground. The time required for the checking-magnet O to open its contact 22 is just sufficient to allow the magnet A to be operated, so that just as contact *a*′ closes and shifts the actuating-circuit to magnet B the actuating-circuit is broken by the checking-magnet at contact 22, and the magnet B is thus checked and cannot be energized. The checking-magnet O remains energized and holds the contact 22 open as long as the actuating-circuit is kept intact at the master-switch K and the throttle F. If the operation of the magnet A, the closing of its contacts 6 and 6′, and the consequent short-circuiting of the resistances R′ and R^5 in the motor-circuit has produced an increase in the current through the motors sufficient to cause the throttle-magnet F to be energized, it opens the contact 16 in the actuating-circuit. This will occur just after the checking-magnet O has opened its contact 22 and will cause the magnet O to be deënergized and to close its contact 22. The magnet B is not energized, because its current is interrupted at 16. If for any reason, however, when a section of resistance is cut out the current in the motor-circuit does not increase sufficiently to cause the throttle-magnet to operate to open the actuating-circuit, the said current will as it decreases in strength, due to the increasing counter electromotive force generated by the motors, fall off until a predetermined current strength is reached, at which the underload-magnet will operate to open the circuit through the checking-magnet, thereby deënergizing said magnet, and thus causing the actuating-circuit to be completed at the contact 22. When after the throttle has been operated the current in the motor-circuit falls to its normal predetermined value, the throttle-magnet F is deënergized and closes its contact 16. Also when after the magnet W has been operated and more resistance has been cut out of the motor-circuit the current in said motor-circuit rises above the point at which the said underload-magnet is set to operate the said magnet will be reënergized and close its contact 23. The operation of either the overload or the underload magnet as just described causes the completion of the circuit to the magnet B, which is energized, closing its contacts 7 and 7′, short-circuiting the resistances R^2 and R^6 in the motor-circuit, closing the contacts *b*′ and b^3, and opening b^2 and b^4. At the same time the magnet O is again energized and cuts off the actuating-circuit as soon as the magnet B is operated and before the magnet C can be energized. The same sequence of operations is repeated for the magnets C and D.

If at any stage of the progression the master-switch is moved to break contact at 1 and not at 2 and 4, the actuating-circuit is cut off from the magnets A B C D and magnet O. Those magnets of the series A, B, C, and D which have been actuated are maintained by the maintaining-circuit, and the magnet O closes the contact 22. If now the contact 1 on the master-switch be closed again, it will actuate the next magnet of the series A, B, C, and D if the throttle-magnet has not opened the contact 16 by reason of rise of the current in the motor-circuit above the normal value. The step-by-step progression of the

magnets A, B, C, and D is thus rendered positive and certain, unimpaired by sluggishness of action of the throttle-magnet, which may be caused by variable or sluggish change of current in the motor-circuit. It is, nevertheless, under the automatic control of the throttle-magnet and underload-magnet and through them of the current conditions in the motors and is also under the voluntary control of the operator, who may through the master-switch check the progression at any point or may allow it to continue. The operation of the master-switch to check the progression need not be rapid and does not require any special quickness or skill on the part of the motorman, since the continuance of the progression after any controlling-magnet has been operated requires that the checking-magnet O be deënergized, and to do this either the throttle-magnet F or underload-magnet W must first open and close its contact or the master-switch must open and close its contact 1. Repeated opening and closing of the circuit either at the throttle, magnet, or at the master-switch is needed to effect the progression of the magnets.

The functions of the checking-magnet governor W will now be described: The contact 23 of this magnet W is in the circuit of the magnet O, and its coil is in shunt to a portion of the resistances of the main motors, so that the current which passes through it is dependent upon the amount of current through the motor resistances. It is so wound and proportioned that it will close its contact 23 at a predetermined value of the motor-current, preferably at about the value required to operate the car-motors at the full or maximum speed on a level track, and will open the contact at a lower predetermined value. Under normal conditions at all times when the car is accelerating the current in the motors will be more than sufficient to operate the magnet W, so that normally contact 23 will be closed and the checking-magnet permitted to act as above described, checking the succeeding magnets from operating until the actuating-circuit is interrupted and again established by the throttle or master-switch. Suppose, however, due to a sudden drop in line-voltage or for any other reason, that the current supplied to the motor-circuit is not of sufficient strength to operate the throttle F to open the circuit at the contacts 16 after the checking-magnet O has operated to open the actuating-circuit at the contact 22, then as the said current in the motor-circuit gradually decreases, due to the increasing counter electromotive force generated by the motors as they increase in speed, a current strength will finally be reached corresponding to that at which the underload-magnet W is set to open. Then the underload-magnet will open the circuit through the checking-magnet and cause the actuating-circuit to be closed at the contact 22. Furthermore, suppose the car be at full speed and that without appreciable slowing of the car the current is cut off from all the magnets and then restored, as would be the case if the car should pass over a break in the contact-rail or if the master-switch should be moved momentarily to off position and back to "on." The interruption of the current will drop all the magnets to their normal or off position, and when current is restored the line-magnet L, series magnet S, and cut-off magnet X would be energized as in starting, and if the checking-magnet governor W were not present the first resistance-magnet A could close, but, owing to the action of the checking-magnet O, the second resistance-magnet would not be operated until the actuating-circuit was first interrupted and reëstablished either by the throttle-magnet or the master-switch; but the low value of the current due to the resistances in circuit and the counter electromotive force of the motors would not operate the throttle-magnet, and the motorman might not be apprised of the presence of too much resistance until he became aware of it by the slowing down of the car. This inconvenience is prevented by the magnet W, for as the current in the motors when contact is restored in the case supposed will be less than that required to energize the magnet W the contact 23 will remain open and will prevent the operation of the checking-magnet O. The magnet O being thus put out of action, there is nothing to prevent the successive operation of the magnets B C D, and they will at once automatically assume the same positions as before the break in the circuit.

If the restoration of the main circuit is delayed, allowing the car to slow or stop, or if for any other reason the motors take a large current when the main circuit is restored, the magnet W will bring the checking-magnet O into action and will check the progressive cutting out of resistance. The throttle also will become effective. With the master-switch now in its position *c* or full-series position, all magnets A, B, C, and D having operated, the motors are operating in series relation with no resistance in circuit.

When the last magnet D has operated, the closing of its contact d' makes circuit to the multiple governing-magnet E, as follows: from the master-switch contact 1, contacts 16 22, resistance r', contacts a' b' c' d', resistance r^6, coil E to ground. This energizes magnet E in a manner similar to the magnets A, B, C, and D under the governing action of the throttle, and its contacts 14 and 15 are closed and 13 opened. Closing the contact 15 causes current which is flowing through contact 4 at the master-switch to be divided, so that leaving the contact 25 of the magnet X current flows through contact 15 and coil E to ground and also through resistance r^3 and contact m^2 to ground. Suppose now the master-switch

handle be moved so that its contacts are in position *d*. Contacts 1 and 2 will be broken and 3 made at the master-switch. Breaking contact 2 cuts off the maintaining-circuit of the magnets S, A, B, C, and D, and these are de-energized and open their contacts 10 10′, 6 6′, 7 7′, &c. Current is thus cut off from the motors and all resistance is cut in. Closing the contact 3 makes circuit as follows: from line-contacts 26 and 27 to 28 and out 3, branching at 3′, part going to other cars and part to contact 14, (magnet E remaining energized during this change,) magnet M, contacts s^2 a^4, resistance r^5, contact L^3 to ground. This energizes the multiple magnet M, which closes its contacts 11, 11′, and m' and opens m^2 and m^4. Closing 11 and 11′ makes circuits through the motors in multiple as follows: from the line-contact or trolley V, branching and part going through blow-out I^7, contact 12, magnet F, blow-out I′, resistances R′ R^2, blow-out I^3, resistances R^3 R^4, contacts J′ J^2, armature of motor No. 1, contacts J^3 J^4, field of motor No. 1, contact 11 to ground, also from line-contact V, blow-out I^6, contacts 11′ 12′, resistance R^5, blow-out I^2, resistance R^6 R^7, blow-out I^4, resistance R^8, contacts J^5 J^6, armature of motor No. 2, contacts J^7 J^8, field of motor No. 2 to ground. If now the master-switch be moved farther to its position *e*, the actuating-circuit through the contact 1 is established and the magnets A, B, C, and D are successively energized and transferred to the maintaining-circuit, as above described for the series relation of motors, until all resistance is cut out and the motors are operating in multiple relation with no resistance. The same series of progression of the magnets will take place if the master-switch had been moved directly to its extreme position *e* from its off position instead of pausing on the intermediate positions.

Suppose that when all magnets have been deënergized and the car is at rest the master-switch be moved quickly from its off position to its extreme position *e*. Current will then pass from the line-contact 26 27 to 28, out 4, through the reverser-magnet G, cut-out magnet X, and line-magnet L, as first described, causing these magnets to be energized. Current also passes out contact 3, branching at 3′, part going to the contact 13 of magnet E to magnet S, contact m^4, &c., as first described, thus energizing the series magnet S. Current will then pass out contact 1, contact 16, &c., as first described, causing the magnets A, B, C, and D to be energized successively and when D is energized will pass through contact d' to magnet E, &c., as above described. Magnet E being energized breaks its contact 13, which cuts off the maintaining-circuit from the magnets S, A, B, C, and D. When these are de-energized and in their normal or off position, circuit is established from contact 3 at master-switch through contact 14 of magnet E (which has been closed when E was energized) and to magnet M, &c. This energizes the multiple magnet M, which puts the motors into multiple relation. Circuit from contact 1 of the master-switch is now reëstablished, and the magnets A, B, C, and D are again successively operated and cut resistance from the motor-circuit.

Fig. 2 shows a modification of the checking device by which the successively-acting magnets are brought under the positive and easy control of the master-switch and the throttle. The main contacts controlled by the magnets A B C D are not shown. Attached to the plungers of the magnets B C D are pistons 30, operating in dash-pots 31, which serve as the checking device to check temporarily or retard the action of the successive magnets. These dash-pots are fitted with valves 32, normally held closed by springs and opened by the pistons when they have made a determined portion of their stroke. Suppose that the master-switch handle be moved to make contact at 1 and 2. Current then flows from line V out 1, contacts 16 a^2, coil A, contact b^4, resistance r^4, contact c^4, resistance r^5, contact d^4, resistance r^6, to ground. This energizes the magnet A, which closes its main contact in the motor-circuit (not shown) and also closes its contacts a' a^3 and opens contact a^2. Opening contact a^2 and closing a^3 shifts the magnet A from the actuating-circuit to the maintaining-circuit and current flows from the line-contact V out master-switch contact 2, through contact a^3, magnet A, contact b^4, resistance r^4, contact c^4, resistance r^5, contact d^4, resistance r^6 to ground and maintains the magnet A. Closing the contact a' causes current to flow out contact 1 of the master-switch, through contact 16, contact a', resistance r', contact b^2, coil B, contact c^4, resistance r^5, contact d^4, resistance r^6 to ground. This energizes the second magnet B; but the dash-pot 31 renders slow the movement of its plunger until the piston 30 strikes the valve 32 and opens it, thus destroying the checking effect, the motion of the plunger being continued through the remainder of its stroke at a rapid rate. The piston has an adjusting-screw 30′, enabling its effective length to be adjusted, so that the checking effect is removed and the rapid motion begun before the main contacts (operated by the magnet and not shown) are closed. A quick closing of these contacts is thus secured. If, however, the operation of the magnet A and the closing of its contacts has caused sufficient current to flow in the main circuit to energize the throttle-magnet F and open its contact 16, the actuating-circuit of the controlling-magnet is thereby interrupted, and the magnet B cannot be energized until the throttle again closes its contact 16.

If for any reason the throttle F is sluggish in its action, the magnet B might be energized

and start to operate, as above described, before the throttle-magnet had opened the actuating-circuit; but the dash-pot 31 on the plunger and the consequent retarding of the first movement of magnet B introduces between its first movement and the closing of its main contacts an interval of time which is made ample to allow the throttle to act or to enable the operator to move the master-switch handle and cut off the actuating-circuit. When this is done, the magnet B resumes its normal position until the actuating-circuit is reëstablished.

I also provide in the motor-circuit a magnet W, which serves the purpose of a governor for the checking device or dash-pots. This magnet operates a vent-valve 32′ in a pipe 32ª, connected with each of the dash-pots 31, and is arranged to operate on a current in the motor-circuit of a predetermined value somewhat less than that required to energize the throttle-magnet F. Its action is as follows: As soon as the circuit is established through the motors with all resistance in sufficient current flows therein to actuate the magnet W, which closes its valve 32′, thus shutting off the vent to the dash-pots, and the magnets are successively operated under the retarding action of the dash-pots. Suppose, however, that all of these magnets have been actuated and that the motors are operating with no resistance in circuit. If now the main-current supply is shut off momentarily and then restored, the magnets A, B, C, and D will drop, and all resistance will be in the motor-circuit. This resistance, together with the counter electromotive force of the motors, will cause the current to be reduced below the amount required to energize magnet W, which will therefore open its valve 32′ and will vent all of the dash-pots. The dash-pots will not have any retarding effect upon the action of the magnets, which will act successively without any time interval and will quickly assume the position they held before the main current was broken.

Fig. 3 shows a further modification of the means whereby the successive action of the magnets is brought under easy control by the introduction of a time element between the operation of the successive magnets. Connected to each plunger of the several magnets A B C are catches 33, engaging with pawls 34 on an arm 35, which is pivoted at one end at 36. Concentric with the pivot of this arm is a ratchet-wheel 37, adapted to engage a pawl 38 on the arm when the arm is moving in one direction. This ratchet-wheel is provided with an escapement-wheel 39 and an escapement-movement 40. Suppose master-switch K be moved to make contact at 1 and 2. Current then flows from the line-contact V to the master-switch K, out 1, contact 16 of throttle F, through contact 22, contact a^2, coil A, contacts b^4 c^4 d^4 to ground. This energizes the magnet A, which closes its contacts a' a^3 and opens contact a^2, and through the catch 33 engaging with the pawl 34 it also lifts the arm 35. When it has completed its motion, the contact 22 is broken by reason of the arm 35 having been lifted. In breaking the contact a^2 the actuating-circuit is cut off from the magnet A, and in closing the contact a^3 circuit is established from line V out contact 2, contact a^3, magnet A, contacts b^4 c^4 d^4, to ground. This maintains the magnet A. If the closing of the main contact of said magnet has caused a large current to flow through the controlled circuit, the throttle F will open the contact 16 in the actuating-circuit. When the plunger of magnet A has lifted the arm 35 to its extreme position, the pawl 34 engages with the pin 41, which unseats it from the catch 33 and the arm 35 starts to fall; but as the pawl 38 now engages the ratchet 37 the arm can only fall by turning the ratchet and the escapement-wheel, which retard it and cause it to fall slowly. When it reaches its lower position, the contact 22 is closed, and if the throttle F has closed its contact 16 current flows from line V to contacts 1 16 22 a' b^2, magnet B, contacts c^4 d^4, to ground. This energizes the magnet B, which closes its contacts b' and b^3 and opens b^2 and b^4 and also lifts the arm 35 and opens its contact 22, the arm being finally released by the pin 41 and slowly dropping to its lower position. This is repeated for each one of the magnets, and the interval thus interposed between the action of the succeeding magnets affords ample time for the throttle F or the operator at the master-switch K to open the actuating-circuit and to check the progression of the magnets with precision.

In Fig. 4, which shows another modification of the means for introducing a delayed action of the successive magnets, the disk or contact-piece 44 of each of the magnets A B C is attached to the stem of the magnet-plunger by a spiral spring 42 and is also attached to the piston 30 of a dash-pot 31. When the magnet B, for example, is energized, the contacts b^2 b^4 are opened and b^3 is closed and the spring 42 is compressed and tends to close the contact b'; but the dash-pot 31 retards the action until the gradual escape of air permits the spring to move the piston sufficiently to close the contact b'. This occupies some time, and as the next magnet C cannot be energized until the contact b' is closed there is ample time for the throttle-magnet F to open the actuating-circuit (in case of excessive current) or for the operator to open the actuating-circuit at the master-switch.

The circuits in Fig. 4 are as follows: Suppose master-switch K has moved to contacts 1 and 2. Current flows from line V, contact 1, contact 16 of throttle-magnet F, contact a^2, magnet A, contacts b^4 c^4 d^4, to ground. This energizes the magnet A, which opens its con-

tact a^2 and closes at the same instant a^3. It also compresses the spring 42, which gradually pushes the piston into the dash-pot and closes the contact a'. . Opening contact a^2 and closing a^3 shifts the magnet A from the actuating to the maintaining circuit, and current flows from master-switch contact 2, contact a^3, coil A, contacts b^4 c^4 d^4, to ground. If now the throttle-magnet F opens its contact 16, or the master-switch is moved from contact 1, the magnet A is maintained, but no other magnets are energized. The slow movement of the contact a' in closing gives ample time in which the throttle can act or contact 1 be opened manually on the master-switch. If the master-switch contact 1 remains closed and throttle-contact 16 is closed, as soon as contact a' is closed circuit is made from line V, contacts 1 16 a', contact b^2, coil B, contacts c^4 d^4 to ground. This energizes magnet B, which closes its contact b^3 and opens b^2 and b^4. It also compresses the spring 42, which gradually moves the piston 30 and closes the contact b'. Magnet B is thus shifted from the actuating-circuit to the maintaining-circuit. These operations continue until all the magnets A, B, C, and D are operated, the operation of each following the preceding one at a given time interval.

Fig. 5 is another modification of the controlling system and shows means whereby a group of magnets each operated by a separate circuit from the master-switch are made successive in their action and in which the rate of progression of the magnets may be controlled automatically and the master-switch be moved directly to its extreme position (either in series or in multiple) or may be controlled manually by progressive movement of the master-switch from contact to contact. When controlled automatically, an interval of time is introduced between the successive action of the magnets, in which the throttle F may open the actuating-circuit. Suppose the contacts of master-switch K be moved to their extreme position. Current flows from line-contact V through contacts 27 26 5, out 1, coil A, contacts a' 16 to ground. This operates the magnet A, which opens contact a' and closes a^2, thereby causing current to pass from the coil A through contact a^2, resistance r' to ground. The spring 42 is compressed and slowly moves the piston into the dash-pot and closes the contact a^3. Current then flows from the contact 2 of the master-switch, coil B, contacts b', a^3, and 16 to ground. Magnet B is thus operated and cuts resistance r^2 into circuit with its coil, and the spring 42 proceeds to close the contacts b^3, &c. During the time between the operation of the respective magnets there is ample time for throttle F to act. It is evident that the master-switch contacts can be moved slowly or stopped at any point, and thereby control the rate of operation of the successive magnets at any rate slower than would take place by reason of the dash-pot's operation.

Fig. 6 is a further modification and shows a control system in which each magnet A, B, C, and D is connected by a separate circuit with the master-switch K and in which the rate of progression of the magnets may be controlled automatically or manually, as desired, as explained above with reference to Fig. 5. Suppose the master-switch handle is moved so that its contacts are in the extreme position. Current will flow from the line-contact V to contact 5, out 43, through magnet L to ground. This will energize the magnet L, which will close its contact 12, causing current to flow through the main motor from the line-contact V, contact 12, throttle-magnet F, magnet W, motor-resistances R^4 R^3 R^2 R' to ground. This current flowing through the motor is sufficient to energize the magnet W and to close its contact 23. Current now flows from the line-contact V, contact 5 of the master-switch, out 1, through coil A, contacts a^2 and 16, branching partly through contact 22, resistance r^5 to ground, and partly through coil O and contact 23 to ground. This energizes the magnet A, which closes its contact 6, thus bridging resistance R', and it also closes a' a^3 and opens a^2. The magnet O being energized opens its contact 22; but as this contact is loose upon its stem it does not open until the magnet A has completed its movement. By opening the contact a^2 and closing the contact a' the current through the magnet A is shifted from the contact 16, &c., through resistance r' to ground and maintains the magnet A. At the same time the contact a^3 being closed current flows from the contact 2 of the master-switch, coil B, contacts b^2 a^3 16, through magnet O and contact 23 to ground. The magnet O is thus maintained, and its contact 22 remains open. As magnet O is made of high resistance, the current maintaining it and passing through magnet B is not sufficient to energize magnet B. If the closing of contact 6 by magnet A and a short-circuiting of the resistance R' has caused an increase of current through the motor sufficient to energize the throttle F, this opens its contact 16, thus cutting off the current from magnet O, which then closes its contact 22. As soon as the current has dropped to its normal value the magnet F closes its contact 16, and the current flowing through the magnet B passes through the contact 16, branching at 22, part going through the magnet O and part through contact 22 and resistance r^5 to ground. If the current in the motor-circuit for any reason does not increase sufficiently to actuate the throttle F, the said current as it falls off due to the increasing counter electromotive force in the motor-circuit will drop sufficiently to allow the magnet W to open the circuit through the magnet O, thereby

allowing the actuating-circuit to be closed at the contact 22. This gives sufficient current to energize the magnet B, which proceeds to close its contact 7, b', and b^3 and open its contact b^2. The resistance R^2 is thus short-circuited, the magnet F energized, &c., as before, and these operations are repeated for the remaining magnets D of the group. Each magnet is thus closed successively and the remaining magnets checked by the magnet O from closing until the throttle-magnet F has opened and closed its contact 16 or the magnet W has operated and closed its contact 23. If all magnets have operated and the motor is running with no resistance in circuit and the main current-supply to the car be interrupted for a short time and then be reëstablished before the motor has materially decreased its speed, the interruption of the current thus occasioned deënergizes all the magnets and opens the motor-contacts. When a main contact is again established, the magnet L will be energized and the motor-circuit established through the resistances $R' R^2 R^3 R^4$; but as the motor speed has not slackened the current in the motor-circuit will be lower than was flowing before the main contact had been broken and will not be sufficient to energize the magnet F or to energize and close the contact of the magnet W. The checking-magnet O is therefore put out of action by interruption of its circuit. Current will flow from 1 of the master-switch through magnet A, contact a^2, contact 16 22, resistance r^5 to ground. As soon as the magnet A has been actuated current flows from the contact 2 of the master-switch through magnet B to contacts b^2 a^3 16 22, resistance r^5, to ground. As soon as B is actuated current flows from the master-switch contact 3 through magnet C, &c., to ground and similarly from contact 4 and magnet D to ground. The magnets are thus energized successively without any checking action and quickly assume the position they held before the break in main contact. If instead of moving the master-switch directly to its extreme position it is moved progressively through its various positions, the magnets A B C D can be controlled directly thereby at any desired rate slower than that produced by the checking-magnet O and the throttle F. If it be moved to any intermediate position, the progression of the magnets A B C, &c., will continue under the influence of the checking-magnet O, the magnet W, and throttle F until the magnets corresponding to the position of the master-switch have been actuated. The progression of the magnets may thus be effected through the master-switch, or the master-switch may be thrown to its extreme position, in which case the progression of the magnets will be entirely automatic.

In Fig. 6 the governing-magnet W is shown with its coil in the motor-circuit, while in Fig. 1 this magnet is shown as having its coil connected in shunt to a portion of the resistance in the motor-circuit. These two arrangements may be used as equivalents, the magnet in each case being energized at a determined value of the current in the motor-circuit.

Within the scope of my invention as defined in the claims the apparatus may be modified in many other particulars, and parts of my invention may be used separately or in other combinations, since

I claim—

1. In a system of electrical control, the combination of a group of successively-operating magnets, a controlling-circuit and master-switch, means for effecting automatic progression of the magnets, and a checking device out of the controlled circuit, acting with the successive magnets and adapted to check temporarily at least the operation of the succeeding magnet, whereby control at the master-switch of the extent of progression of the group of magnets is secured; substantially as described.

2. In a system of electrical control, the combination of a group of successively-acting magnets, means for effecting their automatic progression, a master-switch, circuits operated by the master-switch and adapted to arrest the progression of the magnets and maintain the magnets already actuated, and an automatic checking device out of the controlled circuit adapted to assist the arresting operation at the master-switch; substantially as described.

3. In a system of electrical control, the combination of a group of successively-acting magnets, a controlling-circuit and master-switch, means for effecting automatic progression of the magnets, and a checking device acting with the successive magnets and adapted to check temporarily at least the operation of the succeeding magnet whereby control at the master-switch of the extent of progression of the group of magnets is secured, and an automatic governing-magnet in the controlled circuit adapted to interrupt the controlling-circuit; substantially as described.

4. In a system of electrical control, the combination of a group of successively-acting magnets, a controlling-circuit and master-switch, means for effecting automatic progression of the magnets, and a checking device acting with the successive magnets and adapted to check temporarily at least the operation of the succeeding magnet, whereby control at the master-switch of the extent of progression of the group of magnets is secured, and means for maintaining the magnets when they are operated; substantially as described.

5. In a system of control for electric motors, the combination of a master-switch, a number of successively-operating contact-controlling magnets and their actuating-circuits, and an

automatic circuit-interrupting magnet actuated by the circuit of the master-switch and arranged to follow the motion of the magnets to interrupt the circuit of a succeeding magnet; substantially as described.

6. In a system of electrical control, the combination of a hand-switch, a number of successively-acting magnets controlling contacts, an actuating-circuit and a maintaining-circuit extending from the master-switch, and a checking device not in the controlled circuit acting with the magnets and adapted to interrupt the actuating-circuit of the succeeding magnets; substantially as described.

7. In a system of electrical control, the combination of a hand-switch, a number of successively-acting magnets controlling contacts, an actuating-circuit and a maintaining-circuit extending from the master-switch, and an electromagnetic checking device in the controlling-circuit adapted at successive operations of said circuit to interrupt the same automatically; substantially as described.

8. In a system of electrical control, the combination of a group of successively-acting magnets, a controlling-circuit and master-switch, and an electromagnetic checking device out of the controlled circuit adapted at successive operations of the controlling-circuit to check a succeeding magnet; substantially as described.

9. In a system of electrical control, the combination of a group of successively-acting magnets, a controlling-circuit and master-switch and an electromagnetic checking device out of the controlled circuit adapted at successive operations of the controlling-circuit to interrupt said circuit; substantially as described.

10. In a system of electrical control, the combination of a group of successively-acting magnets operating contacts, a controlling-circuit therefor, and a checking device out of the controlled circuit adapted to free successive magnets as the establishing of the actuating-circuit is repeated; substantially as described.

11. In a system of electrical control, the combination of a master-switch and controlling-circuit, an electromagnetic device controlled by said circuit, and a checking-magnet energized by the operation of the master-switch and adapted to interrupt said circuit automatically, whereby a step-by-step control is effected by repeated operation of the master-switch; substantially as described.

12. In a system of electrical control, the combination of a master-switch and controlling-circuit, an electromagnetic device controlled by said circuit, and a checking-magnet energized by the operation of the master-switch and having a prolonged motion, said checking device being adapted to interrupt said circuit automatically, whereby a step-by-step control is effected by repeated operation of the master-switch; substantially as described.

13. In a system of electrical control, the combination of a group of successively-acting magnets, a controlling-circuit and master-switch, means actuated with the magnets and adapted to include a succeeding magnet in the circuit, and a checking device having a prolonged motion and acting with the successive magnets and adapted to check temporarily at least the operation of the succeeding magnet, whereby control at the master-switch of the extent of progression of the group of magnets is secured; substantially as described.

14. In a system of electrical control, the combination of a group of successively-acting magnets, a controlling-circuit and master-switch, means actuated with the magnets and adapted to include a succeeding magnet in the circuit, and a checking device acting with the successive magnets and adapted to check temporarily at least the operation of the succeeding magnet, and a governing-magnet connected with the controlled circuit and adapted to put the checking device out of action when the current falls below a desired limit; substantially as described.

15. In a system of electrical control the combination of a group of successively-acting magnets, a controlling-circuit and master-switch, means actuated with the magnets and adapted to include a succeeding magnet in the circuit, a checking device acting with the successive magnets and adapted to check temporarily at least the operation of the succeeding magnet, a governing-magnet connected with the controlled circuit and adapted to put the checking device out of action when the current falls below a desired limit, and a throttle-magnet also connected with the controlled circuit and adapted to interrupt the controlling-circuit when the current exceeds a desired limit; substantially as described.

16. In a system of electrical control the combination of a group of successively-acting magnets, a controlling-circuit and master-switch, a checking-electromagnet in the controlling-circuit adapted to act with the said magnets, and a contact actuated thereby; substantially as described.

17. In a system of electrical control the combination of a group of successively-acting magnets, a controlling-circuit and master-switch, resistances controlled by said magnets, a checking-magnet O in the controlling-circuit, and a magnet W energized by the controlled circuit, and adapted to interrupt the circuit of the checking-magnet; substantially as described.

18. In a system of electrical control the combination of a group of successively-acting magnets, a controlling-circuit and master-switch, resistances controlled by said magnets, a checking-magnet O in the controlling-circuit, a magnet W energized by the controlled circuit and adapted to interrupt the circuit of the checking-magnet, and a throttle-magnet in the controlled circuit adapted to interrupt the controlling-circuit; substantially as described.

19. In a system of electrical control the combination of a group of successively-acting resistance-controlling magnets, a master-switch having series and multiple connections, a series magnet and a multple magnet, controlling-circuits common to the resistance-controlling magnets and respectively to the series and multiple magnets, and an electromagnetic checking device adapted at successive operations of the controlling-circuits to check a succeeding resistance-controlling magnet during series and multiple connections at the master-switch; substantially as described.

20. The combination with a motor-controller having a series of separate contacts, of an actuating-circuit controlled by the respective contacts and adapted to effect automatically progressive operation of the contacts, a master-switch having means for arresting the progression of the contacts without releasing the contacts already operated, and a time-limiting device, controlling the closing of the actuating-circuit; substantially as described.

21. In a system of electrical control, the combination of a motor-circuit, a resistance in the motor-circuit, a plurality of magnets controlling separate portions of the resistance and arranged *seriatim*, a normally open circuit through the coil of each magnet, connections between the successive magnets whereby the operation of any one of the magnets completes the circuit through the coil of the magnet next in succession, and a time-interval magnet controlling the operation of the first-named magnets; substantially as described.

22. In a system of electrical control, the combination of a motor-circuit, a resistance in the motor-circuit, a plurality of magnets controlling separate portions of the resistance in the motor-circuit and arranged *seriatim*, the coil of each magnet except the first having a terminal at one end with which a conducting-plate carried by the armature next preceding is adapted to contact to complete the circuit through said coil, a circuit through said magnets, and a time-interval magnet controlling the circuit through said magnets and therefore the operation of the magnets themselves; substantially as described.

23. In a system of electrical control, the combination of a group of successively-operating magnets, a controlling-circuit and master-switch, means for effecting automatic progression of the magnets, a checking device acting with the successive magnets and adapted to check the operation of the succeeding magnet, and means operated by the current in the controlled circuit for releasing the checking device.

24. In a system of electrical control, the combination of a group of successively-operating magnets, a controlling-circuit and master-switch, means for effecting automatic progression of the magnets, a checking device acting with the successive magnets to prevent the operation of the next succeeding magnet, and a throttle-magnet adapted to release the checking device.

25. In a system of electrical control, the combination of a group of successively-operating magnets, a controlling-circuit and master-switch, means for effecting automatic progression of the magnets, an electromagnetically-actuated checking device acting with the successive magnets to prevent the operation of the next succeeding magnet, and a throttle-magnet adapted to open the actuating-circuit of the checking device.

26. In combination, a group of successively-operating magnets, a master-switch, an actuating and a maintaining circuit for the magnets, means whereby the magnets are successively included in the actuating-circuit and shifted to the maintaining-circuit, a checking device acting with the successive magnets to prevent the operation of a succeeding magnet, and means for releasing said checking device.

27. In combination, a group of successively-operating magnets, a master-switch, an actuating and a maintaining circuit for the magnets, means whereby the magnets are successively included in the actuating-circuit and shifted to the maintaining-circuit, a checking device acting with the successive magnets to prevent the operation of a succeeding magnet, and means operated by the current in the controlled circuit for releasing said checking device.

28. In a system of electrical control, the combination of a group of successively-operating magnets, a master-switch, an actuating-circuit and a maintaining-circuit for the magnets, means whereby the magnets are successively included in the actuating-circuit and shifted to the maintaining-circuit, a checking device acting with the successive magnets to open the actuating-circuit, and means operated by the current in the circuit to be controlled for releasing said checking device.

29. In a system of electrical control, the combination of a group of successively-operating magnets, a master-switch, an actuating-circuit and a maintaining-circuit for the magnets, means whereby the magnets are successively included in the actuating-circuit and shifted to the maintaining-circuit, a checking-magnet operating to open the actuating-circuit and arranged to be energized when the actuating-circuit is closed at the master-switch, and means operated by the current in the circuit to be controlled for opening the circuit of the checking-magnet.

30. In a system of electrical control, the combination of a group of successively-operating magnets, a controlling-circuit and master-switch, means for effecting automatic progression of the contacts, a checking device acting with the successive magnets to prevent the operation of the next succeeding magnet, and a

throttle-magnet connected in the circuit to be controlled and adapted to release said checking device when the current in the controlled circuit rises above a predetermined value.

31. In a system of electrical control, the combination of a group of successively-operating magnets, a controlling-circuit and master-switch, means for effecting automatic progression of the contacts, a checking device acting with the successive magnets to prevent the operation of the next succeeding magnet, and an underload-magnet adapted to release said checking device when the current in the controlled circuit falls below a predetermined value.

32. In a system of electrical control, the combination of a group of successively-operating magnets, a controlling-circuit and master-switch, means for effecting automatic progression of the contacts, a checking device acting with the successive magnets to prevent the operation of the next succeeding magnet, a throttle-magnet connected in the circuit to be controlled and adapted to release said checking device when the current in the controlled circuit rises above a predetermined value, and an underload-magnet adapted to release said checking device when the current in the controlled circuit falls below another predetermined value.

33. In a system of electrical control, the combination of a number of successively-operating magnets, a master-switch, an actuating-circuit and a maintaining-circuit for the magnets, means whereby the magnets are successively included in the actuating-circuit and shifted to the maintaining-circuit, a checking-magnet operating to open the actuating-circuit, means for opening the circuit through the checking-magnet when the current in the controlled circuit rises above a predetermined value, and means for opening the circuit through the checking-magnet when the current in the controlled circuit falls below another predetermined value.

34. In a system of electric control, the combination of a motor-circuit, a resistance in the motor-circuit, a plurality of contact devices controlling separate portions of the resistance and arranged *seriatim*, means to close the contacts in succession, and a time-interval magnet to control the operation of said means.

35. In a system of electric control, the combination of a motor-circuit, a resistance in the motor-circuit, a plurality of contact devices controlling separate portions of the resistance and arranged *seriatim*, means to close the contacts in succession, a time-interval magnet to control the operation of said means, and means for controlling the extent of acceleration of the motors in said motor-circuit.

36. In a system of electric control, the combination of a motor-circuit, a resistance in the motor-circuit, a plurality of contact devices controlling separate portions of the resistance and arranged *seriatim*, means to close the contacts in succession, a time-interval magnet to control the operation of said means, a master-controller, and means whereby said time-interval magnet may be thrown out of operation by a movement of said master-controller.

37. In a system of electric control, the combination of a motor-circuit, a resistance in the motor-circuit, a plurality of contact devices controlling separate portions of the resistance and arranged *seriatim*, means to close the contacts in succession, a time-interval magnet to control the operation of said means, and means operated by current in the motor-circuit for controlling the operation of the time-interval magnet.

38. In a system of electric control, the combination of a motor-circuit, a resistance in the motor-circuit, a plurality of contact devices controlling separate portions of the resistance and arranged *seriatim*, means to close the contacts in succession, a time-interval magnet to control the operation of said means, and an overload-magnet having its actuating-coil connected in the motor-circuit adapted to control the operation of said time-interval magnet.

39. In a system of electric control, the combination of a motor-circuit, a resistance in the motor-circuit, a plurality of contact devices controlling separate portions of the resistance and arranged *seriatim*, means to close the contacts in succession, a time-interval magnet to control the operation of said means, and an underload-magnet adapted to control the operation of said time-interval magnet, said underload-magnet having its actuating-coil connected in the motor-circuit.

40. In a system of electric control, the combination of a motor-circuit, a resistance in the motor-circuit, a plurality of contact devices controlling separate portions of the resistance and arranged *seriatim*, means to close the contacts in succession, a time-interval magnet to control the operation of said means, an underload-magnet and an overload-magnet adapted to control the operation of said time-interval magnet, said underload and overload magnets having their actuating-coils connected in the motor-circuit.

41. In a system of electrical control, the combination of a group of successively-acting contact devices, and an electromagnetic checking device out of the controlled circuit adapted as said contact devices successively operate to check the operation of a succeeding contact device.

42. In a system of electrical control, the combination of a group of successively-acting contact devices, a master-controller, means actuated with the contact devices whereby the next succeeding contact device may be operated, and a checking device having a prolonged motion and acting with the successive contact devices to check at least temporarily the operation of the succeeding contact de-

vice, whereby control at the master-controller of the extent of progression of the group of contact devices is secured.

43. In a system of electrical control, the combination of a group of successively-acting contact devices, a master-controller, means actuated with the contact devices whereby the next succeeding contact device may be operated, and a time-interval magnet acting with the successive contact devices to check the operation of the succeeding contact device.

44. In a system of electrical control, the combination of a group of successively-acting contact devices, a master-controller, means actuated with the contact devices whereby the next succeeding contact device may be operated, a time-interval magnet acting with the successive contact devices to check the operation of the succeeding contact device, and means operated by current in the controlled circuit for controlling the operation of said time-interval magnet.

45. In a system of electrical control, the combination of a group of successively-acting resistance-controlling contact devices, a master-controller having series and multiple connections, a series-contact device and a multiple-contact device, means for connecting said contact devices to said master-controller, and a time-interval magnet adapted when the contact devices are successively operated to check a succeeding resistance-controlling contact device during series and multiple connections at the master-controller.

46. In a system of electrical control, the combination of a group of successively-operating contact devices, means for effecting automatic progression of said contact devices, and a checking device operating independently of said contact devices and of the controlled circuit to control the successive operation of said contact devices.

47. In a system of electrical control, the combination of a group of successively-operating contact devices, means for effecting automatic progression of said contact devices, and a checking device operating independently of said contact devices and of the controlled circuit, adapted as said contact devices successively operate to check the operation of a succeeding contact device.

48. In a system of electric control, the combination of a master-switch and controlling-circuit, an electromagnetic device controlled by said circuit, and a checking-magnet energized by the operation of the master-switch and adapted to interrupt said circuit automatically, whereby a step-by-step control is effected, substantially as described.

49. The combination with a motor-controller having a series of separate contacts, of an actuating-circuit controlled by the respective contacts and adapted to effect automatically progressive operation of the contacts, a master-switch, and means for arresting the progression of the contacts without releasing the contacts already operated, and a time-limiting device controlling the closing of the actuating-circuit, substantially as described.

In testimony whereof I have hereunto set my hand.

GEORGE H. HILL.

Witnesses:
JAMES LEITCH,
EDWIN P. JUENGER.