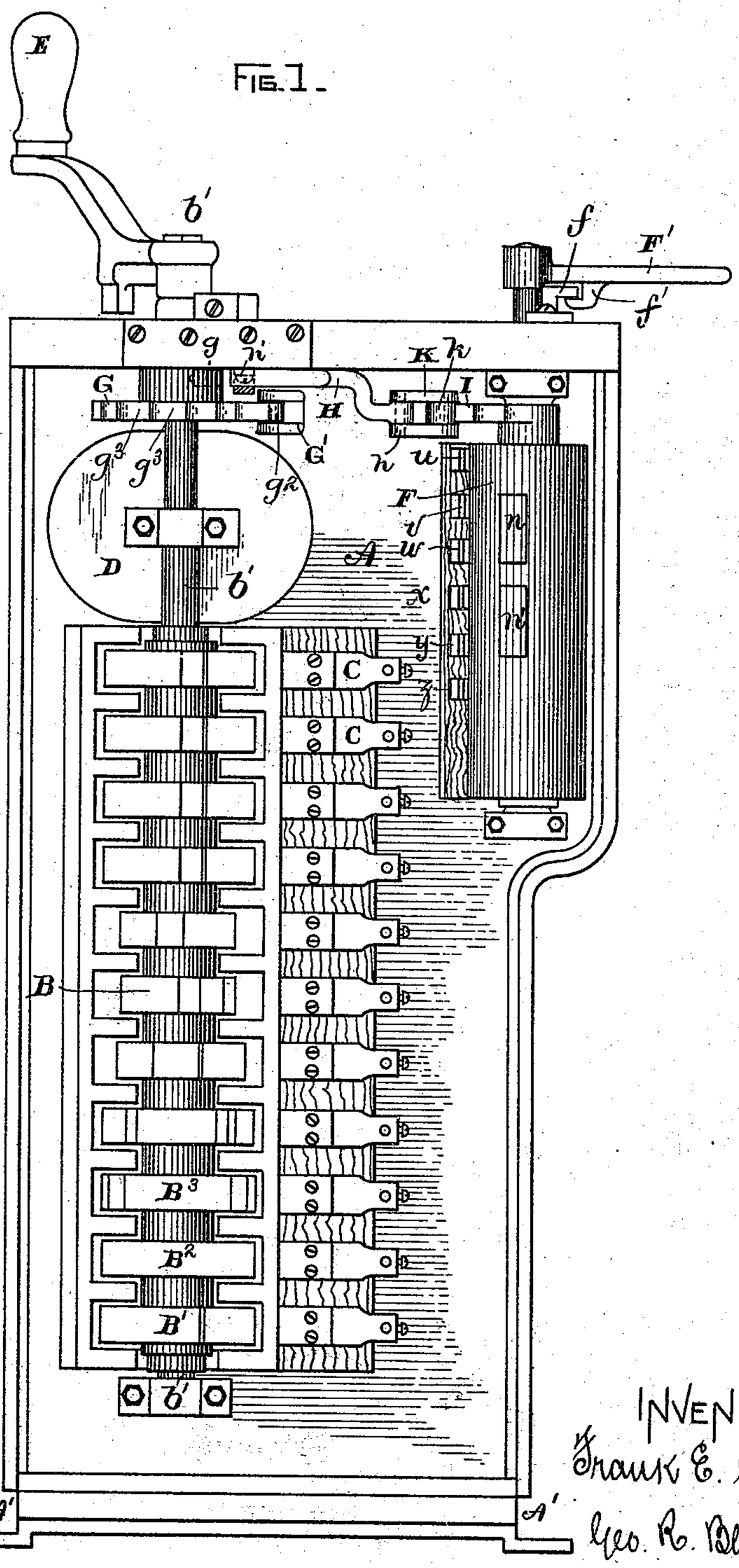
(No Model.) 4 Sheets—Sheet 1.

F. E. CASE.

ELECTRIC BRAKE.

No. 548,952. Patented Oct. 29, 1895.

FIG. 1.



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(No Model.) 4 Sheets—Sheet 2.

F. E. CASE.

ELECTRIC BRAKE.

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FIG. 2

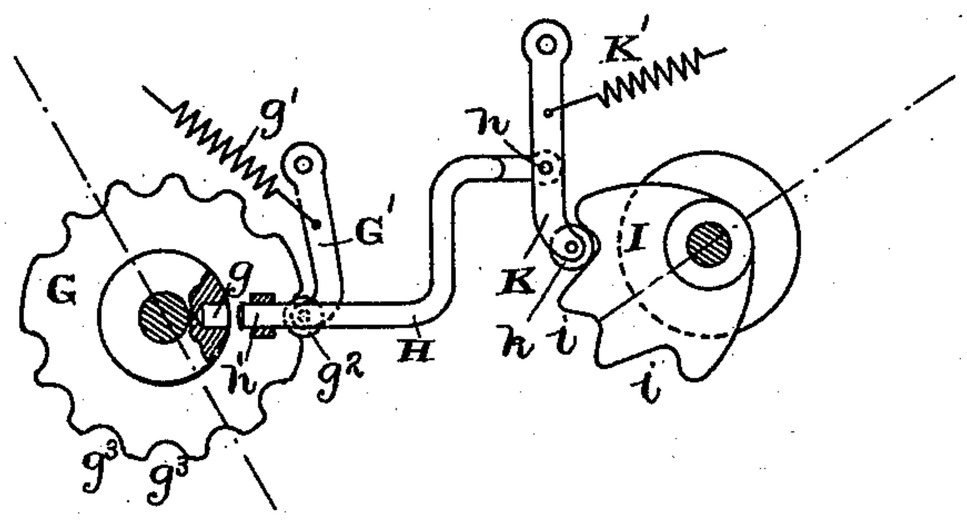


FIG. 3.

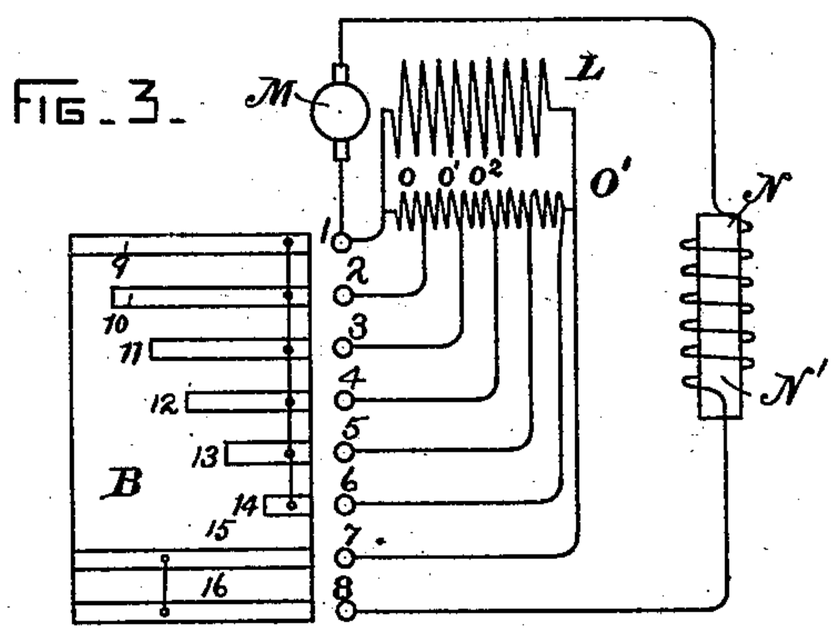
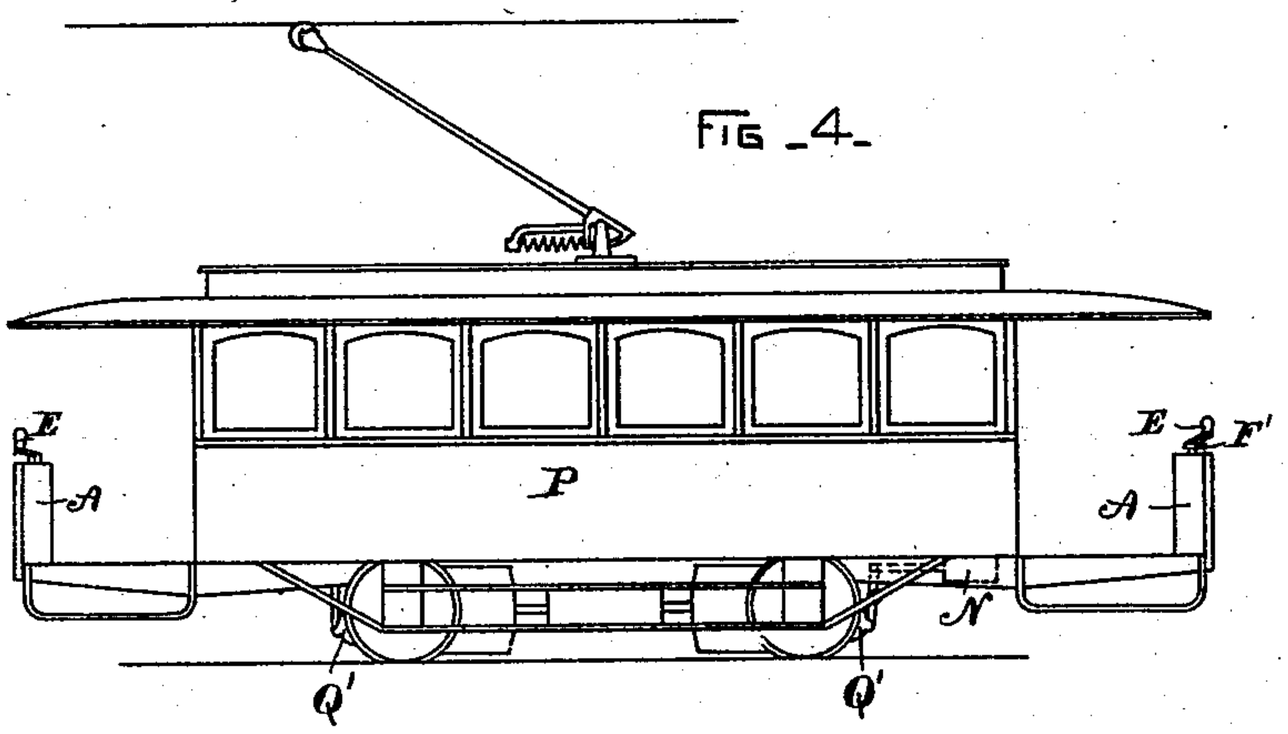


FIG. 4.



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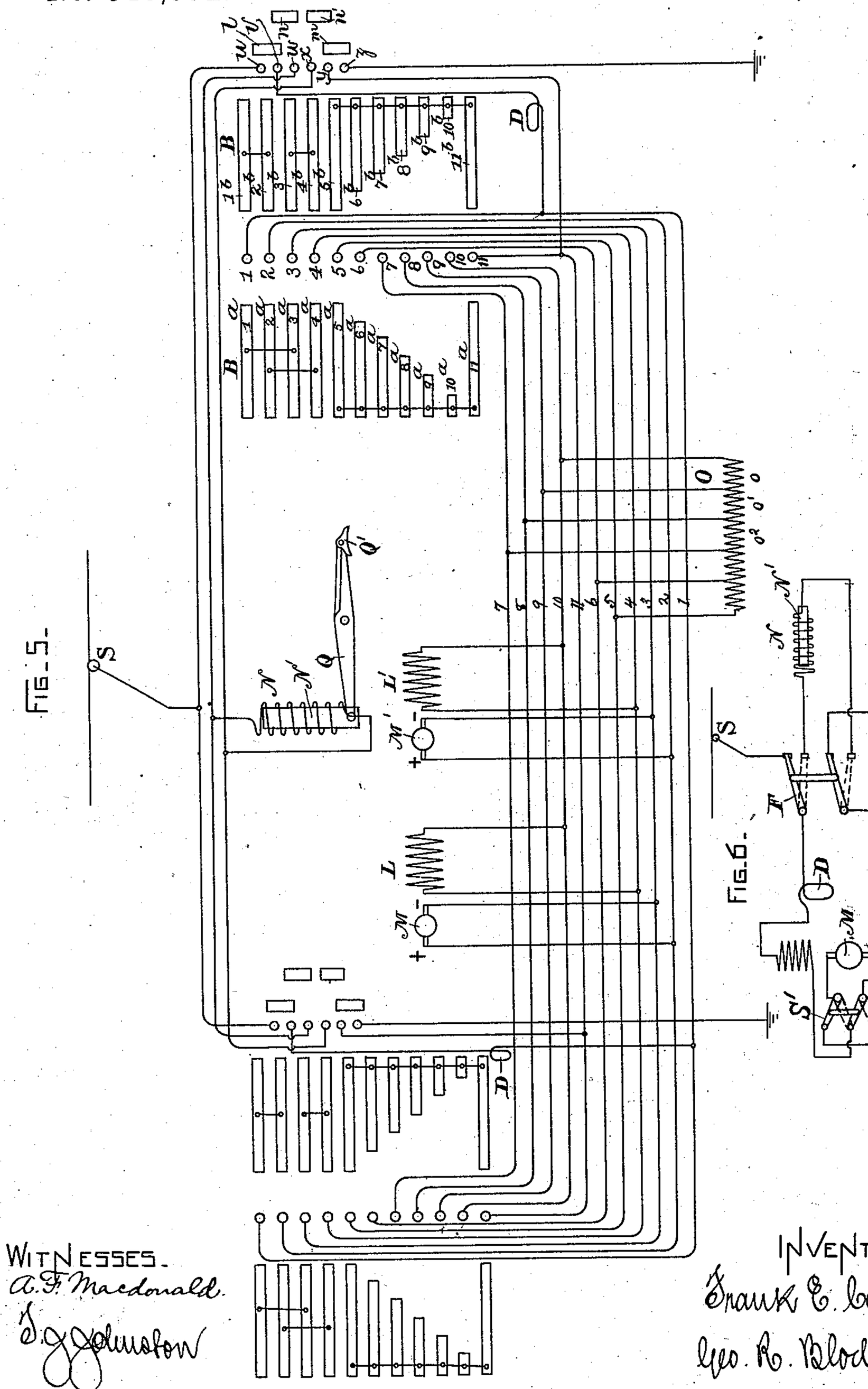
(No Model.) 4 Sheets—Sheet 3.

F. E. CASE.

ELECTRIC BRAKE.

No. 548,952. Patented Oct. 29, 1895.



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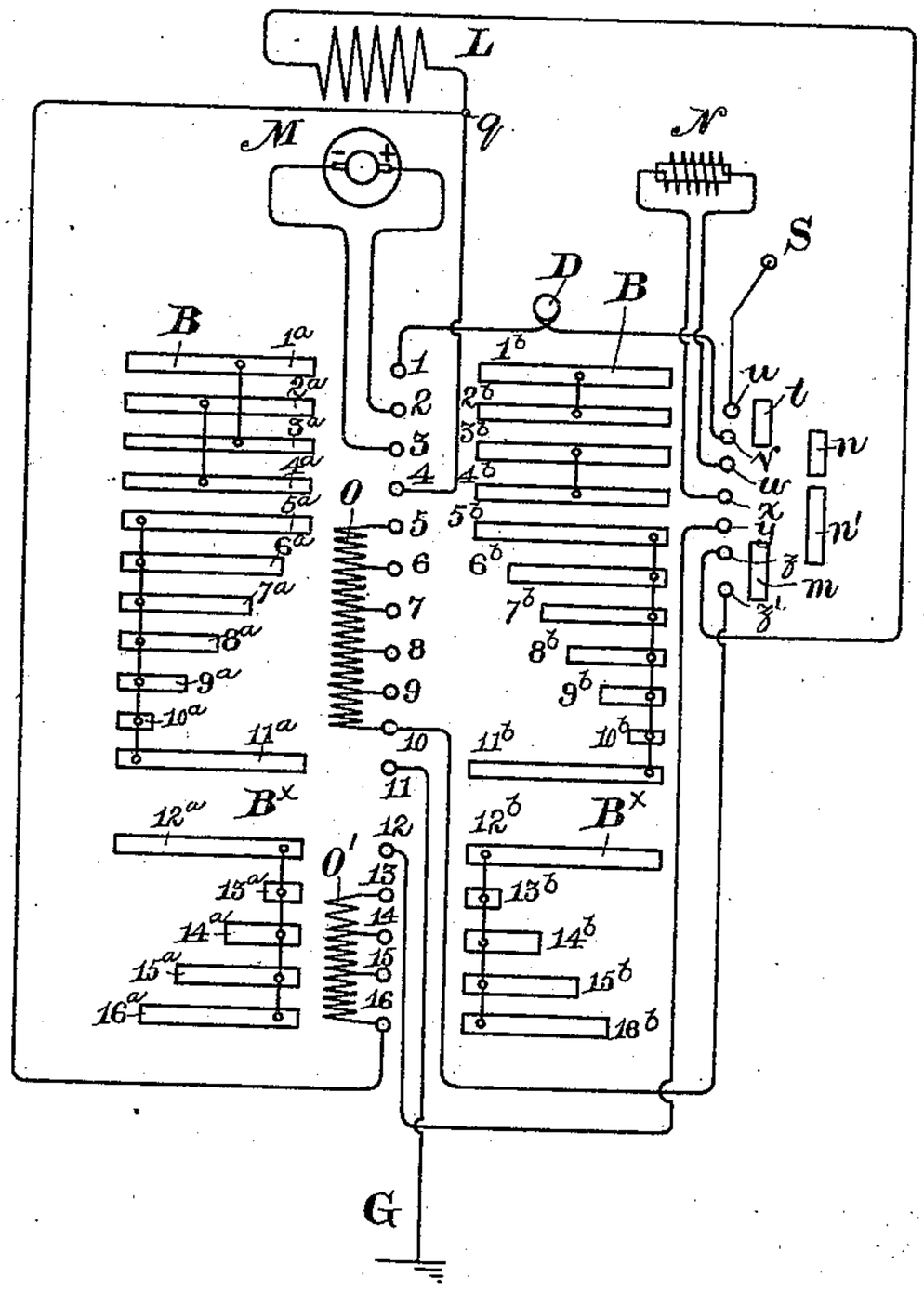
4 Sheets—Sheet 4.

F. E. CASE.

ELECTRIC BRAKE.

No. 548,952. Patented Oct. 29, 1895.

FIG. 7.



WITNESSES—

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UNITED STATES PATENT OFFICE.

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

ELECTRIC BRAKE.

SPECIFICATION forming part of Letters Patent No. 548,952, dated October 29, 1895.

Application filed June 29, 1894. Serial No. 516,039. (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, county of Schenectady, State of New York, have invented certain new and useful Improvements in Electric Brakes, of which the following is a specification.

My invention relates to electric brakes, and has for its object to provide means, including suitable apparatus, for utilizing the wasted force in a motor driving a tram-car or other vehicle and generating electromotive force by its momentum after the current is cut off from it. Ordinarily this electromotive force is either wasted or has to be overcome by the friction of the brake-shoe, thus increasing the difficulty of stopping the car. By my invention, however, I am enabled to utilize this force in applying the brake-shoe to the wheel, and thus assist in stopping the car. At the same time I provide a means for regulating the amount of force applied to the brake, which means is put within the control of the driver of the vehicle, and in the special apparatus in which I have embodied my invention the brake is controlled by a single handle in its application, while the degree of force with which it is applied is regulated by the handle of the motor-controller, and the motorman has thus only the two handles to engage his attention. It is of course designed to add the ordinary hand braking apparatus to provide for emergency in case the magnetic brake should fail to act from imperfection in its construction or from accident; but ordinarily this apparatus will not be employed by the motorman, and it will be unnecessary to make further reference thereto.

To effect the objects of my invention, I therefore provide a controlling apparatus which is adapted to regulate the speed of the motors in either direction, and I provide in the same case with this controller a second switch, preferably cylindrical, which acts to change the circuit connections, so that the motors are brought into local circuit, acting either directly or through suitable gearing upon the brake-shoes. This local circuit is completed through a controlling apparatus, and this apparatus therefore regulates the electromotive force of the motors by cutting in or out resistance either in series with the motor or in shunt to the fields in ordinary ways. In this construction, which is the preferred one, the entire office of the brake or auxiliary handle is to throw the brake into operative condition, and its entire movement is controlled by the handle of the motor-regulator, as pointed out above.

The accompanying drawings show an embodiment of my invention, in which—

Figure 1 is a front elevation of my improved braking apparatus, showing the connection with a controller of the type described, the cover being removed to show the apparatus. Fig. 2 is a view of the interlocking mechanism which I use Fig. 3 is a diagram showing a modification of the circuit connections to be more fully described hereinafter. Fig. 4 is a view of an electric car equipped with my improved brake. Fig. 5 is a diagram showing the wiring of such a car with the controllers at each end and the braking-switch shown in their proper relations. Fig. 6 is an illustrative diagram showing the method of operation in a simple manner; and Fig. 7 is a diagram showing the combination of Fig. 3 with the apparatus as illustrated in Fig. 5, except that only one motor is shown for clearness of illustration.

Referring now to Fig. 1, A is the case of the controller, to which the switches are secured. B is the controlling-switch provided with contacts B' B^2 B^3 and brushes C C, &c. D is the blow-out magnet. b' is the shaft upon which the switch is mounted. E is the handle of the controlling-switch. All of these parts are of common construction and form no part of my invention, except in combination with other features presently to be referred to. F is a cylindrical switch provided with suitable contacts and with a handle F′. The connections and method of operation will be more fully described in connection with other figures.

Referring now to Fig. 2, I show a plan view of the interlocking mechanism employed between the two cylinders or switches, a side elevation of which is shown in the upper portion of the case in Fig. 1, wherein G is a star-wheel with notches g^3 g^3, indicating the running positions of the controller. A pawl

G′, provided with a friction-roller g^2 and a spring g', engages with these notches successively. The notches on opposite sides of the wheel are identical in position, inasmuch as I employ in this construction controlling-switches adapted to run the motors in either direction from a central position, moving the handle in one direction running the car forward and moving the handle in the other direction running it back, although I may employ switches of other forms. H is a lever having a projecting end h', engaging with a notch or stop g on a disk or collar surmounting the star-wheel G. At I is shown a second star-wheel or cam provided with notches $i\,i$ and a pawl K with a friction-roller k, the purpose of these parts being identical with that of the first star-wheel G and its pawl, &c. The lever H is pivoted at h to the pawl K. The operation of these parts is as follows: When the controller-cylinder B is in the "off" position and the circuit is broken, the switch-lever F′ may be thrown to rotate the braking-switch cylinder F. The cam I attached to this cylinder would then be rotated to its central position, breaking the connections, as hereinafter described, and at the same time throwing the pawl K farther from the center of the cylinder F, forcing the end h' of the lever H into the notch g, and holding the cylinder in its off position. The object of this is to prevent the cylinder B from being rotated to turn on current while the connections of the brake are still broken or in process of being changed, thus preventing sparking and the destruction of the contacts on the braking-switch cylinder. When, however, the cam I is rotated so that the pawl K engages with either its upper or lower notch, as shown in the figure, the cylinder B will be free to move and current may be turned in to operate either the braking-magnet or the motors.

Referring now to Fig. 5, I illustrate the connections which are employed. In that figure the parts at the left and right, respectively, of the contacts are developments of the controller-cylinder and the braking-switch cylinder. Upon the controller-cylinder the contact-plates 5, 6, 7, 8, 9, 10, and 11 show the means of cutting in or out the several sections $o\,o'$, &c., of the resistance O, while those marked 1 2 3 4 are the contacts of the motors adapted to reverse them in accordance with the direction of motion of the controlling-handle.

Referring now to Fig. 6, I show in simple diagram the principle of the apparatus, which will be more fully described by further reference to Fig. 5. In this view, Fig. 6, M is the motor, D the blow-out magnet, F is the double-pole switch, N is the braking-magnet, and N′ is its core. I do not illustrate any special form of braking levers or shoes, as these may be of any form known in the art and form no essential part of my invention. At S is the trolley. Following the circuit from the trolley the current enters and, passing through the switch in its illustrated position, goes around the blow-out magnet D through the motor M and resistance O back to the switch by its other blade and out at the ground. When the switch is in its dotted position, however, no current enters from the trolley; but the motor is on a local circuit, which may be traced from M to the switch through the braking-magnet by the other blade of the switch, through the blow-out magnet, and back to the motor, passing on its way through the resistance in series with the motor and through the reversing-switch S′, which, as illustrated, affects only the armature-circuit. When short-circuited upon itself in this way, the motor acts to generate current and the magnet-core N′ is strongly attracted, thus putting on the brake by any suitable connections.

Referring, again, to Fig. 5, the operation thus briefly indicated is carried out by means of the cylindrical switches shown, the parts being diagrammatically indicated without regard to their relative position, which is well known to those skilled in the art. The current entering from the trolley S passes to the contact u on the right of the figure to the plate l, thence to the contact v, around the blow-out magnet D, by the lead to the contact 1, to contact-plate 1^b, cross-connected to the plate 2^b, thence to contact 2, then by the lead to the motor-armatures M M′, returning through the motor-armatures to the contact 3, thence to contact-plate 3^b by cross-connection to contact-plate 4^b, thence to contact 4, then through the motor-fields L L′ through the resistance O to contact 5, then to contact-plate 5^b, thence to contact-plate 11^b, then to contact 11, then by the lead to the contact y, thence to contact-plate m upon the braking-switch cylinder, thence to contact z, and out at ground. In this position it will be seen that the braking-magnet N takes no current, its terminals $w\,x$ being open-circuited, and it will also be observed that further rotation of the cylinder B will cut out successive sections of resistance in the ordinary way and regulate the speed of the motors without actuating the braking-magnet. Also, by referring to Fig. 2 the position of the interlocking mechanism will be seen to correspond with the positions of the cylinders, as shown in Fig. 5.

Assuming, now, that the brake is to be actuated, the controller-handle will be brought so that the contacts are off, as in Figs. 2 and 5. The handle F′ (see Fig. 1) will then be thrown so that the cam I, Fig. 2, is rotated until the pawl K comes into the lower notch i, the intermediate notch i locking the controller-cylinder B until the switch F is entirely thrown; but when the lower notch i is reached the rod H is withdrawn and the controller-cylinder becomes free to move. Now, referring again to Fig. 5, when the locking mechanism is in the new position just de-

scribed the contact-plates $n\,n'$ upon the switch F will connect the terminals $v\,w\,x\,y$, respectively, and the trolley-contact u and the ground contact z will be cut out, thus throwing the motors M M′ into local circuit with the braking-magnet N. Assuming that the positive brushes of the motors M M′ are those marked with a plus-sign, the electromotive force generated in their armatures will send the current from these positive brushes connected in multiple to the contact 2, thence to contact-plate 2^a, (on the development of the switch B, shown on the left of the contacts,) thence by cross connection to contact-plate 4^a, thence to contact 4, thence through the motor-fields L L′, thence through the resistance O to contact 5, then to contact-plate 5^a, thence to contact-plate 11^a, thence to contact 11, thence by the lead to contact y, to contact-plate n', thence to contact x, thence through the braking-magnet, thence to contact w, thence to contact-plate n, thence to contact v around the blow-out magnet D to contact 1, to contact-plate 1^a by cross connection to contact-plate 3^a to contact 3, thence by the lead from contact 3 to the minus brush of the motors, passing, as will be seen, in the reverse direction from that in which it flowed when controlled by the contacts shown in the development of the right-hand half of the cylinder B. This current energizes the braking-coil N and draws up the core N′, thus drawing up the lever Q and applying the brake-shoe Q′ to the wheels. As already pointed out, any form of interposed gear may be employed to increase the leverage or all such gear may be dispensed with, as the engineer may elect. It is unnecessary to further trace the circuits in Fig. 5, inasmuch as the rotation of the cylinder B from this point on effects the regulation of the braking power by cutting in or out sections of the resistance O, as already pointed out. After the car has come to a stop the switch B will be brought to the off position and the switch F then thrown to make the connection again with the trolley.

The apparatus illustrated on the left in Fig. 5 is the counterpart of that shown in the right-hand part of the figure and is operated in precisely the same way from the other end of the car. In order, however, to prevent manipulation of the controller at the opposite end of the car from that where the motorman is stationed, I provide upon the under side of the handle F′ a lug f', moving under a circular segment, which prevents the handle F′ from being removed, except when it is in its central position, in which the middle notch i upon the cam I engages with the pawl K and locks the controller-cylinder in position. It is thus impossible for unauthorized persons to tamper with the controller at one end of the car while the motorman is at the other end.

Referring to Figs. 3 and 7, I illustrate the application of my method of control to the combination of a motor field-magnet shunted through a variable resistance so that the current may be varied by varying the resistance, and therefore the strength of the generated current may be also changed and the effect of the brake-magnet graduated.

In Fig. 3 I do not illustrate the entire combination with the line-circuit, this being a diagram only so as to show the motor and its shunted field in the simplest possible relation. I also employ in these figures only one motor, (although it is manifest that two may be and in ordinary practice would be employed,) so as to exemplify the method of control in the simplest manner possible. Further referring to Fig. 3, after the line-current has been cut off and the motor reversed, so as to send current through its field L in the same direction as the line-current which formerly passed through the field, I may rotate the switch B to cut in a greater or less amount of resistance. In the position shown practically the entire resistance will be cut out when the line of contacts 1 2 3, &c., touches the contact-plates 9 10, &c., and in this position the path of the current will be from the upper brush of the motor through the braking-magnet N to the contact 8, thence to the contact-plate 16, by cross connection to the contact-plate 15, to the contact 7 by the lead to the contact 6, by cross connection to the contact 1, to the other brush of the motor, the second path being from the contact 7 through the field L to the contact 1, to the other brush of the motor, and still a third path being from the contact 7 through the steps $o\,o'\,o^2$ of the resistance O′ to the contact 1, to the other brush. In this way the field is shunted by a connection of practically no resistance and also through the resistance O′. The field-magnet being thus practically unexcited, save for the small amount of residual magnetism remaining in it, very little current is generated by the rotation of the armature of the motor. The further rotation of the switch B acts to cut in more and more of the resistance as the contacts 6 5 4, &c., pass off from the contact-plates 14 13 12, &c., until finally the resistance-contacts are all cut out and the shunt connection around the field L is entirely through the resistance O′, which by this time has become of such an amount as practically to pass the entire current generated in the motor-armature through its field. The potential and volume of current therefore run up rapidly, and the action of the braking-magnet upon its core N′ becomes exceedingly strong.

In Fig. 7 I illustrate, as already pointed out, the combination of Fig. 3 with the other parts of my apparatus, the illustration being merely diagrammatic. In this figure the paths of the current are as follows: The current, entering from the trolley S, passes to the contact u, to the contact-plate l, thence to the contact v, around the blow-out magnet D to the contact 1, to the contact-plate 1^b, by cross connection to the contact-plate 2^b, to the contact 2, through the motor-armature M, to the contact

3, to the contact-plate 3^b, by cross connection to contact-plate 4^b, through the motor-field L, to contact z, to contact-plate m, to contact z', to contact 10, through the resistance to contact 5, to contact-plate 5^b, by cross connection to contact-plate 11^b, to contact 11, and to ground at G, the further rotation of the right-hand part of the switch acting, as before described with reference to Fig. 5, merely to cut out sections of the resistance until it is entirely short-circuited. When, however, the right-hand switch carrying the contact-plates l m n n' is thrown, the contacts 1 2 3, &c., being then in the off position, the current takes a different path. In that case the trolley contacts u v are disconnected as they pass off the contact-plate l, and the series-regulating resistance O is also disconnected as its contacts z z' pass from the contact-plate m. The contact-plates n n' in this position complete the circuits, throwing the armature M and brake-magnet N in series with the field L and resistance O', these latter two being in multiple with each other, as shown diagrammatically in Fig. 3. The path of the current in this case is as follows: Assuming that it passes from the brush marked + of the motor-armature to that marked —, to the contact 2, to the contact-plate 2^a, by cross connection to the contact-plate 4^a, to the contact 4, through the motor-field L, to the contact z, to the contact-plate n', thence to contact x upon the same contact-plate n', then through the brake-magnet N, to the contact w, to the contact-plate n, to contact v, around the blow-out magnet D, to the contact 1, to the contact-plate 1^a, by cross connection to the contact-plate 3^a, to contact 3, and back to the minus brush. At the point q a shunt-circuit through the resistance O' starts, coming to contact 16 and passing in accordance with the position of the switch B x through different sections of the resistance O', its first path being when the contacts 13 14, &c., just touch the contact-plates 13^a, &c., in which case it passes from contact 16 to contact-plate 16^a, by cross connection to contact-plate 12^a, then to contact 12, to contact y, to contact-plate n', to contact z, there joining the lead to the field L. In this position of the switch B x the resistance and the field are entirely shunted and very little current will flow in the field, while, as the resistance is progressively cut in, the field will become more and more strongly magnetized.

In Fig. 4 I design to illustrate the application of my improved braking system to an electric car in a diagrammatic manner, controllers A A being represented upon each end of the car P, which is of any ordinary type. It will be seen that the method of operation which is outlined above is in brief to disconnect the trolley from the car apparatus, close the motors in a local circuit with the brake-magnet and by preference with the blow-out magnets, inasmuch as it is desirable to keep these always energized, so that sparks may not destroy the commutating-switch contacts, and then to move the controller ordinarily employed to regulate the speed of the motors as a means of reversing the motors and then regulating their electromotive force. It is important that the motors be reversed when they are placed upon local circuit, which, however, is not a closed circuit until the controller-handle is moved—that is to say, the switch F breaks the trolley-circuit and closes, with the exception of one break, the local circuit through the motors and the braking-magnet; but this break is not closed until the rotation of the controller-handle is begun, the first step of this rotation determining the direction of the current and the second and further steps controlling the amount of resistance in circuit.

The object of reversing the motors (by which expression I mean such a reversal of the relation of armature and field as would act, if the line-current were still on, to rotate the armatures in the opposite direction if they were free to move in that direction, and would act first to stop the car and then to force it in the other direction) is to cause the current from the armature to pass through the field in such a direction as to build up its magnetism—that is to say, to cause the electromotive force generated in the motor-armatures to send the current through the fields in the same direction in which it would pass when driven by the impressed electromotive force of the line-current. If the direction of current through the motor as a whole be reversed, the motor will, of course, while still continuing to run in the same direction, beat down or demagnetize its own field, and will then cease to operate as a generator.

The order of steps which I have pointed out as one embodying my invention presents great advantages because of the absence of sparking in the braking-switch contacts and their consequent destruction, the circuit being always broken at the motor-controller before the switch controlling the braking action is thrown. The blow-out magnet of the main controller serves to prevent sparking in the same manner when used on the trolley-circuit and when used on the local circuit with the motors and the braking-magnet, so that no harmful effect is experienced.

It is manifest that in addition to the mechanical friction of the brake-shoe the magnetic drag of the revolving motor-armature must be overcome by the momentum of the car, and the combined effects of the two act to bring the car quickly to a standstill.

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

1. The means for controlling the current flow in the circuit of an electric braking apparatus supplied from a series motor or motors operated as a generating source by the momentum of a moving vehicle or load, consisting of means for controlling the excitation of the motor or motors, and thus regulating the amount of current supplied to the circuit.

2. The means for controlling the current flow in the circuit of an electric braking apparatus supplied from a motor or motors operated as a generating source by the momentum of a moving vehicle or load, consisting of a shunt around the field-magnets of the source of current, and contacts for opening and closing the shunt.

3. The means for controlling the current flow in the circuit of an electric braking apparatus supplied from a motor or motors operated as a generating source by the momentum of a moving vehicle or load, consisting of a shunt around the field-magnets of the source of current, contacts for opening and closing the shunt, and a resistance included in the circuit.

4. The means for controlling the current flow in the circuit of an electric braking apparatus supplied from a motor or motors operated as a generating source by the momentum of a moving vehicle or load, consisting of a shunt around the field-magnets of the source of current, contacts for opening and closing the shunt, a resistance in the circuit, and means for varying the amount of resistance.

5. In an electric brake and in combination, a line circuit, motors operating an electrically propelled apparatus, mechanism adapted to open the line circuit, to shunt the field-magnets of the motors, to reverse the motors and to include them in a local circuit, substantially as described.

6. In an electric brake and in combination, a line circuit, motors actuating an electrically driven apparatus, a resistance, mechanism adapted to open the line circuit, to reverse the motors, to include them in a local circuit and to shunt the field-magnets of the motors through the resistance.

7. In an electric brake and in combination, a line circuit, an adjustable resistance, motors operating an electrically driven apparatus, and mechanism adapted to open the line circuit, to reverse the motors, to include them in a local circuit to shunt the field-magnets of the motors through the resistance, and to vary the resistance in the shunt.

8. In an electric brake and in combination, a line circuit, motors actuating an electrically driven apparatus, a local circuit including a brake magnet, mechanism adapted to open the line circuit, to shunt the field-magnets of the motors, and to reverse the motors through the local circuit.

9. In an electric brake and in combination, a line circuit, motors operating an electrically driven apparatus, a local circuit including a brake magnet, a resistance, and mechanism adapted to open the line circuit, to shunt the field-magnets of the motors through the resistance, and reverse the motors through the local circuit.

10. In an electric brake and in combination, a line circuit, motors operating an electrically driven apparatus, the local circuit including a brake magnet, an adjustable resistance, a mechanism adapted to open the line circuit, to shunt the field-magnets of the motor through the adjustable resistance, to reverse the motors in the local circuit, and to vary the resistance in the shunt.

11. In an electric brake, a motor or motors driving an apparatus, a controller for such motor or motors adapted to break the external circuit, to reverse the current in the motor to regulate its speed, a switch adapted to disconnect the motor from the external source of current and to put it in an open local circuit including the controller and a resistance operated thereby, and a brake magnet in the local circuit; whereby the switch effects the changes in the relation of the motors, the external circuit, and the brake magnet, while the circuit is open, and the controller closes the circuit to reverse the motors and regulate the braking action after the switch is operated, substantially as described.

12. In an electric brake, a motor or motors driving an apparatus, a controller for the motor or motors including a cut-out, a resistance, and a reversing switch, a second switch adapted to break the external circuit and put the motor or motors on local circuit with a brake magnet, and interlocking mechanism between the controller and the switch; whereby either the switch or controller may be operated only when the other is in proper position, substantially as described.

13. In an electric brake, motors driving an electric car or apparatus, a controller for such motors comprising a resistance and a switch adapted to cut in or out successive sections of resistance, to reverse the motors, and to cut off the current, a second switch adapted to disconnect the external circuit and put the motors in a local circuit including the motor-controller, a brake magnet in such circuit, and interlocking mechanism between the switch and the controller, consisting of a stop upon the controller and a lever upon the switch, such mechanism adapted to prevent the motion of the controller while the switch is being thrown, and to prevent the motion of the switch while the current is on.

In witness whereof I have hereunto set my hand this 27th day of June, 1894.

FRANK E. CASE.

Witnesses:
B. B. HULL,
GENEVEIVE HAYNES.