No. 697,445. Patented Apr. 15, 1902.

F. E. CASE.

ELECTRIC CONTROLLER.

(Application filed June 22, 1898.)

(No Model.) 3 Sheets—Sheet 1.

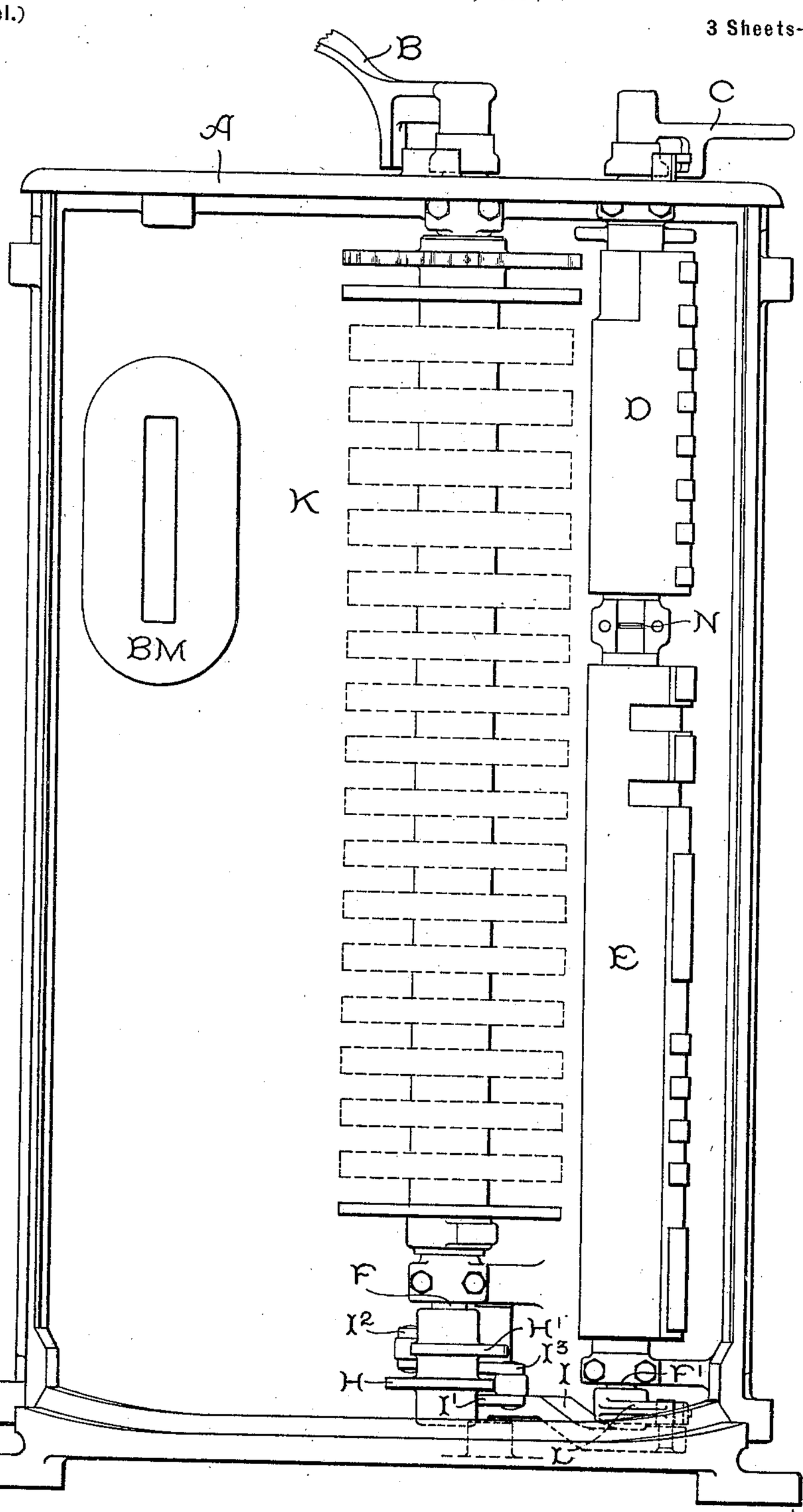

FIG. 1.

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(No Model.) 3 Sheets—Sheet 2.

FIG. 2.

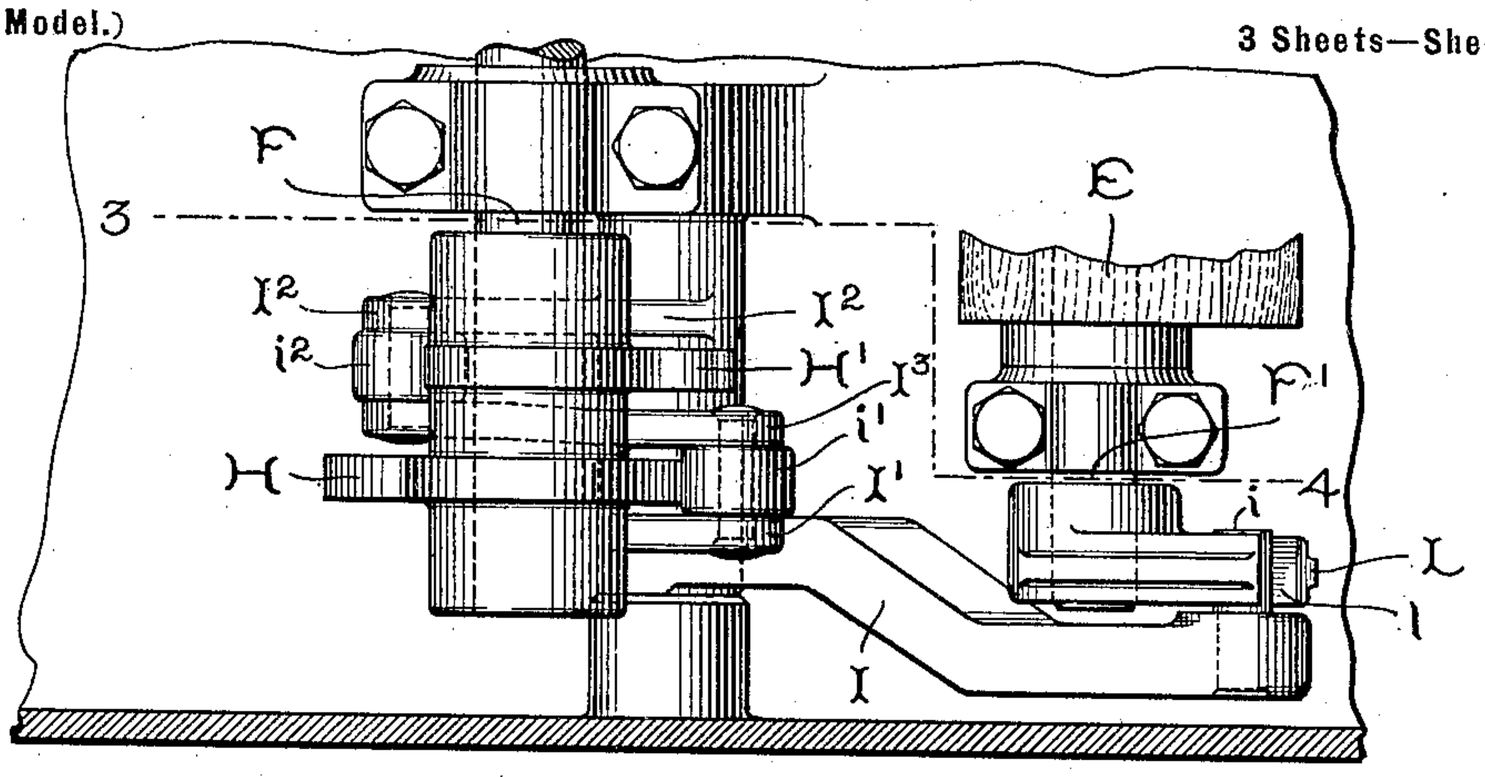


FIG. 3.

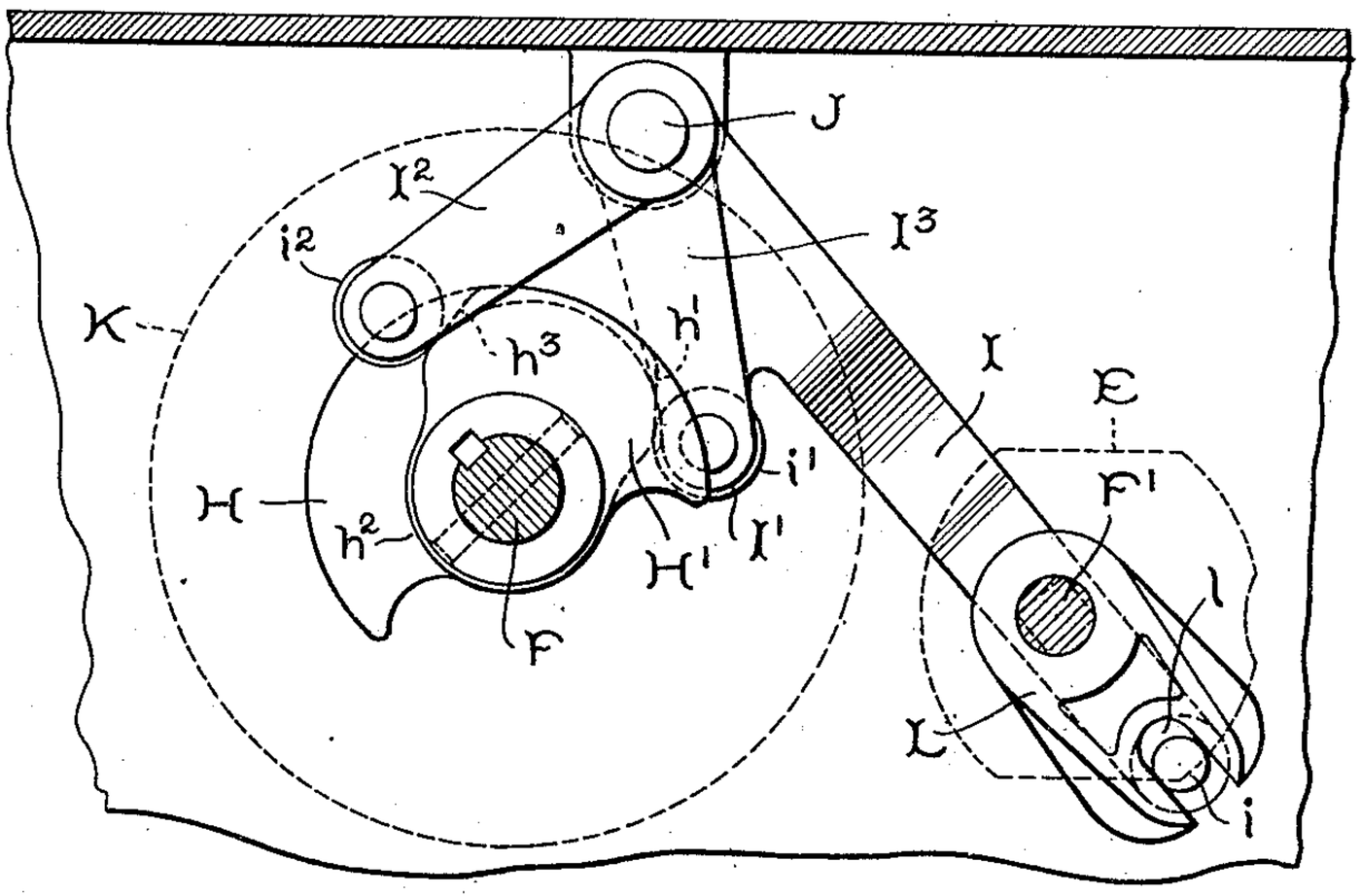
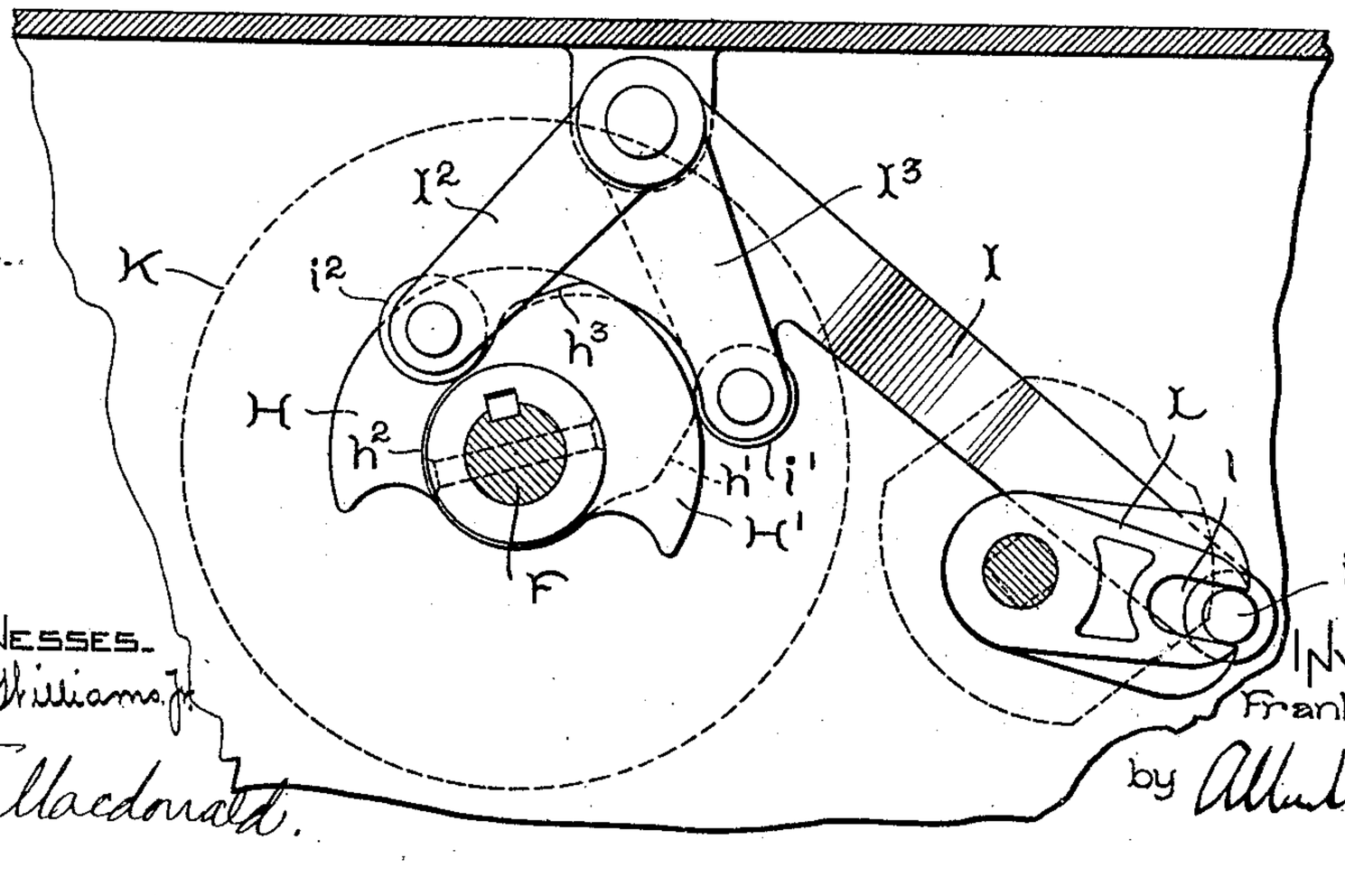


FIG. 4.



WITNESSES.
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F. E. CASE.

ELECTRIC CONTROLLER.

(Application filed June 22, 1898.)

(No Model.)

3 Sheets—Sheet 3.

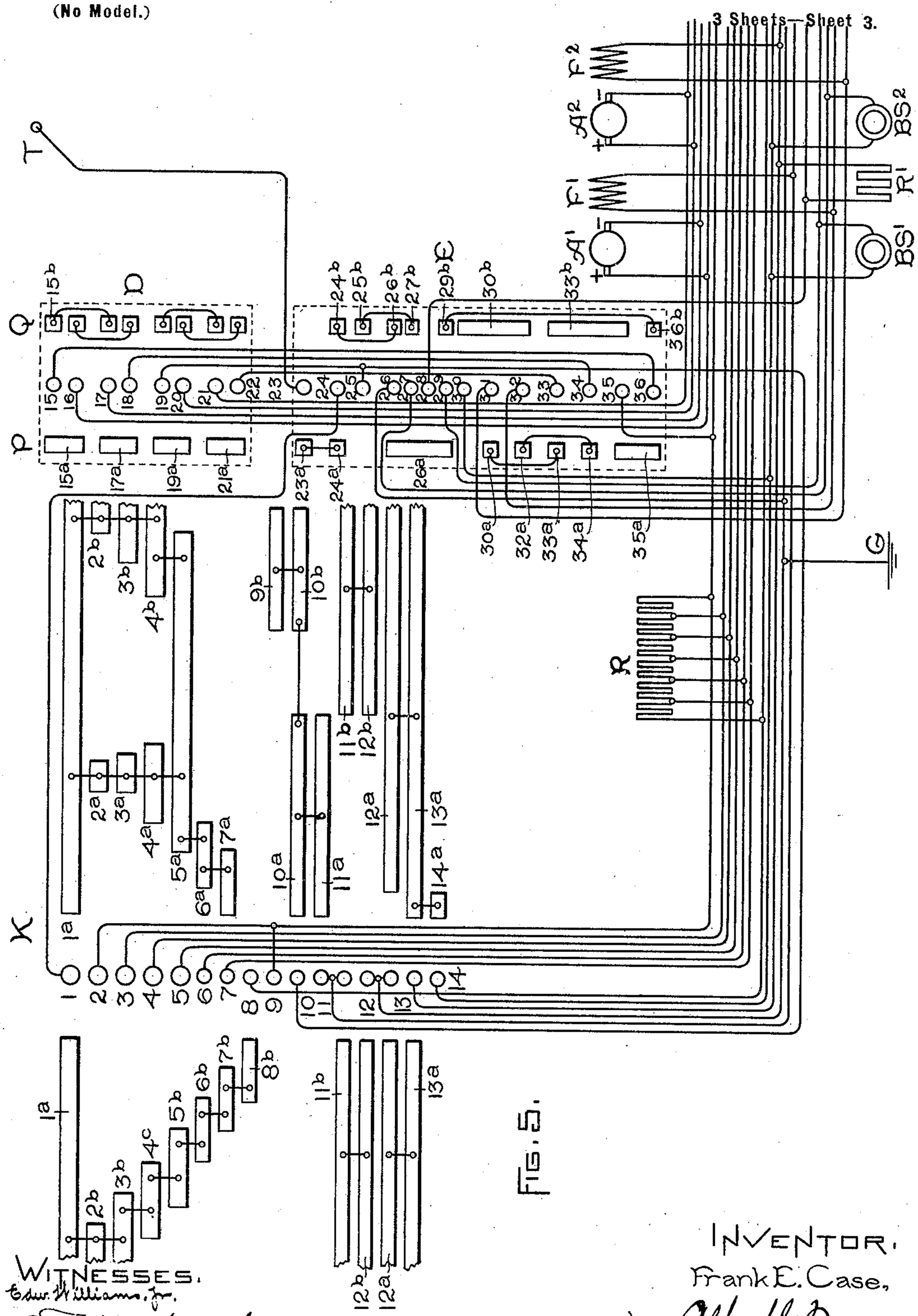

FIG. 5.

WITNESSES.
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UNITED STATES PATENT OFFICE.

FRANK E. CASE, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRIC CONTROLLER.

SPECIFICATION forming part of Letters Patent No. 697,445, dated April 15, 1902.

Application filed June 22, 1898. Serial No. 684,119. (No model.)

To all whom it may concern:

Be it known that I, FRANK E. CASE, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Electric Controllers, (Case No. 749,) of which the following is a specification.

My present invention relates to the construction of controlling devices for electric motors, and has for its object to devise a controller which shall be adapted to regulate the motors from rest to highest speed when used for propulsion and by turning the handle of the controller in the opposite direction to convert the motors into generators for use with electric brakes. This type of controller is now well-known in the art. In general these controllers embody all the connections in a single cylinder, with the exception of the usual reversing-switch. The difficulty with this construction has been that it makes the cylinder unduly long, so that the case of the controller is higher than is convenient for the operator. The connections have also been embraced in two cylindrical switches operated by separate handles and, with the reversing-switch, provided with interlocking devices of one kind or another, such that the improper manipulation of the various handles is prevented. While this is a good and efficient form of apparatus, as is also the first one named, it is also open in some degree to the objection of making the controller unduly large and to the further objection of having a multiplicity of motions which must be carried out in predetermined sequence in order to effect the purposes of the device. The objections to this, while in some degree known, are not fully appreciated until the car is actually manipulated. While the device operates readily enough under all ordinary conditions, the operator having a number of handles to think of, some of which must be brought to one position before the others can be operated, is apt to become confused in moments of emergency.

In all manner of controlling devices it is now customary to employ contacts for changing the resistance of the motor-circuit by cutting in or out sections of "dead" resistance, so called, either at transition-points of the controller or in making minor gradations of speed between those which are effected by changing the grouping of the motors. I therefore find it unnecessary in a braking-controller to use more than one resistance-switch, inasmuch as the resistance employed to regulate the motor speed may well be employed to regulate the output of the motors as generators, and therefore the braking effect. By availing myself of this fact I am enabled to construct a brake and power-controller in more compact form than it has hitherto taken by using the resistance-contacts of the main regulating-switch for operating the brake-circuits and employing an auxiliary switch which so shifts the connections that the motors are coupled in the proper way to act as braking-generators, while of course the trolley or other current-supply is cut off. The "brake-switch," as I prefer to call it, is mechanically connected to the main regulating-switch, so that the great advantage of a single handle with continuous rotation may be employed—that is to say, while there is an off position, in which none of the electrical apparatus is operative, in the ordinary control of the car the motorman in making a stop turns directly from the power positions, in which the motors are driving the car, to the brake positions, in which the motors are acting as braking-generators. No special separate locking means are necessary for the brake-switch, because being mechanically connected to the regulating-switch it is locked when that is locked by the reversing-switch in the usual way. In the practical embodiment of the invention I place the brake-switch directly beneath the reversing-switch and locate all of its contacts on a cylinder of small size, this being all that is necessary, because the switch has only two operative positions. The mechanical connection is such that its contacts are open when the regulating-switch is brought to the off position, and before the fixed contacts of the latter switch connect with the movable contacts the brake-switch is brought to one or the other of its operative positions to accord with the direction of movement of the operating-handle. By this arrangement no provision need be made for sparking at the

brake-switch contacts, inasmuch as it is always manipulated when the circuit is open. The usual blow-out magnet is provided on the regulating-switch, and as all the makes and breaks by which current passes are made there no damage can be done to the apparatus.

The accompanying drawings show an embodiment of my present invention, Figure 1 being a front elevation, with the cover removed, of a controller in which it is employed. Figs. 2, 3, and 4 are views upon an enlarged scale of the mechanical connection between the brake-switch and regulating-switch, Figs. 3 and 4 being plans of the operating cam and lever looking down from the line 3 4 of Fig. 2. Fig. 5 is a diagram of the circuits.

I will first describe the mechanical constructions shown in Figs. 1 to 4.

In Fig. 1, A is the case of the controller, B is the single operating-handle of the motor-controlling mechanism, and C is the handle of the reversing-switch D. E is the brake-switch, and K is the controlling or regulating switch. The contacts of the latter are not illustrated in full, because they will be better understood from the description of the circuits as shown in Fig. 5. BM is the coil of the blow-out magnet, the pole-piece of which is arranged as described, for instance, in the patent to W. B. Potter, No. 524,396, but is not illustrated herein.

The mechanical connection between the regulating-switch and the brake-switch E (which, it will be seen, is upon the same line as the reversing-switch D, but is not moved by the same handle, the shafts being divided at N) is shown in the bottom part of Fig. 1; but it will be better understood from the larger Figs. 2, 3, and 4. In these latter figures, F is the shaft of the regulating-switch, and F′ that of the brake-switch. Upon a stud J is pivoted the cam-lever I. This is a three-arm lever, the arm I, carrying a pin i, moving in the slot l of the crank-arm L, fixed to the shaft F′ of the switch E. In Fig. 3 this is shown in the intermediate or off position of the switch, as illustrated in Fig. 5. Another arm I^2 of the cam-lever carries a cam-roller i^2, moving upon the upper one of two cams H′ H, fixed to the shaft F of the power-switch K. Another arm I′ of the cam-lever, with its corresponding roller i', moves upon the lower cam H of the two just referred to. The connecting-web I^3 strengthens the parts, the whole of the cam-lever I, with its arms and the connecting-web, being cast in a single piece, although of course it may be made in other ways. As already explained, the switch E stands, in Fig. 3, in its off position. Fig. 4 illustrates the same parts when the switch E is turned to the power position by the partial rotation of the regulating-switch K. In this case the cam-roller i' rides upon the concentric portion of the cam H, which it reaches by the incline h', (shown in dotted lines,) while the cam-roller i^2 rides upon the concentric portion h^2 of the cam H′, to which it is carried by the incline h^3. (Shown in full lines.) It will be manifest that no further change in the position of the rollers or of the lever I will occur unless the switch K is again brought to its off position. The movement of the parts when the switch is brought to the braking position it is unnecessary to illustrate, as it is simply the reverse of that shown in Fig. 4.

In Fig. 5 I illustrate the circuits of the controller. Here T is the trolley or other source of current. The motor-armatures are marked, respectively, A′ A^2 and their fields F′ F^2, the brake-shoes BS′ BS^2, the regulating-resistance R. At R′ is shown a small shunting-resistance for the brake-shoes, which is brought into operation at the first point of the controller, so that a small portion of the trolley-current is sent through the brake-shoes to demagnetize and release them. I do not claim this in the present application. The controller K is a series-parallel controller of the well-known shunt type, in which one of the motors (or more than one where a number of motors are employed) is shunted directly to ground around the other, the circuit of the other motor being then opened to effect the parallel connection in a way well understood, these changes being carried out by the contacts 10^a, 11^a, 11^b, and 12^b. It is to be understood that the switch E is brought to one or the other of its two operative positions by the cam-lever I before the brushes of the switch K make contact with the switch-cylinder. In Figs. 2 to 4 it will be seen that the parts working on the cam are shorter than the lever I, so that it is geared up, the switch E moving faster than the switch K. In the power position the row of contacts marked P of the switch E touch the brushes, while in the brake position the row of contacts marked Q is brought into circuit. The row of contacts marked P on the switch E connect the dynamo-electric machines so that they will operate as motors to drive the car in a direction determined by the position of the reversing-switch. The row of contacts marked Q on this switch operate to change the circuit connections of the dynamo-electric machines, so that they will operate as generators and also to complete certain equalizing connections hereinafter referred to. It will be noted, therefore, that this switch, which I have termed the "brake-switch," is provided both with circuit-changing contacts and with equalizing-contacts. The main regulating-switch of the controller is provided with current-regulating contacts, some or all of which are used both in the power and the braking positions of the controller, and also with series-parallel contacts, which are used only in the power positions of the controller. The first circuit of the power position is as follows: from the trolley T to the contact 23, to 23^a 24^a 24, thence to the contact 1 upon the controller K, and then through the various cross-connections of the switch to contact 7, then to the

resistance R, and through the last six sections of that resistance (it being now well known in the art that a larger resistance is employed for braking than for motor regulation) to the contact 35, thence to contact 36, then to contact 15 on the reversing-switch, contact 16, thence through the armature A′, contact 17 on the reversing-switch, contact 18, contact 34, contact 32 by the cross connection between the contact-plates 34^a and 32^a, thence through the field F′, back to the controller at contact 11, to contact 10, to contact 19 upon the reversing-switch, contact 20, through the armature A^2, contact 21 upon the reversing-switch, contact 22, through the field F^2. After passing through this field the current divides, part of it passing through the resistance R′ and from the other terminal of that resistance to the contact 28 upon the switch E. The other path of the current is to the contact 13 on the controller, by the cross connection to contact 14, thence to the upper terminals of both of the brake-shoes BS′ BS^2. After passing through BS′ the current in this circuit passes to contact 29 on the switch E, and after passing BS^2 current goes to contact 27 upon the switch E. Thus the two brake-shoes and the resistance R′ are connected in multiple between the end of the field F^2 and the contact-plate 26^a of the switch E. Here the paths unite and current flows by contact 26, through the three contacts 27, 28, and 29 to the ground at G. The effect of this is, as already pointed out, to pass current through the brake-shoes, the bulk of the current passing through the resistance R′, which is of such small amount that only a small fraction of current passes through the brake-shoes. At the next step of the controller the contact 14 is open-circuited, and by tracing the connections it will be found that this open-circuits the shoes BS′ BS^2. It does not open-circuit the resistance R′, however, and current may still pass through this as before to contact 28, contact 26 upon the switch E, and to ground; but this resistance is short-circuited by contact 12 on the controller K, which here makes contact with plate 12^a, providing a direct path to ground for current from the field F^2 through contact 13, contact 12, and the ground-wire to ground at G. The other circuits of the controller regulate the motors by changing the amount of the resistance R in the circuit—that is, as the contact 6 touches contact 6^a a portion of the resistance is cut out. This occurs progressively, until when the contact 2^a touches 2 all of the resistance is cut out and the motors at this time are in series with no resistance in circuit, giving the usual series arrangement with maximum torque per ampere. As the contacts 2 3 4 pass off the cylinder-contacts in the continued rotation of the switch resistance is again cut into circuit until the time when contact 11 touches both contacts 11^a and 11^b. At this time a shunt is thrown around the second motor and current passes from the end of the field F′ to contact 11, and thence to the plus-terminal of armature A^2 by contact 10 and contacts 19 and 20 upon the reversing-switch, and so on through the field F^2, contacts 13 and 12 to ground. The other or shunt circuit is closed when 11 touches 11^b and contact 12 touches at the same time 12^b, the two being cross-connected and giving a path from the contact 11 to contact 12, and thus to ground at G. When contact 11 breaks with contact 11^a, the circuit of armature A^2 is opened, contact 10 at the same time passing off contact 10^a, thus opening the circuit in two places. When contacts 9 and 10 touch 9^b and 10^b, an independent current-path to the second motor is provided from one end of the resistance R to contact 9, thence to contact 10 and to contacts 19 and 20 upon the reversing-switch, and so on through armature A^2, field F^2, contacts 13 and 12 to ground. Further rotation of the switch cuts out sections of resistance in this multiple position of the motors by means of contacts 4^b, &c., in the same way as already described with reference to their series position. Whenever the switch E is passed through its off position and is brought so that the contacts touch the plates in the row Q, the brushes of the controller K pass to the left and touch the contacts on that side, as shown in the development of the cylinder. This is the first braking position, and in this case the armatures A′ and A^2 act to supply current from their plus-terminals, being connected in multiple, the brake-shoes being connected between the armatures and fields and equalizers being thrown across both ends of the fields and armatures. This arrangement has particular advantages, which, however, are not claimed in this application, although of my invention. They are more fully set out in my pending applications, Serial No. 642,908, June 30, 1897, and Serial No. 644,884, July 17, 1897. In these applications claims both broad and specific are made to this invention. The arrangement of the brake-shoes with the resistance R′ is also described and claimed in the cases referred to. Beginning with the armature A′ current passes from its plus terminal to contact 16 upon the reversing-switch, then to contact 15, (it being understood that the contacts of the reversing-switch are not shifted when the switch E is turned, but that they still remain upon the row of contacts P.) From contact 15 current passes to contact 36, which now rests on contact 36^b, thence to contact 29, thence through the brake-shoe BS′, passing to the left to contact 30. Here the current has two paths, one from contact 31, the other from contact 32. Passing from contact 32 it goes through the field F′, thence to contact 11, which here touches contact 11^b. The other path from the switch E is from contact 31, passing from the field F^2 and reaching the contact 13, which here touches contact 13^a on the left, being thus connected to contact 11. Current also passes from the

plus terminal of the armature A^2 to contact 20 upon the reversing-switch, contact 19, to contact 25, the lead beyond this contact being open-circuited at 10 upon the controller, from contact 25 to contact 27^b, and thus to contact 27, through the brake-shoe BS^2. It will thus be seen that the armatures A' A^2 are connected in multiple and their current is fed through the brake-shoes in multiple and the fields in multiple, each brake-shoe being connected in series between the armature and field of the motor operating it, with a connection between the leads which connect each brake-shoe to the field. These all unite at the contacts 11 and 13 of the controller. From these current passes over the lead from the brush 12 to the ground-wire. This wire is here used like any other lead in the controller, and its being grounded has no relation to the circuit except as a safety precaution. Current passes over it to contact 26, thence to contact 26^b, contact 24^b, contact 24, then to contact 1 upon the controller K. The next contact in circuit on this side in the first position is contact 8, which thus leads to the first section of the resistance. Current passes, therefore, through all of the resistance to contact 35 on the switch E, thence to contacts 34 and 33. From 34 current passes to contact 18 on the reversing-switch, to contact 17, thus to the other side of the armature A'. From 33 the circuit is to contact 22 on the reversing-switch, contact 21, and to the other side of the armature A^2. Further revolution of the controller K acts simply to cut out sections of resistance until the resistance is all cut out, leaving the two motors in multiple feeding current through the brake-shoes.

It will be seen that some of the contacts on the controller are illustrated as broken, which is intended to indicate that they extend around the back of the cylinder, so that the same contact is used in two different relations.

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

1. The combination of a regulating-switch, a brake-switch, a reversing-switch, and a mechanical connection between the regulating and brake switches, such that movement of the regulating-switch handle brings the brake-switch into an operative position, and the further movement of the handle actuates only the regulating-switch.

2. The combination of a regulating-switch, a brake-switch, a reversing-switch, and a mechanical connection between the regulating and the brake switches, such that the movement of the regulating-switch handle brings the brake-switch to one of two operative positions, and further movement of the handle actuates only the regulating-switch.

3. The combination, in a controller, of three separate cylindrical switches, two of which have a common axis, and a mechanical connection between the third switch and one of the other two, moving them simultaneously.

4. The combination in a controller, of a regulating-switch of cylindrical form, a reversing-switch and a brake-switch the axes of which are in line, and a mechanical connection between the regulating and brake switches.

5. The combination, with a motor-regulating switch of combined resistance-changing and series-parallel type, of a second switch mechanically connected thereto and having contacts by which, when the motor-regulating switch is moved in one direction from its off position, the circuits are established by the second switch for motor regulation, and when moved in the opposite direction braking-circuits are established, including the resistance-changing contacts only of the power-switch.

6. The combination of the cams on the regulating-switch, the crank on the brake-switch, and a lever having its short arm operated by the cam and its long arm actuating the crank; whereby the brake-switch is brought to operative position before the contacts are closed at the regulating-switch, and further movement of the handle affects only the regulating-switch.

7. In an electric controller, the combination with a regulating-switch, of a separate brake-switch, a single actuating device for said switches, attached to said regulating-switch, and an independently-working reversing-switch.

8. In a controller, the combination with regulating and brake switches, of means for operating the regulating-switch, means for operating the brake-switch, the latter switch being operative only by the operation of the regulating-switch, and an independently-working reversing-switch.

9. In a controller, the combination with regulating and brake switches, of an actuating-handle for the regulating-switch, means whereby the movement of the regulating-switch, exclusive of other means, operates the brake-switch at a time when the regulating-switch connections are broken, and an independently-working reversing-switch.

10. In a controller for dynamo-electric machines, the combination of a switch adapted to regulate said electric machines, both when operating as motors and as generators, a switch adapted to make connections whereby the machines are changed from motors to generators at a time when the connections of said regulating-switch are open, a single actuating means for said switches, and an independent reversing-switch.

11. In a controller for electric machines, the combination of a switch adapted to regulate said machines both when operating as motors and as generators, a switch adapted to change the mode of operation of said machines, a single actuating means for said switches, adapted to operate the brake-switch at a time when the connections of the regulating-switch are broken, and an independent reversing-switch.

12. In a controller for dynamo-electric ma-

chines, the combination of power and brake circuits for said machines, a regulating-switch adapted to be used in both the power and brake circuits, means for operating said switch, and a separate switch for connecting the machines to operate as motors or generators, said switch being adapted to be actuated only by the movement of the regulating-switch from its open position to its power or brake positions.

13. In a controller for dynamo-electric machines, the combination of power and brake circuits for said machines, a regulating-switch adapted to be used in both power and brake circuits, means for operating said switch, a separate switch for connecting the machines to operate as motors or generators, and means whereby the said switch can be actuated only by the moving regulating-switch when the latter is passing over its off position.

14. In a controller for electric machines, the combination of power and brake circuits for said machines, a regulating-switch for both said circuits, a separate switch for causing the machines to operate as motors or generators, a single actuating-handle for said switches attached to the regulating-switch, a mechanical connection between said switches, whereby the said separate switch is actuated, and an independent reversing-switch.

15. In a controller for electric machines, the combination of power and brake circuits for said machines, a regulating-switch for both said circuits, a separate switch for causing the machines to operate either as motors or generators, a single actuating-handle for said switches attached to the regulating-switch, means controlled by said actuating-handle for operating said separate switch when the regulating-switch is in its off position, and an independent reversing-switch.

16. In an electric controller for power and brake circuits, the combination with a regulating-switch arranged to regulate the flow of current both in the power and in the brake circuit, of a reversing-switch, a separate brake-switch, and means for actuating the regulating-switch, said means also exclusively controlling the operation of the brake-switch.

17. In a controller for electric machines, the combination of a switch adapted to regulate said electric machines both when operating as motors and as generators, a switch adapted to make connections whereby the machines are changed from motors to generators, a single actuating means for said switches, and a third independently-operated switch adapted to change the direction of motion of said machines.

18. In an electric controller, the combination with a regulating-switch and a reversing-switch, of a brake-switch, means for actuating the regulating-switch, and a mechanical connection between the switches whereby alone motion is communicated to the brake-switch.

19. In a controller, the combination with a regulating-switch and a reversing-switch, of a brake-switch, means for actuating said regulating-switch, a mechanical connection between the regulating and brake switches, and guiding means on each switch adapted to engage the mechanical connection to intermittently and exclusively operate the brake-switch.

20. In a controller, the combination with a regulating-switch and a reversing-switch, of a brake-switch, means for actuating said regulating-switch, a mechanical connection pivoted independently of the switches, and guiding means on the regulating and brake switches adapted to engage the mechanical connection to intermittently operate the brake-switch.

21. In a controller, the combination with regulating, brake, and reversing switches, of means for actuating the former, cam-surfaces on the regulating-switch, a slotted crank on the brake-switch, and a mechanical connection between the switches adapted to engage with the cams and crank.

22. The combination with two electric switches, of supporting-shafts therefor, means for actuating one shaft, two cam-surfaces on the latter, a slotted crank on the other shaft, and an independently-pivoted lever adapted to engage with said cams and crank, whereby the driven shaft is partially rotated during a part of the rotation of the actuating-shaft.

23. The combination with two electric switches, of supporting-shafts therefor, means for actuating one shaft, two cam-surfaces on the latter, a slotted crank on the other shaft, and an independently-pivoted three-armed lever carrying a pin on one arm to engage with the slotted crank, and rollers on the other arms for engaging with the cams.

24. In a controller, the combination with a regulating-switch, actuating means therefor, a separate brake-switch, means whereby the latter is actuated by the operation of the regulating-switch, and an independently constructed and operated reversing-switch having its axis in the same line with that of the brake-switch.

25. In combination, in a controller having contacts for power and braking, a main switch provided with current-regulating contacts, and an auxiliary switch provided with circuit changing and equalizing contacts.

26. In combination, in a controller having contacts for power and braking, a main switch provided with current-regulating contacts, an auxiliary switch provided with circuit changing and equalizing contacts, and an independent reversing-switch.

27. In combination, in a controller having contacts for power and braking, a main switch comprising current-regulating and series-multiple contacts, and an auxiliary switch comprising circuit changing and equalizing contacts.

28. In combination, in a controller having contacts for power and braking, a main switch

comprising current-regulating contacts, an auxiliary switch comprising circuit changing and equalizing contacts, and a mechanical connection between said switches.

29. In combination, in a controller having contacts for power and braking, a main switch comprising current-regulating contacts, an auxiliary switch comprising circuit changing and equalizing contacts, and a mechanical means whereby the auxiliary switch is thrown into one of its operative positions by the movement of the main switch from its off position.

30. In combination, in a controller having contacts for power and braking, a main switch comprising current-regulating contacts, an auxiliary switch comprising circuit changing and equalizing contacts, and a mechanical means whereby the auxiliary switch is thrown into one of its operative positions by the initial movement of the main switch from its off position.

31. In combination, in a controller having contacts for power and braking, a main controlling-switch, an auxiliary controlling-switch, a reversing-switch, and a mechanical connection between the main and the auxiliary controlling-switches.

In witness whereof I have hereunto set my hand this 20th day of June, 1898.

FRANK E. CASE.

Witnesses:

B. B. HULL,

A. H. ABELL.