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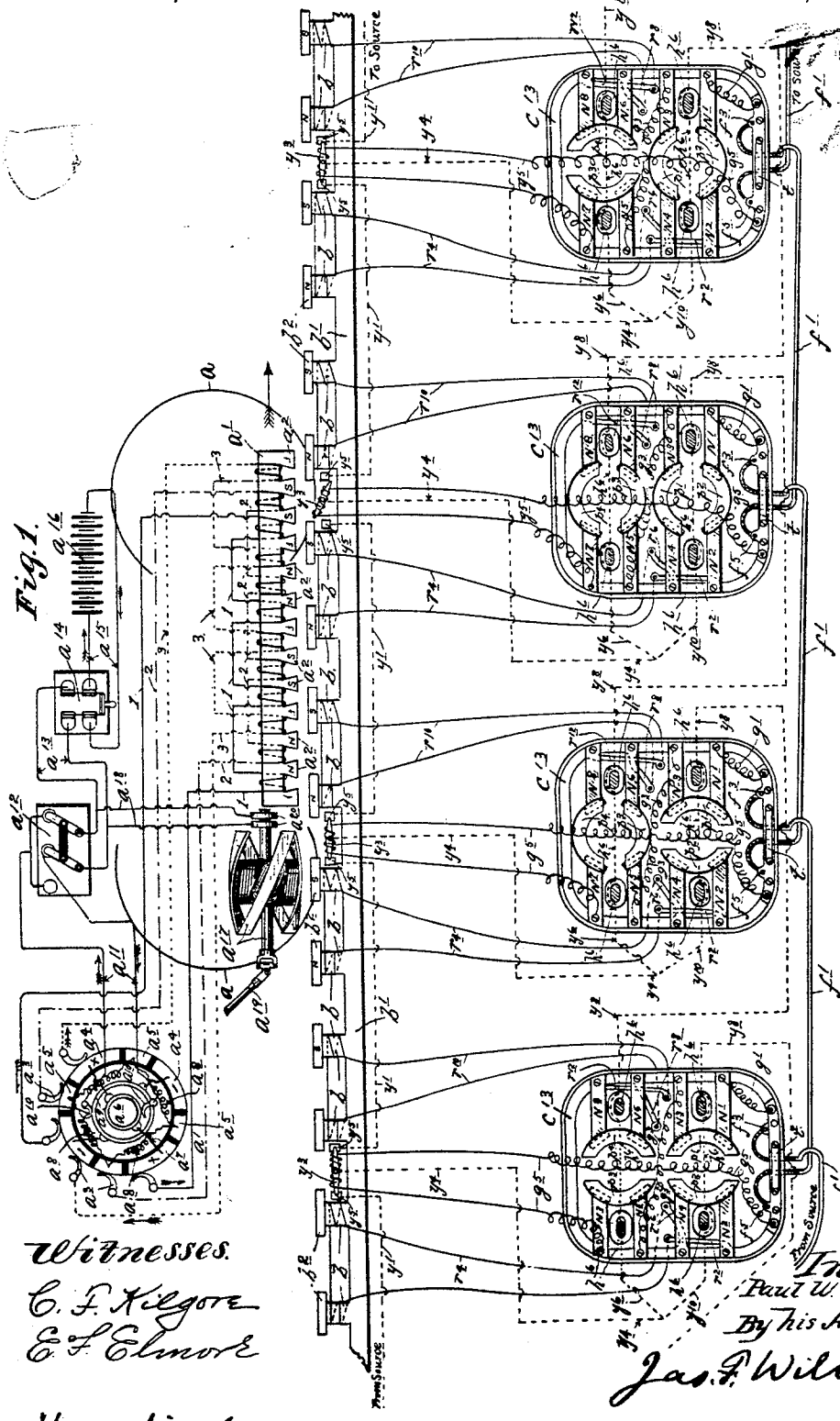
(No Model.) 4 Sheets—Sheet 1.

P. W. LEFFLER.

ELECTRIC RAILWAY, &c.

No. 573,822. Patented Dec. 22, 1896.

Fig. 1.



Witnesses.
C. F. Kilgore
E. F. Elmore

Inventor.
Paul W. Leffler.
By his Attorney
Jas. F. Williamson.

Copy in Magnetic Closers

(No Model.)

4 Sheets—Sheet 2.

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No. 573,822.

Patented Dec. 22, 1896.

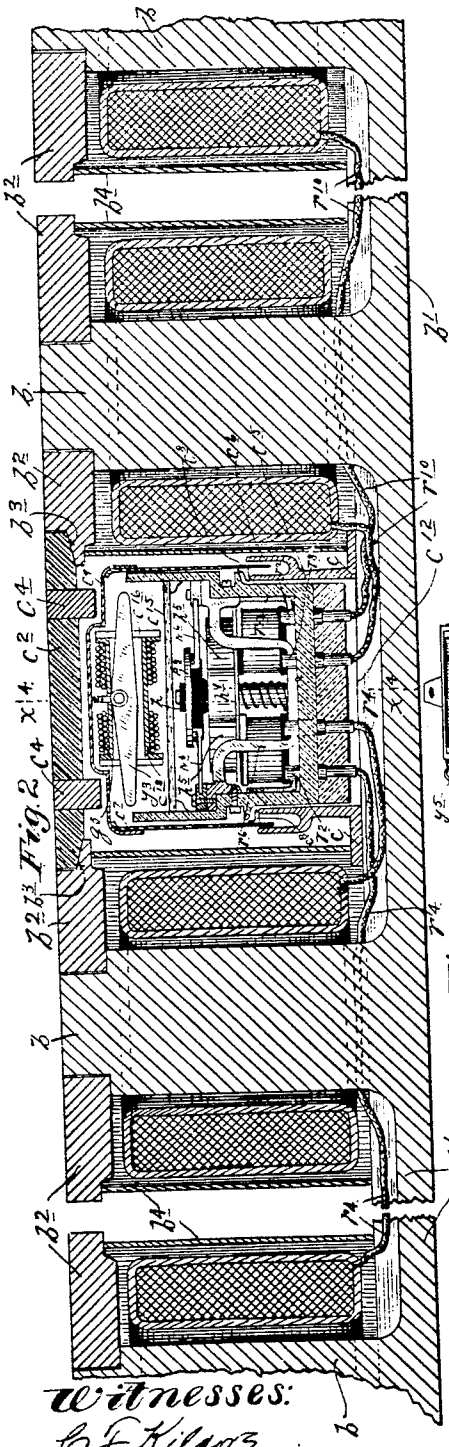

Fig. 2.

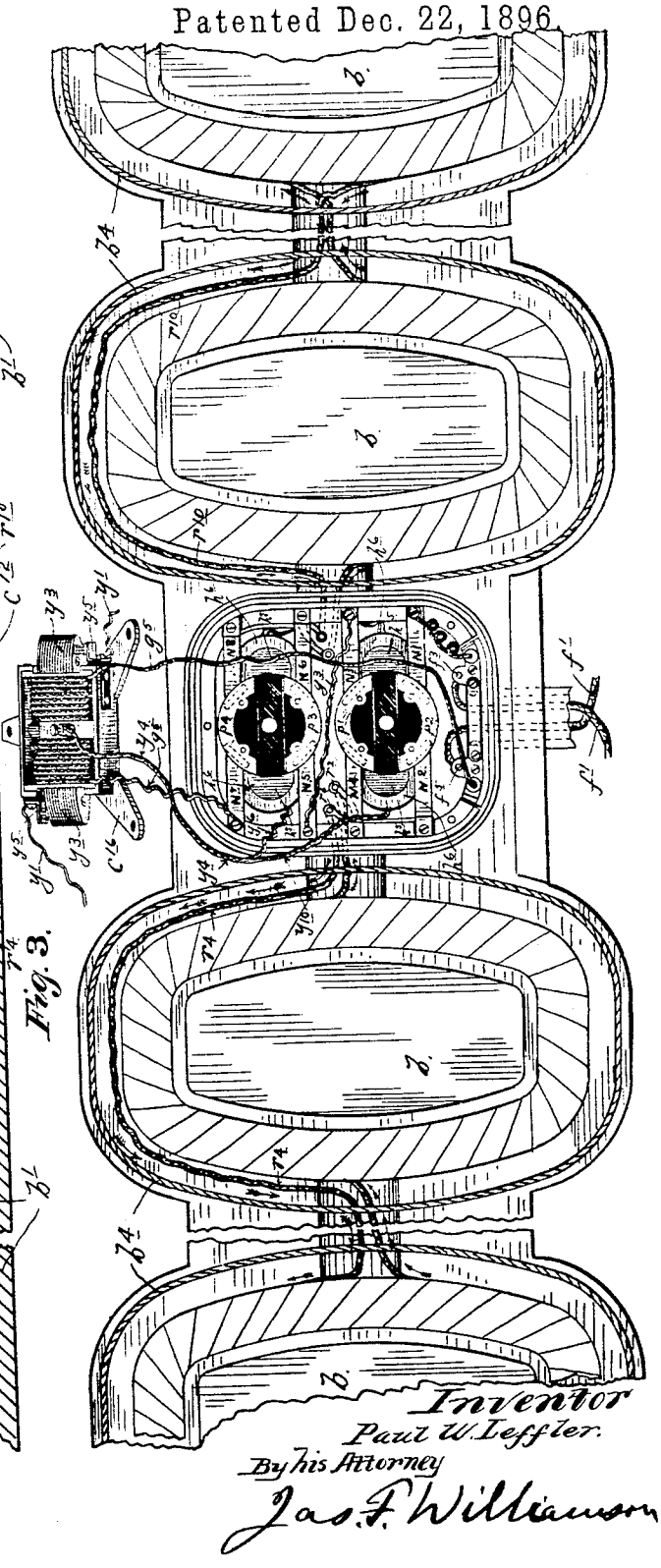

Fig. 3.

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Jas. F. Williamson

(No Model.)

4 Sheets—Sheet 3.

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Fig. 4.

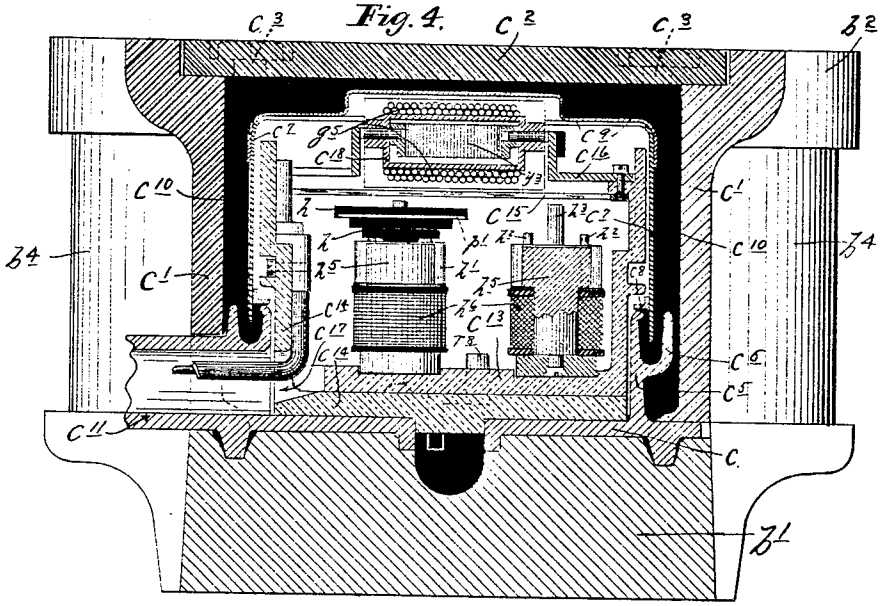


Fig. 5.

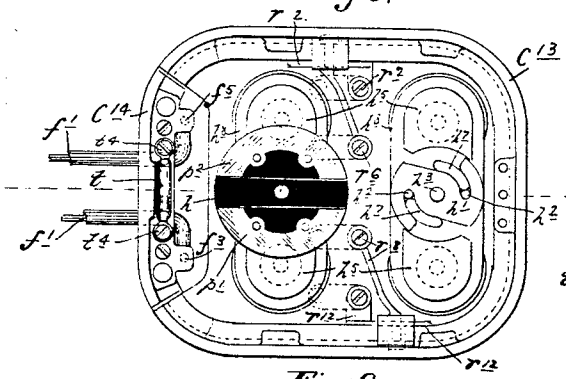


Fig. 7.

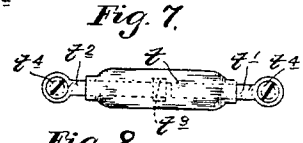


Fig. 8.

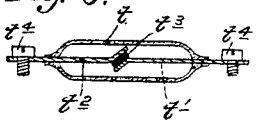
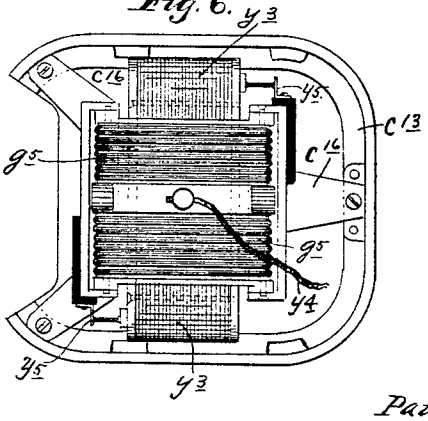


Fig. 6.



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(No Model.)

4 Sheets—Sheet 4.

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Fig. 10.

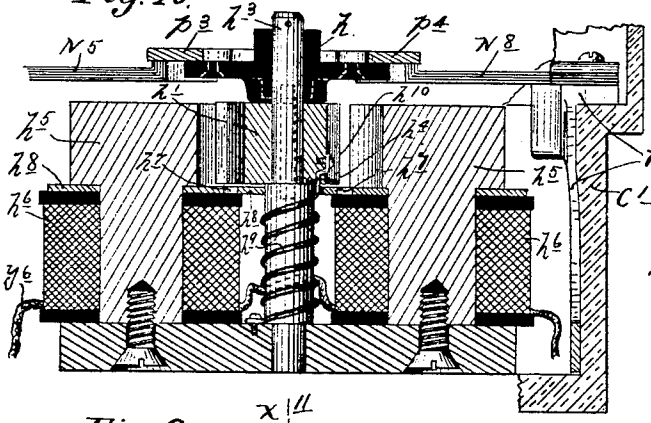


Fig. 15.

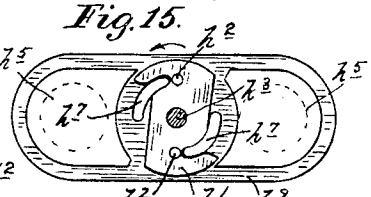


Fig. 16.

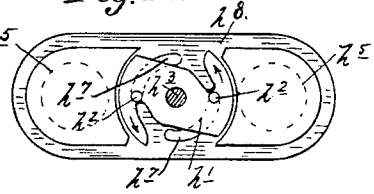


Fig. 9.

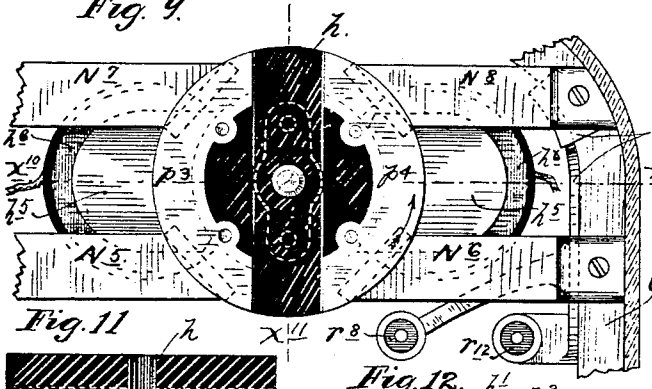


Fig. 17.

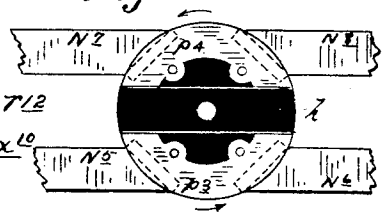


Fig. 18.

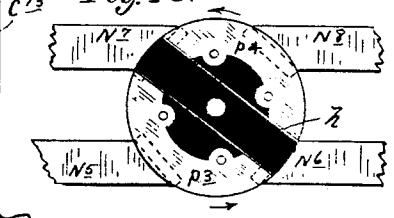


Fig. 11.

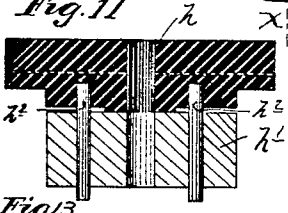


Fig. 12.

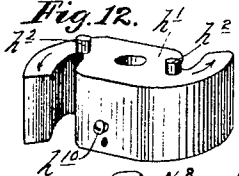


Fig. 13.

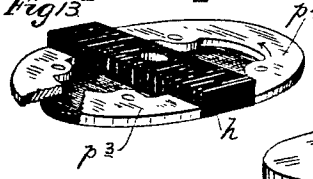
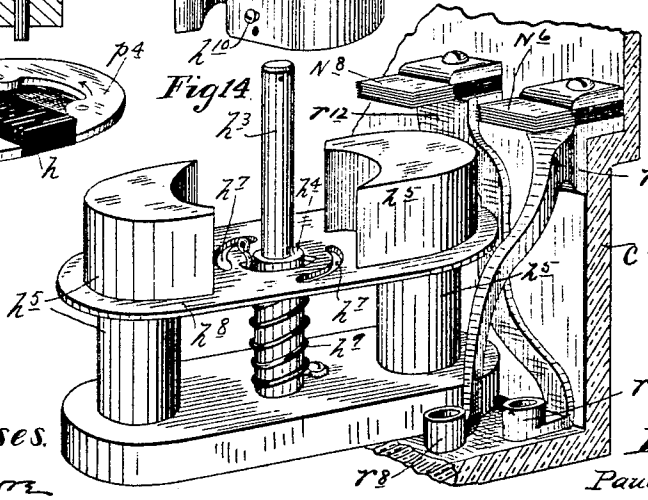


Fig. 14.



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UNITED STATES PATENT OFFICE.

PAUL WILLIAM LEFFLER, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE LEFFLER ELECTRO MAGNETIC RAILWAY COMPANY, OF SAME PLACE.

ELECTRIC RAILWAY, &c.

SPECIFICATION forming part of Letters Patent No. 573,822, dated December 22, 1896.

Application filed March 11, 1896. Serial No. 582,760. (No model.)

To all whom it may concern:

Be it known that I, PAUL WILLIAM LEFFLER, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Electric Railways, &c.; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates especially to that system of electric propulsion for railways and other traveling bodies which is disclosed in certain prior patents and pending applications of mine, identified as follows: United States Patent No. 514,561, of date February 13, 1894; United States Patent No. 514,718, of date February 13, 1894; application, Serial No. 558,992, filed August 12, 1895; application, Serial No. 558,993, filed August 12, 1895; application, Serial No. 559,702, filed August 19, 1895; application, Serial No. 563,716, filed September 26, 1895, and application, Serial No. 564,981, filed October 8, 1895. In said system, as will appear from the patents, a non-rotating armature is carried on the car or traveling body and field-magnets are located in the line of travel. The armature is supplied with current from a small storage battery on the car or from any other suitable source, and the field-magnets are supplied from a dynamo or other source at a central generating-station. The field-magnets are connected up so as to form successive sections adapted for independent connection with the supply-circuit, and corresponding automatic switch-boxes are located in the line of travel, which are operative under the control of the car to cut into the supply-circuit the particular section or sections of the field over which the car is passing and to cut out of the supply-circuit the sections of the field already passed over by the car.

My present invention is within the generic claims of my above-identified patents and applications, but is in the nature of an improvement over the means shown in said prior cases for controlling the field-sections, with a view of increased efficiency, greater safety, and better adaptation to higher speeds.

To these ends my invention consists of the novel devices and combinations of devices, which will be hereinafter described, and defined in the claims.

The exact relation of my present invention or improvements to the inventions disclosed in my said prior cases can best be noted after the detailed construction of my present mechanism has been considered. It will probably only be necessary to compare with the above-identified Patent No. 514,718 and the above-identified application, Serial No. 558,993.

The accompanying drawings illustrate my present invention, wherein, like notations referring to like parts throughout the several views—

Figure 1 is a view, chiefly in diagram, showing the relative arrangement of the electrical connections. Fig. 2 is a vertical longitudinal substantially central section through one of the switch-boxes and the magnets of the field-section controlled thereby, with some parts broken away and with the coal-tar or other impervious insulating setting material removed. Fig. 3 is a plan view of the parts shown in Fig. 2, with the caps of the field-magnet pole-pieces removed and with the top of the switch-box removed and the solenoid-controller for the switch-magnet circuit pulled out from the box and shown in perspective to one side of the same. Fig. 4 is a vertical cross-section through one of the switch-boxes on the line X^4 X^4 of Fig. 2, with some parts broken away and others removed. Fig. 5 is a plan view of some of the parts shown in Fig. 4, the outside casing of the switch-box, the solenoid-controller, and some other parts being removed. Fig. 6 is a plan view showing one section of the switch-box casing detached, with the solenoid-controller in position thereon. Figs. 7 and 8 are details in plan and vertical section of the safety device or welding bridge-contact employed at the switch-boxes. Fig. 9 is a detail in plan with some parts broken away, showing one pair of the switch-magnets in the switch-box, the armature switch-lever, and the switching-contacts controlled thereby. Fig. 10 is a vertical section on the line X^{10} X^{10} of Fig. 9. Fig. 11 is a vertical section through the armature-lever on the line X^{11} X^{11} of Fig. 9. Fig. 12 is a perspective view of the

Z-shaped armature switch-lever detached. Fig. 13 is a perspective view of the insulating-block and the segmental contacts carried by said armature-lever, with some parts broken away. Fig. 14 is a perspective view of part of one of the switch-boxes, showing the cores of the switch-magnets, the pole-pieces thereof, and the seat for the armature switch-lever, with some parts broken away. Fig. 15 is a diagram view in plan showing the relation of the armature-lever to its co-operating pair of magnets when the said parts are in their normal position or as shown in Fig. 9. Fig. 16 is a view similar to Fig. 15, but showing the said parts as they would appear when the switch-magnets are energized as required to cut the field-sections into the supply-circuit. Fig. 17 is a plan view showing the contacts in the position which they would occupy when the armature-lever is in the position shown in Fig. 16. Fig. 18 is a view similar to Fig. 17, but showing the contacts in a different position for illustrating the lap of the switch-contacts, whereby the supply-circuit is never broken.

So far as the parts carried on the car are concerned, the same may be dismissed with brief notice, for the reason that the said parts on the car are or may be identical with parts shown for the same purpose in my prior cases. The parts herein shown as intended to be carried on the car, with certain details of exception, are substantially the same as corresponding parts shown in my above-identified application, Serial No. 558,992.

The car is not fully shown, but the truck-wheels a are indicated in Fig. 1. From the car-truck is supported in any suitable way a non-rotating armature, composed of a continuous core a' and downwardly-projecting pole-pieces a^2, wound by wires 1, 2, and 3, represented, respectively, by full, broken, and dotted lines in Fig. 1. The coils are wound around the body of the core a' between the pole-pieces a^2 and are so connected up as to form three series or sets, which are sufficiently distinguished by the said wires 1, 2, and 3. The said wires 1, 2, and 3 have their terminals connected to corresponding brushes a^3, which coöperate with the segments a^4 and a^5 of a suitable commutator, the shaft of which is indicated at a^6. The said segments a^4 are live or alternating plates in respect to the armature-coils with the opposite or pairs thereof of like polarity electrically connected together by wires a^7 or other suitable means, while the segments a^5 are idle or non-alternating plates in respect to the armature-coils and are electrically connected together by resistance-coils a^8. With the armature feed-rings a^9 coöperate a pair of brushes a^{10}, which are connected by wires a^{11} with the proper contact members of a reversing-switch a^{12}. The movable contacts of the reversing-switch a^{12} are connected by wires a^{13} with the proper contact members of an ordinary cut-out switch a^{14}, which in turn is connected by wires a^{15} with the poles of a battery or other suitable source, (indicated at a^{16}.) The commutator is driven by a rotary pole-changer a^{17} through suitable connections, (partly indicated at a^{19}.) The coils of the pole-changer a^{17} are supplied with current from the battery a^{16} through wires a^{18}, tapping the wires a^{13} and connecting through suitable brushes (not shown) with feed-rings a^{20} on the pole-changer shaft. This pole-changer a^{17} is subject to the action of the field-magnets hereinafter noted and drives the commutator with a speed which varies according to the speed of the car, thereby alternating the current through the armature-coil wires 1, 2, and 3 and changing the polarities of the several series of pole-pieces a^2 of the armature a' a^2, as required for the proper action thereof.

The parts so far noted as carried by the car operate the same as in my prior cases. The relative arrangement of the idle or non-alternating plates a^5 of the commutator in electrical connection with each other through the resistance-coils a^8 is, however, a material detail of improvement for preventing sparking at the commutator.

Turning now to the field-magnets and the electric connections for controlling the same, b represents magnets the cores of which rise from and are a part of iron base-plate b', which rests on the top of the ties. (Not shown.) The said magnets b are properly spaced apart from each other in the line of travel, and are so wound that when energized adjacent magnets are of opposite polarity. The electrical connections for said field-magnets b are so arranged as to divide the field into successive sections, adapted to be connected up in series in the supply-circuit. A corresponding series of switch-boxes are provided with the contacts so arranged that normally the field-sections are cut entirely out from the supply-circuit, but that the field-sections may be cut into the supply-circuit under the control of the armature on the car, so as to energize only the section or sections of the field over which the car is passing. The said switch-boxes contain switching contacts in the supply-circuit, which are carried by armature-levers normally held by a spring or equivalent device to close the supply-circuit through a direct path independent of the field-sections, but subject to switch-magnets for closing the supply-circuit through the field-sections, as a by-pass or indirect way. The said switch-magnets are in an independent circuit entirely distinct from the field-supply circuit, and magnetic controllers are located in the connections for said switch-magnets, which controllers normally close a direct path or way independent of the switch-magnets, but are adapted to break the direct path and force the current to pass through the said switch-magnets when the said controllers are under the influence of the armature on the car. Otherwise stated, the said switch-circuit controllers are magnetic and form a part of the

direct or easy path for the switch-circuit current when in their normal or closed positions, but are adapted to be thrown into their open positions when under the influence of the armature on the car, and when the said controllers are thus in their open position the only available path for the switch-circuit current will be from the first controller in normal or closed position in advance of the armature to the first controller in normal or closed position to the rear of the armature. The controllers for the switch-circuit are in the form of pivoted levers constituting the armatures of solenoid-coils which form parts of the direct-way connections of the field-supply circuit. The switching-contacts in said boxes for the supply connections for the field are of such a character as to effect the shift without breaking the supply-circuit and are duplex or in duplicate sets within each box.

With the foregoing general statements in mind it is thought that the details of the construction or arrangement of the connections can more readily be followed. These details will now be given.

The box-frames.—(See Figs. 2, 3, 4, 5, and 6.) The switch-box frames may be regarded as made up of triple casings. The external or outside casing is made up of a bed-casting c, two vertical side plates c', and a horizontal top plate c^2, rigidly connected together by vertical tie-bolts c^3. This leaves the external casing open at its front and rear, or where facing the two field-magnets b, between which the switch-box is placed. The bed-plate c rests on the bottom or body bar b' of the field-magnet cores, and the top plate c^2 fits in the rabbeted seats b^3, formed in the removable pole-pieces b^2 of the said field-magnet cores. The side plates c' and the top plate c^2 are composed of non-magnetic steel or other suitable material, and in the top plate c^2 are set two soft-metal transverse blocks c^4, spaced apart from each other on opposite sides of the longitudinal center of the switch-box. The bed-casting c is provided with a vertical flange c^5, which coöperates with the base portion of said casting to form a cup-like body, and the said flange c^5 is provided on its exterior with a hook-like flange c^6, as best shown in Figs. 2 and 4. A shell c^7 is provided with an internal angular rim or flange c^8, which rests on the top of the flange c^5, with the lower edge of the shell extending into the opening between the body-flange c^5 of the cup and the hook-flange c^6. A cap c^9 engages over the top of the shell c^7. Hence the parts c^5 c^6 c^7 c^8 c^9 coöperate to form what may be called the "central" or "intermediate" casing. When the switch-box is in position, coal-tar c^{10} or other impervious insulating material is run into the spaces between the external casing and the intermediate or central casing just noted, into all the spaces between the switch-boxes and the casings b^4 of the field-magnets b, and into the recesses of the field-magnet-core bar b', which material c^{10} thus forms a setting for the switch-boxes, serving to rigidly unite the parts of the intermediate or central casing and seal the same water-tight. The cup-flange c^5 of the base-casting c c^5 is provided with a side thimble c^{11}, which extends outward through one of the side plates c' of the external casing to afford a passage-way for the feed-wire sections of the supply-circuit, as will be presently noted. The base-casting c is provided with a central slot c^{12}, which affords a passage-way for various electrical connections which will also be noted later on.

The inside casing is made up of a pair of incomplete porcelain cup-sections c^{13} and c^{14}, which are so constructed that when together they will form a complete cup, as shown in Figs. 2, 4, and 5, but will permit the section c^{13} to be removed without disturbing the section c^{14}. The said section c^{13} is shown so removed in Fig. 6. The porcelain section c^{13} is fitted with a glass plate c^{15} near its top which separates certain of the operative parts, as will presently appear. The porcelain section c^{13} carries above the glass plate c^{15} a bearing-spider c^{16}. (Shown best in Figs. 3 and 4.) The porcelain section c^{14} is provided with a side passage c^{17}, which registers with the thimble c^{11} of the base-casting c c^5. All the necessary contacts and operative parts of the switches are carried by the porcelain or inside casing-section c^{13} and c^{14}. These electrical connections or operative parts will now be specified.

Switch-box connections.—(See all views, chiefly Fig. 1.) The main feed-wire or supply-conductor for the field from and to the dynamo or other source (not shown) is made up of a series of sections f', which only connect with each other through suitable contacts within the switch-boxes. The inleading and outleading ends of said feed-wire sections f' enter and leave the switch-boxes through the thimbles c^{11} and the openings c^{17}. The inleading end of each feed-section connects with a contact or binding-post f^3, and the outleading end of said feed-section connects with a similar contact or binding-post f^5. Both of the said binding-posts f^3 and f^5 are carried by the porcelain section c^{14}.

Within the inside or porcelain casing of each switch-box are located eight horizontal brush-contacts, (marked n' to n^8, respectively,) which said contacts are arranged in sets of four each, running lengthwise of the switch-boxes. In said switch-boxes are also located four segmental contacts, (marked p' to p^4, respectively.) The said segmental contacts are mounted to be turned through about ninety degrees in the horizontal plane by means which will hereinafter be noted, as required for the proper coöperation with the brush-contacts n' to n^8. Normally the said segmental contacts stand crosswise of the brush-contacts, as shown in the switch-box at the extreme left in Fig. 1, by reference to which it will be seen that the odd-numbered segments

normally connect the odd-numbered pairs of brush-contacts. The inleading terminal f^3 of any given feed-wire f' is connected by wire g' or other conductor with the brush-contact n'. The brush-contact n^3 is connected by wire g^3 or other conductor with the brush-contact n^5. The brush-contact n^7 is connected by wire g^5 with the outleading terminal f^5 of the feed-wire section f'. It will thus be seen that the odd-numbered parts, to wit: the contacts n' n^3 n^5 n^7, the segments p' p^3, and the wires g' g^3 g^5, taken collectively, constitute connections within the switch-boxes, affording, normally, a direct path for the supply-circuit current entirely independent of the field-magnets b. The wire g^5 in its course winds about a soft-metal armature y^5, which constitutes the controller for the switch-magnet circuit, as will presently be more fully noted. In the further description it will be convenient to call the wire-section g^5 the "solenoid" or "controller" section of the supply-circuit wires, inasmuch as the coil thereof surrounding the core or armature y is a solenoid.

To the even-numbered brush-contacts n^2 n^4 are attached arms r^2 r^6 within the switch-boxes forming the terminals of a wire loop r^4, which extends outward from the switch-boxes and either forms or connects with the coils of the two field-magnets b to the left of the switch-box, as shown in Fig. 1. To the other pair of even-numbered brush-contacts n^6 n^8 are connected a corresponding pair of contact-arms r^8 r^{12} within the switch-box forming the terminals of a corresponding loop-wire r^{10}, which extends outward from the switch-box and either forms or connects with the coils of the two field-magnets b to the right of the switch-box, as shown in Fig. 1. It will be convenient to call the wires r^4 and r^{10} the "field" or "field-magnet" loops. The said field-loop wires r^4 and r^{10} pass in and out of the switch-boxes through the bottom slot c^{12} in the base-casting c.

By inspection of the switch-box at the extreme left in Fig. 1 it will be seen that all the even-numbered connections are cut out or separated from all the odd-numbered connections within the said boxes, and it has already been noted that the said odd-numbered connections within the switch-box normally connect the inleading and the outleading terminals of the two adjacent feed-wire sections f' of the supply-circuit. Hence it follows that all the even-numbered parts within the switch-box are normally cut out from the supply-circuit. No current, therefore, can reach the field-magnets b; or, otherwise stated, the four field-magnets b, controlled by the said switch-box at the extreme left in Fig. 1, are cut entirely out from the supply-circuit.

Before tracing the path taken by the current through the switch-box and the field-loops r^4 and r^{10} when the field-section is cut in it is necessary to note the way in which the segmental or movable switch-contacts p' to p^4, inclusive, are mounted and controlled. This will now be given. This will be readily understood on reference to Figs. 9 to 18, inclusive. The said segmental contacts p' to p^4 are carried in pairs on a suitable head h of insulating material properly constructed to insulate the pair of contacts carried thereby from each other. The said insulating-head h is of disk-like form, with a raised central portion, and each of said disks h carries one odd-numbered and one even-numbered segmental contact. The said head h is fixed to a **Z**-shaped soft-iron armature-lever h', the connection between the two being made by upper ends of brass dowel-pins h^2, as shown best in Fig. 11. The **Z**-shaped armature h' and the head h are loosely mounted on a bearing-spindle h^3. The said spindle h^3 is shouldered at h^4 to form a seat for the armature h' and is centrally located in respect to the pole-pieces h^5 of a pair of small switch-magnets h^5 h^6. The dowel-pins h^2 in the armature h' have their lower ends extended and working in curved slots h^7 of a brass plate h^8. A coiled spring h^9 encircles the spindle h^3, with its lower end attached to the base-plate of said switch-magnets and its upper end attached by a set-screw h^{10} or otherwise to the **Z**-shaped armature h'. The ends of the **Z**-shaped armature h' are of curvilinear form and work between the pole-pieces h^5 of the said switch-magnets h^5 h^6, which pole-pieces have faces of corresponding curvilinear form, forming a comparatively close joint with the end of the armatures h' when the armature is in line with the pole-pieces. The said spring h^9 normally holds the **Z**-shaped armature h' at right angles to the pole-pieces h^5 or as shown in Fig. 15; but when the coils h^6 are closed into the switch-magnet circuit, which will presently be noted, the armature h' will be turned by the magnetic forces into the position shown in Fig. 16, or substantially into line with the pole-pieces h^5. This magnetic movement of course sets the spring h^9 under tension, which will become effective to return the armature h' into its normal position, as shown in Fig. 15, as soon as the switch-magnets are deënergized. Hence it is obvious that under the coöperation of the said switch-magnets h^5 h^6 and the said spring h^9 the **Z**-shaped armatures h' and the parts carried thereby may be given substantially quarter-turns in reverse directions whenever so required; but the armatures h' carry each one pair of the segmental or switching contacts p' to p^4 and therefore control the switching movements of the segmental contacts. The **Z** shape of the armature h' is important in order to insure the proper action thereof. In virtue of the **Z** shape a sufficiently long throw thereof can be obtained to effect the movement required for the proper action of the switching-contacts. A straight bar could not be employed on account of the air-gaps which would occur at the end of an extremely small throw thereof at the joints between the ends of the same and the pole-pieces h^5. The brass

dowels h^3 also have the effect of extending the non-magnetic path for the forces through the armatures h'. Otherwise stated, the form of switch-lever herein employed is constructed for torsional action under the action of the switch-magnets in one direction and under the action of the spring h^9 in the other direction.

As hereinbefore noted, the said switch-magnets h^5 h^6 are supplied with current at the proper times from a circuit which is entirely independent of the field-supply circuit hitherto fully described. The main or direct path for the said switch-magnet circuit is made up of a series of wire sections y', the solenoid-armature or switch-magnet controller y^3, and pairs of contacts y^5 in the switch-box adapted to be connected or separated by the controller or solenoid-armature y^3. The said contacts y^5 are carried by and insulated from the bearing-spider c^{16}, as shown in Figs. 3 to 6, and the controller y^3 is provided with projecting parts which may be contacted or separated from the parts y^5; but it will be more convenient, on account of the diagram view Fig. 1, to treat the controller-body y^3 as directly engageable with or separable from the said contacts y^5. The wire sections y' connect with the contacts y^5. The controller y^3 is pivotally mounted in the bearing-spider c^{16}, and constituting, as it does, the armature of a solenoid formed by a coil in the wire member g^5 of the main or field-supply circuit is always energized from the said solenoid-coil and will normally occupy a horizontal position and thereby will be operative to connect the contacts y^5 or adjacent sections y' of the switch-circuit conductor. Hence normally the current on the switch-circuit can pass directly through the odd-numbered parts y' y^3 y^5 as an easy or direct path without going through the switch-magnet coils h^6.

The controller y^3 is connected by wire y^4 and branch y^6 with the coils h^6 of the pair of switch-magnets most distant from the observer in one of the switch-boxes, as shown in Fig. 1, and which, for convenience, it will be well to call the "upper pair," as distinguished from the nearest pair, which may be called the "lower pair" of switch-magnets. A wire y^8 extends from the said upper pair of switch-magnets in any given switch-box to the right-hand member of the lower pair of switch-magnets in the next adjacent box toward the right with respect to Fig. 1. A wire y^{10} connects the left-hand member of the lower switch-magnets in any given box with the wires y^4 and y^6. The wires connecting each pair of switch-magnet coils h^6 within the boxes are marked with the same notation as the magnet-coils themselves, to wit, h^6. The said even-numbered connections y^4 to y^{10}, inclusive, constitute indirect or by-pass connections or switch-magnet loops, over which the current of the switch-circuit will be obliged to pass from the first controller y^3 in normal or closed position, to the rearward of the armature on the car, to the first controller y^3 in normal or closed position, in advance of the said armature on the car. Otherwise stated, whenever any given controller y^3 is tilted, under the control of the armature a' a^2 on the car, out of its normal position into the inclined position shown, for example, by the third controller y^3 from the left in Fig. 1, the direct or easy path for the current on the switch-circuit will be broken at that point, and hence the current will have to pursue the indirect path, through certain of the switch-magnets, over the even-numbered connections y^4 to y^{10}, inclusive, as hitherto noted. This course can readily be traced on Fig. 1 by considering the relation of the second, third, and fourth controllers from the left. The direct path of the switch-circuit current being broken at the third controller, the current must pass over the wire y^4, leading from the second controller to the branch wire y^6, and through the coils h^6 of the upper pair of switch-magnets in the second box to the wire y^8, and thence to the lower pair of switch-magnets in the third box, and thence over the wire y^{10} to the wire y^6 of the third box, whence the path repeats through the upper pair of magnets in the third box and the lower pair in the fourth box back to the wire y^{10} of the fourth box; but from this point the current will pass over the wire y^4 of the fourth box to the fourth controller y^3 and main-switch circuit-wire y' and onward to source. Hence when any given controller y^3 is tilted into its open position under the influence of the armature on the car both pairs of switch-magnets in that box and one pair in each of the two adjacent boxes will be energized, thereby shifting the corresponding segmental or switching contacts p' to p^4 of the field-supply circuit into line-and-line positions with the brushes n' to n^8, as shown in the second, third, and fourth boxes in Fig. 1. When the segmental contacts p' to p^4 are thus shifted, the main or field supply circuit will no longer be closed over the direct-way connections, (signified by the odd-numbered parts within the switch-boxes, as hitherto noted;) but more or less of the even-numbered parts will be brought into action, so as to close the supply-circuit through either one or both of the field-loops r^4 r^{10} of each box, according to whether only one or both pairs of the segmental or switching contact p' to p^4 have been turned from their normal or crosswise position into their parallel or lining position with respect to the brush-contacts n' to n^8.

For example, in the second box, as shown in Fig. 1, the lower member of the duplex or duplicate switch has been thrown into action, while in the third box both members of the duplex switch have been thrown into action. Hence in the second box the path of the supply-circuit current will be over the parts g' n' p' n^3 g^3 n^5 p^3 n^6 r^8 to the loop-wire r^{10}, thence through the coils of the two field-magnets in advance or at the right of the box and back to the contact r^{12} in the switch-box, thence

over the parts r^{12}, n^8, p^4, and n^7 to the solenoid-wire g^5 and over the same to the contact f^5 and the next field-wire section f'. On reaching the third box the course will be over the parts g' n' p^2 n^2 r^2 to the loop-wire r^4 and through the left-hand pair of field-magnets b back to the contact r^6, thence over the parts n^4 p' n^3 g^3 n^5 p^3 n^6 to the contact-arm r^8 and the loop-wire r^{10}, thence through the two field-magnets in advance of the box back to the contact r^{12} and over the parts n^8 p^4 n^7 to the solenoid-wire g^5, and thence to the contact f^5 and the next feed-wire section f'. On reaching the fourth box the course is the same as for the third box until the current reaches the brush n^5, whence it will pass over the contact p^3 directly to the brush n^7, and thence to the solenoid-wire g^5 and out over the contact f^5 to the next section f' of the feed-wire. The parts in the fifth box (not shown) would stand in the same positions as those shown in the first box, and hence the current would follow the odd-numbered parts therethrough without affecting the field-section connected with the fifth box.

From the foregoing detailed statement it is obvious that whenever the controller y^3 in any given switch-box is tilted under the influence of the armature on the car both of the duplicate supply-circuit switches in that box and one member out of the adjacent boxes will be actuated with the effect of cutting into the supply-circuit four field-loops or eight field-magnets.

For convenience of statement let the box whose controller y^3 is tilted or under the influence of the armature on the car be called the "open" box and the others or those whose controllers y^3 are horizontal or beyond the car-armature be called the "closed" boxes. Then we may say that both field-coils from the open box and one field-coil from each of the adjacent closed boxes are cut into the main or field supply circuit, or, otherwise stated, that the whole bipartate field-section—to wit, the four field-magnets b, connecting with the open box—and one-half—to wit, two field-magnets b of each of the adjacent closed boxes—are cut into the supply-circuit. The same rule would hold true in case the armature on the car was of a length to span several boxes, as all thereunder would be open and all field-loops thereof, together with one field-loop of the next adjacent closed box in either direction, would be cut into the field-supply circuit. This holds true in either direction of the car's travel, and the field-loop cut in from the said adjacent closed boxes is always the advance or forward loop with respect to the direction of the car's travel. Just as quick as the rear end of the car-armature passes beyond the controller y^3 of any box the rear field-loop of that box is cut out. Otherwise and more generally stated, the duplex switches and bipartate field-sections enable only the minimum required amount of the field to be cut into the supply-circuit and insure the cutting out of the field immediately rearward of the car-armature.

The foregoing statements describe the action of the switch-boxes, but certain further details require notice. The switch-magnet wires y' and y^8 enter and leave the switch-boxes through the central slot c^{12} in the bed-casting c, but are not shown in Figs. 2, 3, or 4, in order to avoid confusion.

The solenoid-coils in the field-supply circuit-wire sections g^5 are not of course wound directly around the armatures or controllers y^3 of the switch-magnet circuit, but are wound about a suitable shell or hollow box-like core c^{18}, as best shown in Figs. 2 and 4. This shell c^{18} is fixed to the bearing-spider c^{16} in a horizontal position, and the controller or armature y^3 is pivoted therein with freedom for the necessary tilting motion. Otherwise stated, the shell c^{18} is of a depth or cross-section sufficient to permit the said pivotal movement of the said armatures or controllers y^3. In the diagram Fig. 1 the said shells c^{18} are omitted for distinctness of illustration, and hence at the open box the coil itself, as well as the controller, appear to be tilted.

The use of the plate c^3, of non-magnetic steel, as the top or cover for the external casing of the switch-boxes, together with the soft-iron block c^4 set therein, insures the proper action of the pole-pieces a^2 of the car-armature on the controllers y^3, or, otherwise stated, the magnetic forces from the car-armature can only act on opposite sides of the pivotal center of the controller, and the parts are so proportioned and disposed that the forces from the armature will always coöperate to move the controller y^3 in a common direction. Hence the proper pivotal movement of the controllers y^3 is insured.

Each switch-box is provided with a safety or short-circuiting device in the form of a bridge composed of a pair of contacts t' t^2, projecting from an exhausted glass bulb t, with their inner ends separated by insulating material t^3, as best shown in Fig. 8. This device is applied with the projecting ends of the contacts t' t^2 made fast by screws t^4 or otherwise to the inleading and outleading terminals f^3 f^5, respectively, for the feed-wire sections f', as shown in Figs. 1, 3, and 5. The resistance offered by the insulating material t^3 is sufficient to make the current follow its normal path or paths through the switch-box under normal conditions; but if anything gets wrong in the switch-box the insulating material t^3 will burn out and cause the contacts t' t^2 to fuse together within the bulb t and afford a bridge or a short-circuit connection between the two adjacent terminals f^3 f^5.

When making repairs or inspecting the boxes, the workman would use a portable bridge to connect the two adjacent field-circuit main-wire sections f' at the terminals f^3 f^5 inside the box, thereby avoiding all danger in handling the parts within the box.

Comparison with my prior cases.—In my prior patent, No. 514,718, of date February 13, 1894, the system of distribution for the field was one of constant pressure with the field-sections connected up in multiple, and the switch-magnets were operated by shunt-circuits from the main field-circuit.

In my pending case, Serial No. 558,993, filed August 12, 1895, and allowed November 20, 1895, the system of distribution for the field is one of constant amperage, with the field-section connected up in series and the switch-magnets in shunt-circuits from the field-circuit.

In my present case the system of distribution for the field is one of constant amperage, with the field-sections normally entirely cut out from the supply-circuit, but adapted to be connected up in series therein, and a separate or distinct circuit is used for the switches. My said pending case, Serial No. 558,993, in a broad point of view has many points of similarity with and contains generic claims covering my present case; but the differences between the two are also very material.

In both of my said prior cases there was always a possibility of short-circuiting through the field-magnets when not desired, in case, for example, of a ground, for the reason that the field-magnets were not entirely disconnected from the feed-supply conductors. In my present case such a result is rendered impossible, for the reason that, normally, the field-magnets are entirely disconnected or separated from the feed-supply-circuit conductors. The use of the independent circuit for the switch-magnets is also a material improvement, for the reason that injury to the switch-magnets and their connections by current from the main or field supply circuit is thereby avoided. The work on the switch-magnet circuit is light and that on the field-circuit is heavy, and by the use of the independent circuits as above noted all the parts may be better graduated for the work required and be rendered more safe and reliable.

Most of the other peculiar advantages of my present invention have been already noted in the general statement or in the detailed description. Further attention is, however, directed to the fact that on account of the peculiar construction of the switches herein shown the system of propulsion is rendered better adapted for high speed. The controllers y^3 are sufficiently sensitive to respond quickly to the armature on the car and require but little movement to cut in the switch-magnets, and the Z-shaped armatures h' are quickly responsive to the said switch-magnets, and hence may be relied upon to effect the proper movements of the segmental or switching contacts p' to p^4 in the supply-circuit connections.

By actual usage I have demonstrated the practicability or operativeness of the invention herein disclosed.

Of course it will be understood that minor changes might be made without departing from the spirit of my invention.

It should have been noted that the segmental contacts p' to p^4 and the heads of the brushes n' to n^5 are of such size and so related that the said segments will lap three brush-heads in turning from their normal or crossing position to their lining position in respect to the said brushes, or vice versa, as shown best in Fig. 18. In virtue of this construction the main or supply circuit is never broken at the switching-contacts therein, or, in other words, the cutting-in connections will be established before the cutting-out connections are broken, or vice versa. This avoids sparking at the said switches, while at the same time connecting two terminal brushes of the field-circuit, avoiding any magnetic kick from the field-magnets, which would occur if this circuit was suddenly opened.

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

1. The combination with a car or other traveling body, having an armature, of field-magnets, in the line of travel, and supply-circuit connections for said field, arranged to divide the same into successive sections, adapted to be connected up, in series, into the supply-circuit, and including, as parts thereof, a series of automatic switches which normally cut the field-section magnets entirely out of the supply-circuit, but are operative, by the car, to close into the supply-circuit the particular section or sections of the field over which the car is passing, substantially as described.

2. The combination with a car or other traveling body, having an armature, of field-magnets, in the line of travel, and supply-circuit connections, for said field, arranged to divide the same into successive sections, adapted to be connected up, in series, into the supply-circuit, and including, as parts thereof, magnetic switches which normally cut the field-sections entirely out of the supply-circuit, but which are operative, by the armature on the car, to cut in the field section or sections over which the car is passing, substantially as described.

3. The combination with a car or other traveling body, having an armature, of field-magnets, in the line of travel, supply-circuit connections, for said field, arranged to divide the same into successive sections, adapted to be connected up into the supply-circuit, magnetic switches forming parts of said field connections, which switches normally cut said field-sections out of the supply-circuit, but are adapted to cut the same into the supply-circuit, under the influence of the armature on the car, and independent circuit connections for the magnets of said switches, substantially as and for the purposes set forth.

4. The combination with a car or other traveling body, having an armature, of field-magnets in the line of travel, supply-circuit connections dividing the field into successive sections adapted to be connected up, in series, into the supply-circuit, magnetic switches, in said connections, normally cutting out said field-sections entirely, but adapted to cut the same in, when the switch-magnets are energized, an independent circuit for said switch-magnets, and controllers, in said switch-circuit connections, normally cutting out the switch-magnets but adapted to cut the same into the switch-circuit, under the influence of the armature on the car, substantially as described.

5. The combination with a car or other traveling body, having an armature, of field-magnets, in the line of travel, supply-circuit connections for said field, arranged to divide the same into successive sections, adapted to be connected up, in series, in the supply-circuit, and magnetic switch-boxes, in said connections, with switching-contacts for the supply-circuit, which normally afford a direct way or path for the current, entirely independent of the field-magnets, but adapted to establish a by-pass through the magnets of the field-sections, independent circuit connections for the switch-magnets, arranged to normally afford a direct or easy path for the switch-circuit current, independent of the switch-magnets but including a magnetic controller subject to the armature on the car, adapted, when thrown out of its normal position, to break the direct path and force the current of the switch-circuit to pass through the switch-magnets, substantially as and for the purposes set forth.

6. The combination with a car or other traveling body, having an armature, of field-magnets, in the line of travel, and supply-circuit connections for said field, arranged to divide the same into successive sections, adapted to be connected up into the supply-circuit, and including, as parts thereof, magnetic switches having controllers operative by the armature on the car and normally closing a direct or easy path for the switch-circuit current, but so arranged, that, whenever one or more controllers are thrown into their open position, by the armature on the car, the only path for the switch-circuit current will be from the first controller in closed or normal position, in advance of the armature to the first controller, in normal or closed position, to the rear of the armature, and hence through all the intermediate switch-magnets, substantially as and for the purpose set forth.

7. The combination with a car or other traveling body, having an armature, of field-magnets in the line of travel, and supply-circuit connections for said field-magnets, including a series of switch-boxes provided each with duplicate switches, arranged to normally afford a direct way for the supply-circuit current, independent of the field-magnets, but adapted, under the control of the car, to connect up the field-magnets, in bipartate sections into the supply-circuit, substantially as and for the purposes set forth.

8. The combination with the car or other traveling body having an armature, of the field-magnets in the line of travel, and the supply-circuit connections for said field-magnets, comprising the main feed-circuit, the independent switch-magnet circuit, and the duplex switches, arranged to afford a direct way for the supply-circuit current but adapted to connect the field-magnets up in bipartate sections, into the supply-circuit, and having controllers for the switch-circuit connections, normally affording a direct and easy path for the switch-circuit current, independent of the switch-magnets, but adapted, under the influence of the armature on the car, to cut in the switch-magnets and operate the supply-circuit switching-contacts, substantially as and for the purposes set forth.

9. The switch-box frame, composed of the incomplete external casing $c\,c'\,c^2$, as described, the intermediate casing composed of the parts $c^5\,c^6\,c^7\,c^8\,c^9$, as described, and the internal or inside casing consisting of the separable porcelain cup-sections $c^{13}\,c^{14}$, coöperating to form a complete cup of insulating material, for holding the electrical connections in the box, substantially as and for the purposes set forth.

10. The combination with the car or other traveling body, of the field-magnets in the line of travel, and the supply-circuit connections for said field-magnets, including the series of switch-boxes, with switches therein, arranged to afford a direct way for the supply-circuit current, independent of the field-magnets, but adapted, under the control of the car, to connect the field-sections, into the supply-circuit, and the safety-bridges $t\,t'\,t^2\,t^3$ connecting the terminals f^3 and f^5 of the supply-circuit feed-wire sections f', at the switch-boxes, substantially as and for the purposes set forth.

11. The combination with a car or other traveling body, having an armature or other magnetic mass, of the field-magnets, in the line of travel, the supply-circuit connections for the field, the switch-boxes in said connections having centrally-pivoted magnetic controllers, subject to the action of said armature or magnetic mass on the car, and covers, for said switch-boxes, composed of non-magnetic material, but provided with soft-iron blocks set therein, on opposite sides of the controller's pivot, substantially as and for the purpose set forth.

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

PAUL WILLIAM LEFFLER.

Witnesses:
C. W. FERGUSON,
OTTO JOHNSON.

Gray 5-346422 Mag. Closers