(No Model.) 2 Sheets—Sheet 1.

G. T. WOODS.

ELECTRO MOTIVE RAILWAY.

No. 385,034. Patented June 26, 1888.

Fig. 2

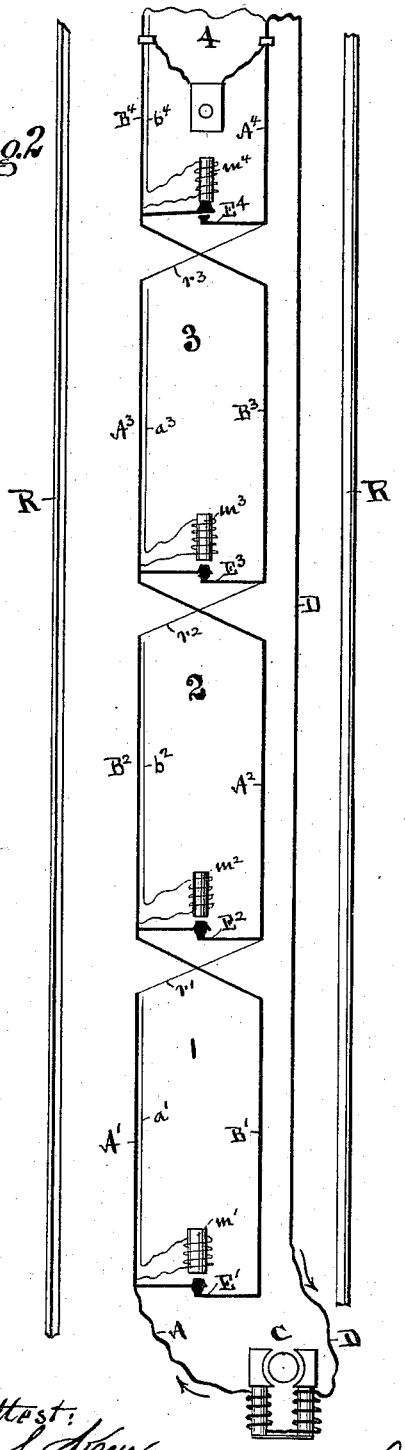


Fig. 1

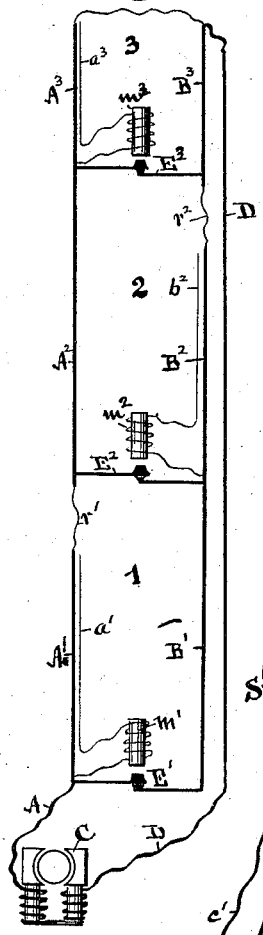
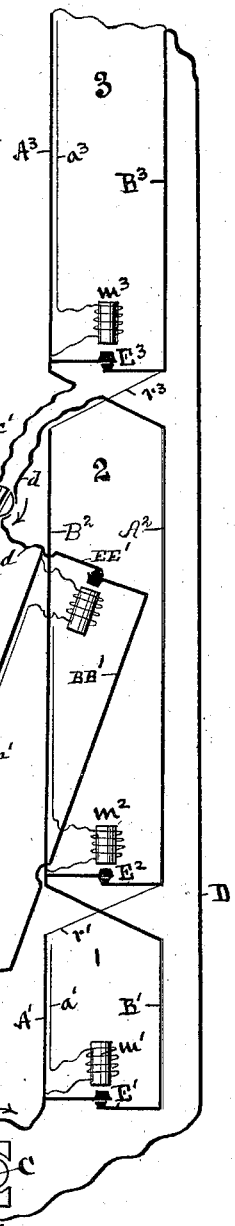


Fig. 3



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(No Model.) 2 Sheets—Sheet 2.

G. T. WOODS.

ELECTRO MOTIVE RAILWAY.

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Fig. 4

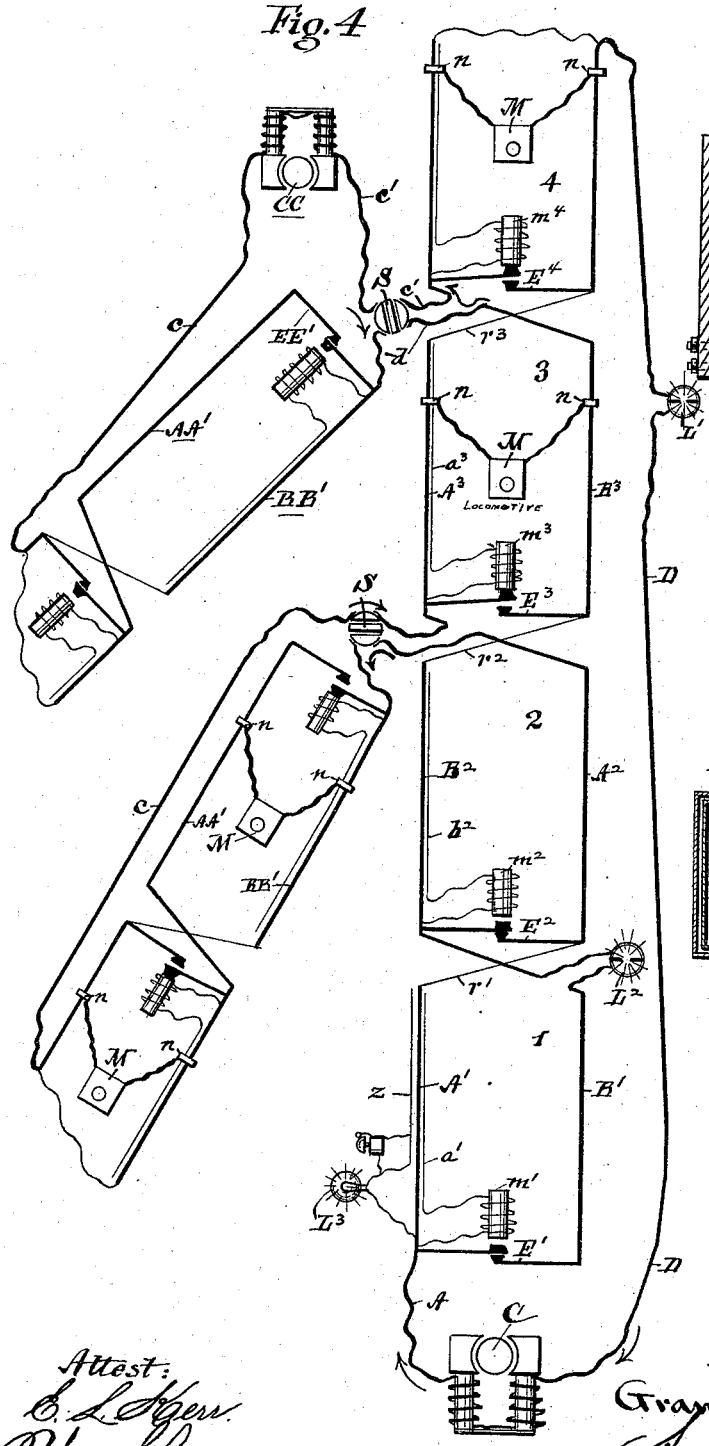


Fig. 5

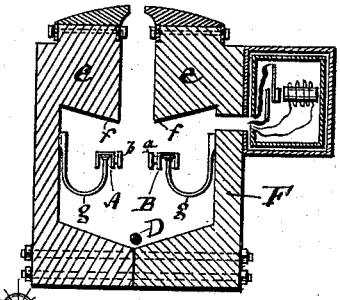


Fig. 6

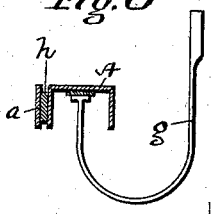
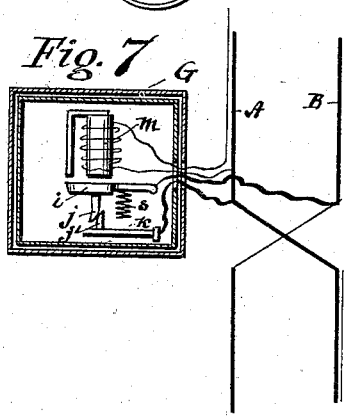


Fig. 7



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Atty.

UNITED STATES PATENT OFFICE.

GRANVILLE T. WOODS, OF CINCINNATI, OHIO, ASSIGNOR TO THE WOODS ELECTRIC COMPANY, OF SAME PLACE.

ELECTRO-MOTIVE RAILWAY.

SPECIFICATION forming part of Letters Patent No. 385,034, dated June 26, 1888.

Application filed August 23, 1886. Serial No. 211,602. (No model.)

To all whom it may concern:

Be it known that I, GRANVILLE T. WOODS, a citizen of the United States, residing at Cincinnati, Ohio, have invented new and useful Improvements in Electro-Motive Railways, of which the following is a specification.

My invention relates to electrical railways, and embodies improvements in the system of construction and mode of operation, as set forth in the following specification and claims.

In the drawings accompanying and forming part of this specification, Figure 1 is a diagram plan view showing the arrangement of conductors in its simplest form for operating locomotives in series; Fig. 2, a plan diagram showing the arrangement of conductors preferred for actual use; Fig. 3, a diagram showing the arrangement of independent conductors for side tracks in connection with a main line; Fig. 4, a diagram of main line and two side-track systems, with switches, generators, automatic shunts, cars, and an auxiliary system of lighting by means of the motor-current. Fig. 5 is a vertical cross-section of the conductor-conduit, showing the conductors in position and the shunt apparatus attached; Fig. 6, an enlarged detail section of the conductor and elevation of its supporting-bracket; Fig. 7, a plan of the shunt, showing its magnet and armature contacts.

Referring now to the drawings, A B are two metallic conductors constituting independent parts or branches of a single outgoing conductor, which as a whole is continuous and unbroken throughout the line. These are preferably arranged in a suitable conduit beneath the surface of the roadway, supported on brackets, and formed as hereinafter more fully described, to enable a "brush" or system of brushes attached to the car to maintain a sliding contact therewith as the car moves upon the track. They may, however, be arranged overhead or at the side of the track, above-ground, either in or out of a covering-tube. C designates a current-generator, and D a return-conductor, united with the terminals of both branches of the main conductor and completing a metallic circuit for the distribution of the motive power along the line.

Referring now to Fig. 1 for purposes of preliminary explanation, the line of railway is divided into "blocks" of any convenient length, (indicated by the numbers 1, 2, 3, &c., in the drawings.) The outgoing conductor is divided into two parallel branches, (designated generally by the letters A B,) and further divided into sections corresponding with the blocks of the system, and each section of the conductor is numbered to indicate the block to which it belongs—thus, A' A^2 B' B^2, &c. The same use of the numbers is made to localize the other parts hereinafter described.

The letter used without an indicating-number will be understood to designate a part or element in reference to its general function merely, without reference to its place in the blocks.

At the beginning of each block is arranged a transverse contact-switch, E' E^2 E^3, &c., extending from A' to B', A^2 to B^2, &c., held normally closed by a retractile spring, but thrown open by an electro-magnet, m' m^2 m^3, when the latter is temporarily energized. The magnet is in a short normally-open circuit composed of a section, as A' B^2 A^3, &c., of the outgoing conductor and a short auxiliary conductor, a' b^2 a^3, &c., a portion of which is laid parallel with the said section of the main conductor in such relation that the contact-brush of the locomotive, while on a given block and during its travel thereon, will close the magnet-circuit in a shunt-loop with the main conductor to hold the transverse switch E open while the locomotive is on said block. Alternating in the successive blocks in each branch of the conductor A B a resistance, r' r^2, &c., is interposed just at the generator side of each transverse switch E—that is, in the conducting-line from the source of electrical energy to said switch.

Supposing no locomotive to be on the line, Fig. 1, the circuit from the generator C is traced as follows: From generator C the current on line A divides. The greater portion, following the line of least resistance, passes by switch E', line B', switch E^2, line A^2, switch E^3, line B^3, and back by return-conductor D to generator. The smaller portion of the current, passing resistance r', merges with the main current on A^2, while that passing resistance r^2 merges with the main current on B^3, &c. The divided current thus traverses both branches

of the outgoing conductor, but in unequal quantity upon the corresponding sections of each block. Thus while a relatively great quantity is flowing on B′ a relatively small quantity flows upon A′, because of the resistance r', interposed at the end of the block between A′ and A^2, and similarly as to the succeeding blocks.

It may now be explained that my system of propulsion contemplates a traveling brush-contact upon the two branches A B of the outgoing conductor, connecting them at corresponding points through the motor apparatus, and depending upon the unequal pressure or potential between the branch conductors at said points and the tendency of the current toward an equilibrium of electro-motive force on both. Supposing, now, a locomotive to be traversing block 1, its contact-brushes would complete the magnet-circuit a', energize the magnet m' by a small shunted portion of the current, and open the switch E′. The entire current would now flow upon the branch A′, and the traveling motor-brush would become a moving substitute for the switch E′ and conduct the excess of current over to the branch B′, a limited portion continuing on through resistance r'. When the locomotive passes from block 1 to block 2, the brush leaves the auxiliary conductor a', thus opening the magnet-circuit, and the switch E′ closes. The main current there flows upon B′, and as the brush passes upon the auxiliary conductor b^2 the switch E^2 opens, the brush-contacts of the locomotive transfer the excess of current over to branch A^2, and so on throughout the line. It will be seen that in this case the direction of flow through the locomotive is reversed at each successive block, which would reverse the direction of the propelling apparatus unless the same were provided with a suitable switch acting in unison with such reversal to counteract such tendency. I do not herein show or describe such switch, as many forms of such apparatus are known to and in use among electricians and may be used here.

While the construction referred to is practicable and illustrates to some extent the fundamental principles of my invention, I have adopted as a preferred form of construction that illustrated in Fig. 2 *et seq.* In these illustrations I have preserved the same system of reference-letters and block-numbers as already indicated. The branch conductors are shown crossed at the junction of blocks, the resistance being interposed at such crossings. The description already given applies here with only such modifications as will be obvious on inspection of the figures. The current in this case is not reversed through the motor apparatus in passing from one block to another, because of the reversed position of the branch conductors in successive blocks. The shunt-loop circuits of the switch-magnets m are thus brought to the same side of the line throughout.

In Fig. 2 the system of conductors is shown as arranged between the track-rails R, such location presupposing the conductors to be laid in a sub-surface tunnel or conduit, which will be described more fully later in connection with other mechanical and constructive features. Continuing now the description of the electrical system employed, Fig. 3 represents the mode of operating a branch line or switch upon which an independent motive power is desired. In such case the same system of outgoing conductors is used, the elements of which are indicated in the drawings by the same letters used double. Thus A A and B B are the two side-track branches of the main conductor, the side track being divided, if necessary, into blocks in the same manner as the main line, and designated by numerals indicating the blocks in the same manner—thus, A A′ B B′, &c. The junction being, for example, near the outer end of block 2 of the main line, the side-track conductors A A′ B B′ start at corresponding points adjacent to the main conductors A^3 B^2, so that the locomotive-brushes in leaving the main line at once engage with the conductors of the side track and open the first transverse switch E E′ by closing the local magnet-circuit $a\,a'$. The outer terminals of the side-track conductors are electrically connected by line c with the independent generator C C, and the latter by line c', through a switch, S, with the branch conductors A^3 of main line. The inner terminals of the side-track conductors are electrically connected by line d, through the switch S, with the branch B^2 of the main line, the usual connection between B^2 and A^3 being severed. The switch S is preferably a double plug-switch, consisting of two outer segments of conducting material separated by an interposed filling of insulating material.

When turned in the position indicated in Fig. 3, the electrical connections are as just described—that is, the circuit upon the side-track line is from main-line branch conductor A^3, line c', generator C C, line c, side-track branches A A′ B B′, (and their switch-connections,) lines d, and switch S to main branch conductor B^2. In this case the electro-motive force of both generators is combined upon both the main and side track lines, which are brought into one general circuit, of which the line D is the return-conductor; but by turning the switch S all electrical connections between the main line and the side track are cut off and the lines c' d connected at each side of the switch S, thus restoring the main-line circuit to its independent operative condition, the connection B^2 A^3 being now formed through the switch S. The side-track circuit is also rendered independently operative by the connection d S c', forming a return-conductor.

The side-track system thus described, embodying an auxiliary generator, may be useful in many cases where a side track or branch road of some length is to be operated, or where for any special reason—such as heavy gradients—it is desirable to employ the larger amount of electro-motive force realized by com-

bining an additional generator with the main system. For the ordinary side-track purposes such additional generator will not be required, in which case it may be omitted, and the arrangement otherwise will be such as already described and as indicated in Fig. 4, which figure is a diagram of the entire system, including both systems of side-track connections, together with certain other features, which I will now describe. In this figure are shown four blocks of the main-track conducting system, with locomotives M M in position upon two of them, with their brushes *n n* bridging and completing the circuit between conductors A B. The mode of operation by which the motor force is transmitted to the locomotives has been already sufficiently explained, and it will be obvious that so long as but one locomotive occupies a block it receives the full effect of the equalizing tendency of the transmitted current, and thus locomotives occupying different sections of the conductor will be connected in series.

Lamps may be interposed in the outgoing conductor, as at L′, or in the return-conductor, as at L^2; or a lamp, L^3, for temporary signal purposes, may be brought into circuit by a local shunt-loop, Z, constructed and energized in the same manner as the magnet-loops $a' b^2$, &c., already described.

Having now described the salient features of the system as a whole, reference may be made to certain minor features of importance affecting the details of operation. Thus the branch conductors A B and the local magnet-circuit conductors $a' b^2$, &c., are so arranged that the brushes *n n* break the magnet circuit before passing from the section or block, thus allowing its switch E to close while the brushes *n n* are still in contact with conductors A B of the given block, whatever be the direction of locomotion. This arrangement prevents the sparking and burning out of the contacts of the switches. Again, the block-junctions are arranged so that the locomotor has no electrical connection with the conductors while passing over junctions. The electrical connection between conductors and motors is, therefore, not constant, and short-circuiting is thereby avoided. The advantage gained by having the conductors continuous and unbroken is that if any of the circuits upon the locomotives should by accident fail or become broken no sparking can occur, as the main current has an unbroken outlet to follow while the active shunts are closing. The shunt-circuits, it will be observed, are not placed in the main circuit, but form a temporary loop-connection with the same. Therefore the operation of the shunts does not break the main circuit at all.

Lamps may be arranged, in the manner and in the position shown, in the return-conductor or at the junction of blocks.

Lamp L^3 is incandescent, and its temporary shunt-circuit may also operate a bell-signal—as, for example, in crossing bridges or avenues.

Referring, now, to the features of mechanical construction, the conductors and conduit are preferably formed and arranged as follows: The conduit F, Fig. 5, is composed of wood or other suitable material, preferably placed in the ground between the track-rails R. It may be made of two separate strips, *e e*, grooved and bolted together to form a tunnel-way opening by a continuous narrow slot through the surface of the roadway. The opposite sides, edges, and top of the slotway are faced with iron suitably secured and placed at such an elevation and inclination as to shed water away from the slot. The inner roof of the tunnel proper is formed, as shown, with overhanging projections *f f*, to shed water approximately in the central vertical plane of the slot, and the bottom of the tunnel is suitably formed and provided to conduct to the proper sewer-connections any water penetrating into the tunnel. The overhanging roof-sides *f* of the tunnel afford shelter for the conductors A B, which are supported upon brackets *g* at the sides of the tunnel.

The preferred cross-sectional form of the conductor is indicated in Fig. 6. They consist of strips of conducting material (preferably copper) of inverted-U section insulated upon their supports *g*. The magnet or shunt circuit conductors $a' b^2$, &c., may consist of ordinary rectangular sectioned strips secured at the side of the main conductor, separated by an insulating-strip, *h*, therefrom, as shown.

The preferred form and arrangement of the shunt magnets and connections are indicated in Fig. 7. The magnet *m* is of ordinary construction; but its armature *i* is provided with a finger, *j*, forming a sliding contact with a corresponding finger, *j′*, of the contact-piece *k*, and is normally held in electrical contact by its retractible spring *s*. This form of contact produces a rubbing friction at each action, which assists in preserving a perfect electrical contact, improving by use. The magnet and its connected parts are mounted in a suitable box or casing, preferably of glass or other insulating material, and the whole inclosed in a protecting-casing, G, attached to the side of the tunnel, as shown in Fig. 5.

The conductors being used in sections separated by resistance-connections at points of non-contact with the motor-brushes, provision for the lineal expansion and contraction may be made at such points. If required at intermediate points, rabbeted expansion joints may be used.

The returning conductor is located within the conduit, preferably near the bottom, as shown in Fig. 5, and receives the benefit of any moisture contained therein. I have not described herein the construction and arrangement of the locomotive, as various constructions are known and used which are adapted for operation upon the railway herein described. It may be mentioned, however, as a general constructive condition for motors

adapted to operate upon my improved railway, that they must be provided with a traveling contact brush acting upon and preserving electrical connection with the outgoing conductors and shunts, and derive their propulsive force from the current transmitted from branch A to branch B of the conductor, there being several known constructions answering these conditions.

I claim as new and of my invention—

1. The combination, in an electric railway, of an outgoing and incoming conductor constituting a closed metallic circuit, the outgoing conductor being divided into two branches and having resistances interposed in opposite branches at successive intervals, normally-closed switches connecting said branches at the generator side of said resistances, adapted to be opened automatically by the passage of the motor-contacts, and locomotives forming traveling contact-bridges between the two branches of the outgoing conductor in the intervals of such resistances, and operated by the excess of current passing from the branch of greater to the branch of lesser resistance, substantially as set forth.

2. In an electro-motive railway, a closed metallic circuit, the outgoing portion of which consists of two continuous parallel branches in sections or blocks having resistances interposed in opposite branches at successive block-junctions, and a normally-closed switch connecting opposite branches at the beginning of each block, in combination with locomotives forming traveling contact-bridges between said branches, and means, substantially as described, for causing the locomotive contacts to open said switches automatically in succession, thereby alternating the resistances of the branches and shunting the excess of current from one to the other, substantially as and for the purpose set forth.

3. The combination, in an electro-motive railway, of a double outgoing conducting-path in parallel branches of the same polarity, but of unequal resistances, arranged in successive blocks, and electric motors having traveling contacts electrically bridging said branches and in series with each other upon successive blocks, and normally-closed switches connecting the branches at the generator side of said resistances, adapted to be automatically opened by the passage of the motor-contacts, substantially as set forth.

4. The combination, in an electro-motive railway, of an outgoing conducting-path composed of two parallel branches having resistances interposed alternately at predetermined intervals in said branches, with electrically-operative normally-closed switches controlled by magnets connecting said branches in the intervals between said resistances, said switches being in normally-open loop-circuits formed in each case by one of said branches, and a third independent conductor adjacent to and parallel therewith, and adapted to be closed by an extension of the locomotive traveling contact bridging between said third conductor and its adjacent branch of the main conductor, substantially as set forth.

5. In an electro-motive railway, a double outgoing electrical conducting-path of the same polarity divided into blocks of predetermined length, the respective branches of said conductor crossing each other at the junctions of successive blocks, so as to be out of contact with the motor-brushes, and provided alternately with high resistances at said crossings, and normally-closed switches controlled by the motor-contacts connecting the opposite branches, substantially as set forth.

6. The combination, in an electric railway, of a conductor-conduit constructed and arranged as described, two parallel outgoing conductor-branches secured therein in sheltered positions beneath the overhanging roof-sides, and a return-conductor arranged at or near the bottom of the conduit, substantially as set forth.

7. The combination, in an electric railway, of the motor-supporting rails and an open-slotted conduit parallel therewith upon or in the roadway, two bared parallel conductors within said conduit, adapted to maintain sliding contact with the traveling motor-brushes, said conductors being insulated from each other and from other conductors (such as return-conductors) and the conduit and carrying electric currents in the same direction, and a third conductor within said conduit arranged as a common return to complete a continuous metallic circuit with the first-mentioned conductors, substantially as set forth.

8. In an electro-motive railway, in combination with the two branches of a divided current-conductor, a connecting-shunt and a magnet for operating the same in a normally-open loop-circuit with one of said branches, a portion of which said loop-circuit is formed by a conductor laid parallel with said main conductor-branch, so as to be temporarily closed by the traveling contact-brush of the electro-motor, substantially as set forth.

9. In combination with an electro-motive railway such as described, a connecting-railway or "side track" having an electrical conducting-path constructed and arranged in the same manner—that is to say, with an outgoing conductor divided into two parallel continuous branches of the same polarity and a return-conductor, said outgoing and return conductor being looped into one branch of the outgoing conductor of the main line, substantially as set forth.

10. In combination with an electro-motive railway having an outgoing conducting-path in two parallel continuous branches of the same polarity and arranged in successive blocks, as described, whereby locomotives upon a block are in series with those of another block, a side track or connecting-railway having a similarly-arranged conducting-path and

locomotives upon one of its blocks in series with those upon other blocks, substantially as set forth.

11. In combination with an electro-motive railway having an outgoing conducting-path in two parallel continuous branches of the same polarity, arranged in successive blocks, as described, whereby locomotives upon a block are in series with those of another block, a side track or connecting-railway electrically connected with the main line by means of a switch and similarly arranged, whereby electric motors upon the several blocks of the side track are in series with those upon other blocks of the same and with those of the main line, substantially as set forth.

12. In combination with an electric railway having an outgoing conducting-path composed of two members of the same polarity, a side track or branch looped into said main outgoing conductor, one side of said loop being the branch outgoing conductor and the other or return side of said loop being composed of two parallel branches of unequal resistances, and motors on said side track provided with brushes bridging said return branches of the loop, substantially as set forth.

13. An electric railway having a conducting-path such as described, combined with a side track or branch railway having a conducting-path looped in the main outgoing conductor, an independent generator interposed in the outgoing side of said loop, and a double or "two-way" switch, arranged substantially as and for the purpose set forth.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

GRANVILLE T. WOODS.

Witnesses:
L. M. HOSEA,
E. L. KERR.