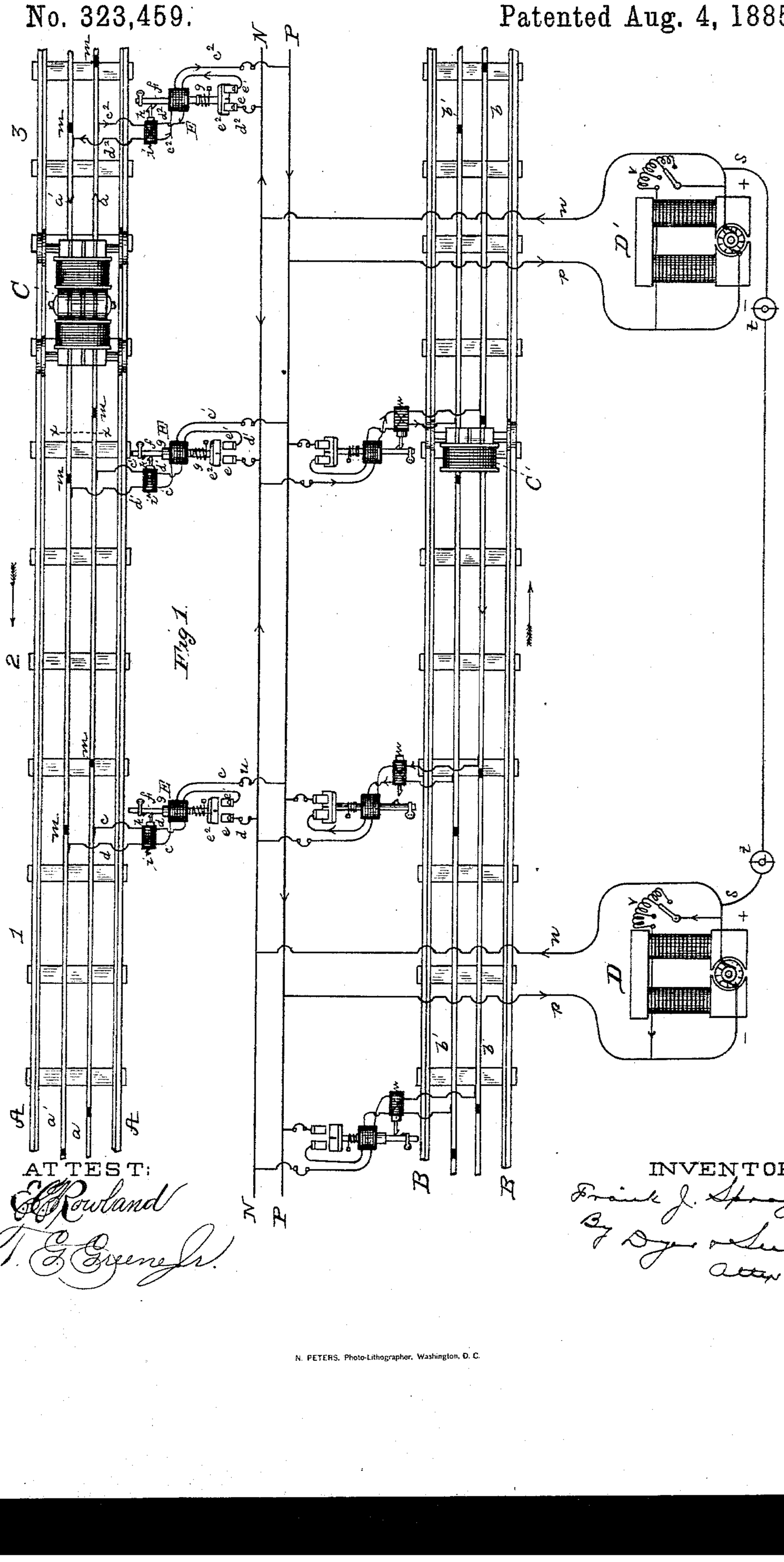
(No Model.) 3 Sheets—Sheet 1.

F. J. SPRAGUE.

ELECTRIC RAILWAY SYSTEM.

No. 323,459. Patented Aug. 4, 1885.



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ELECTRIC RAILWAY SYSTEM.

No. 323,459. Patented Aug. 4, 1885.

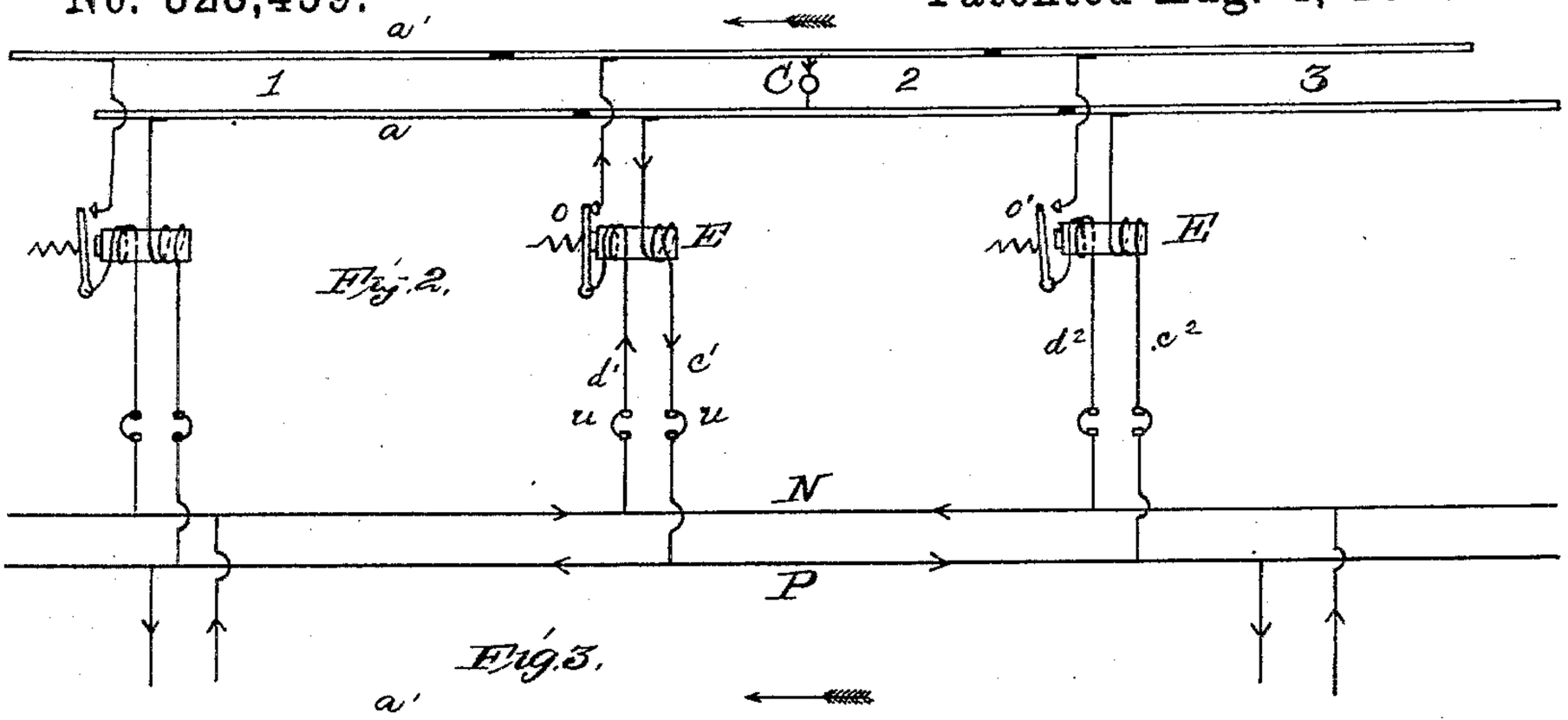

Fig. 2.

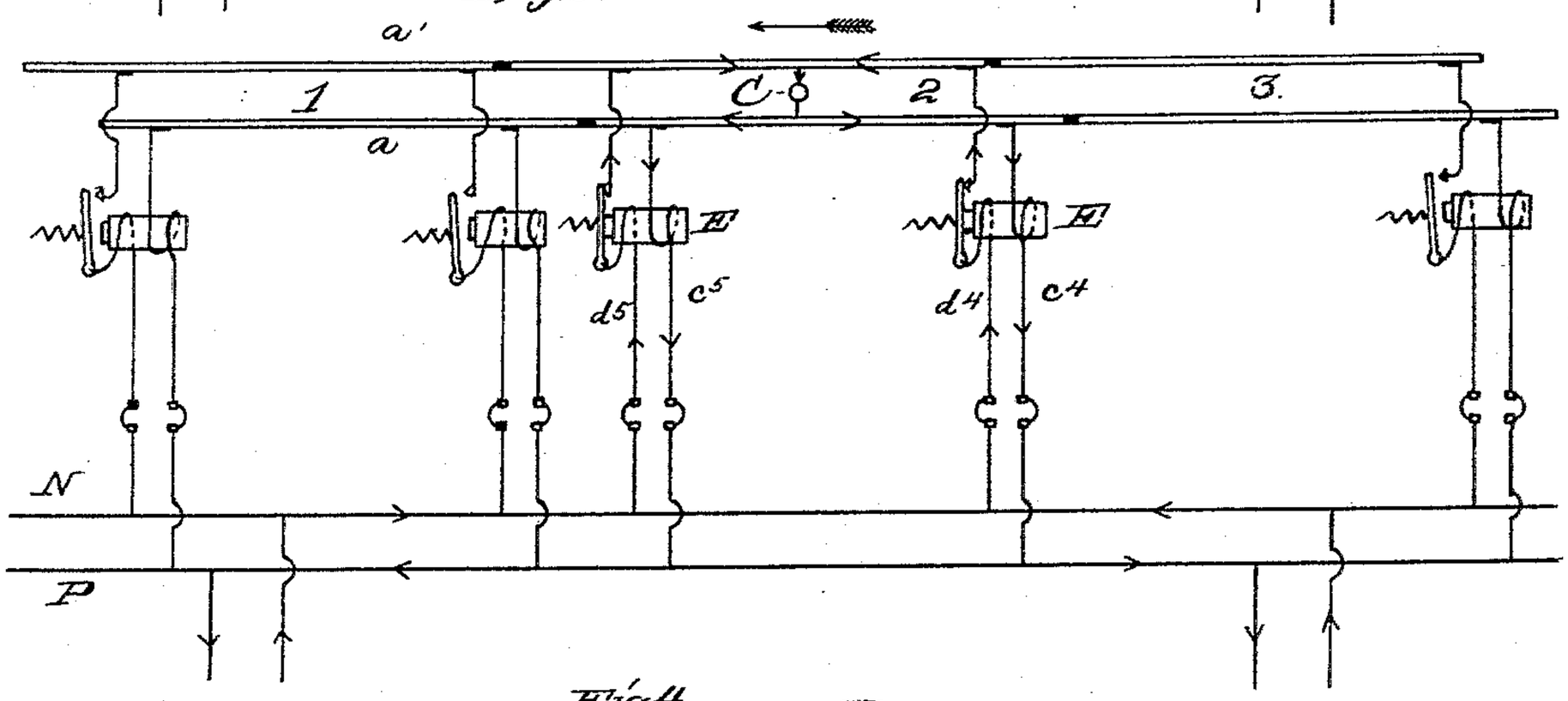

Fig. 3.

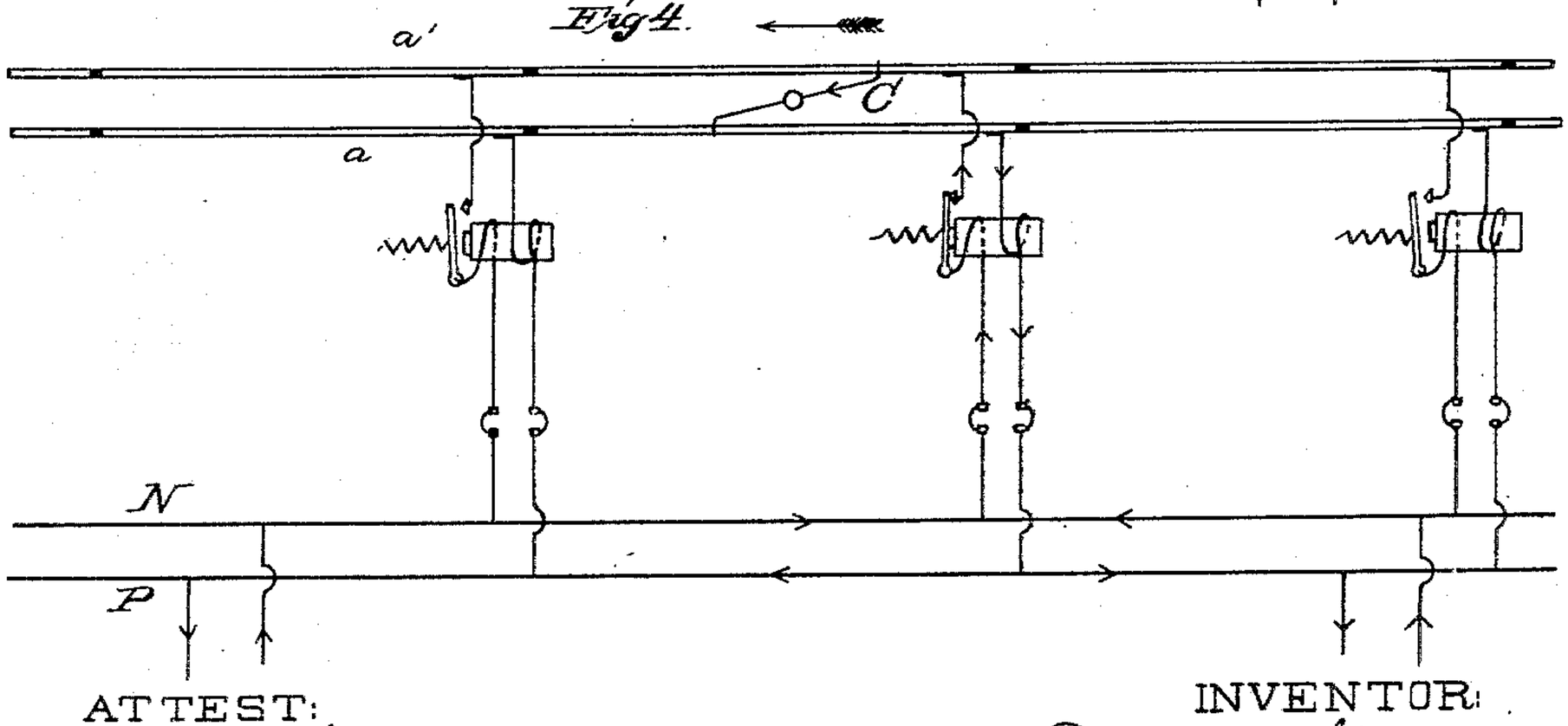

Fig. 4.

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ELECTRIC RAILWAY SYSTEM.

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Fig. 5.

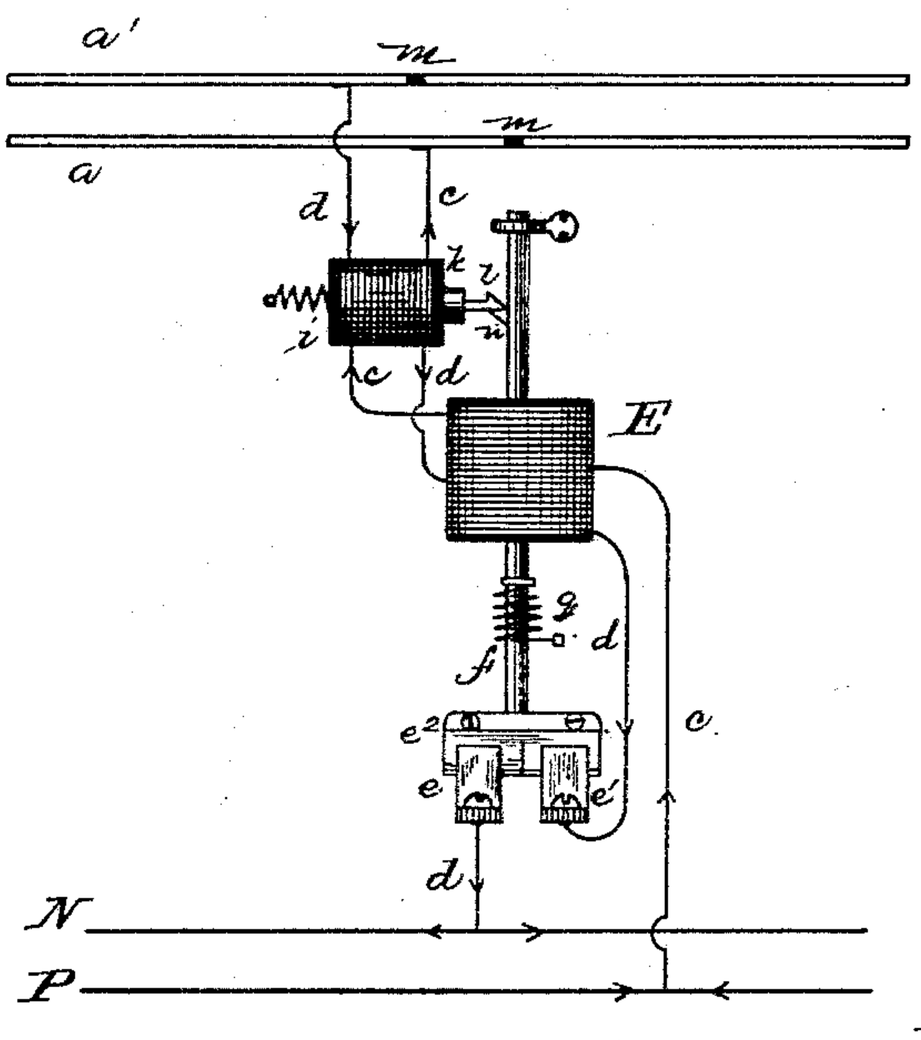


Fig. 6.

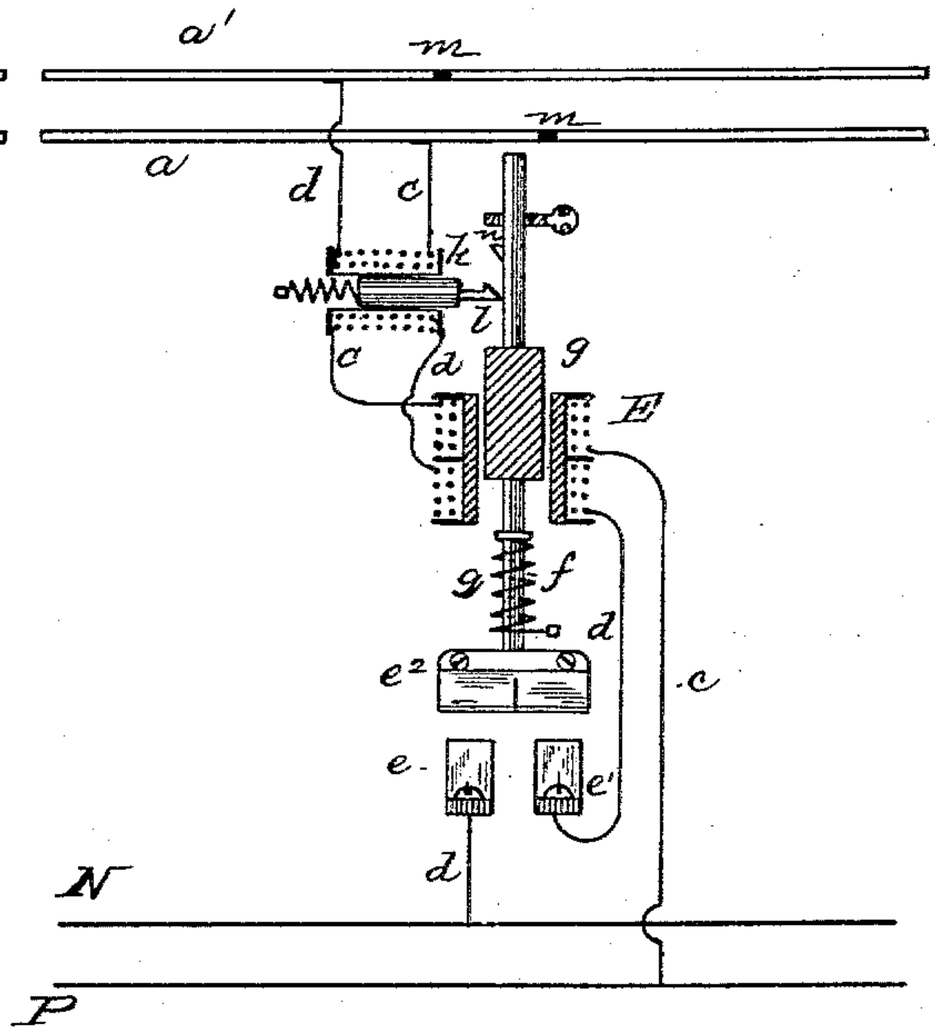
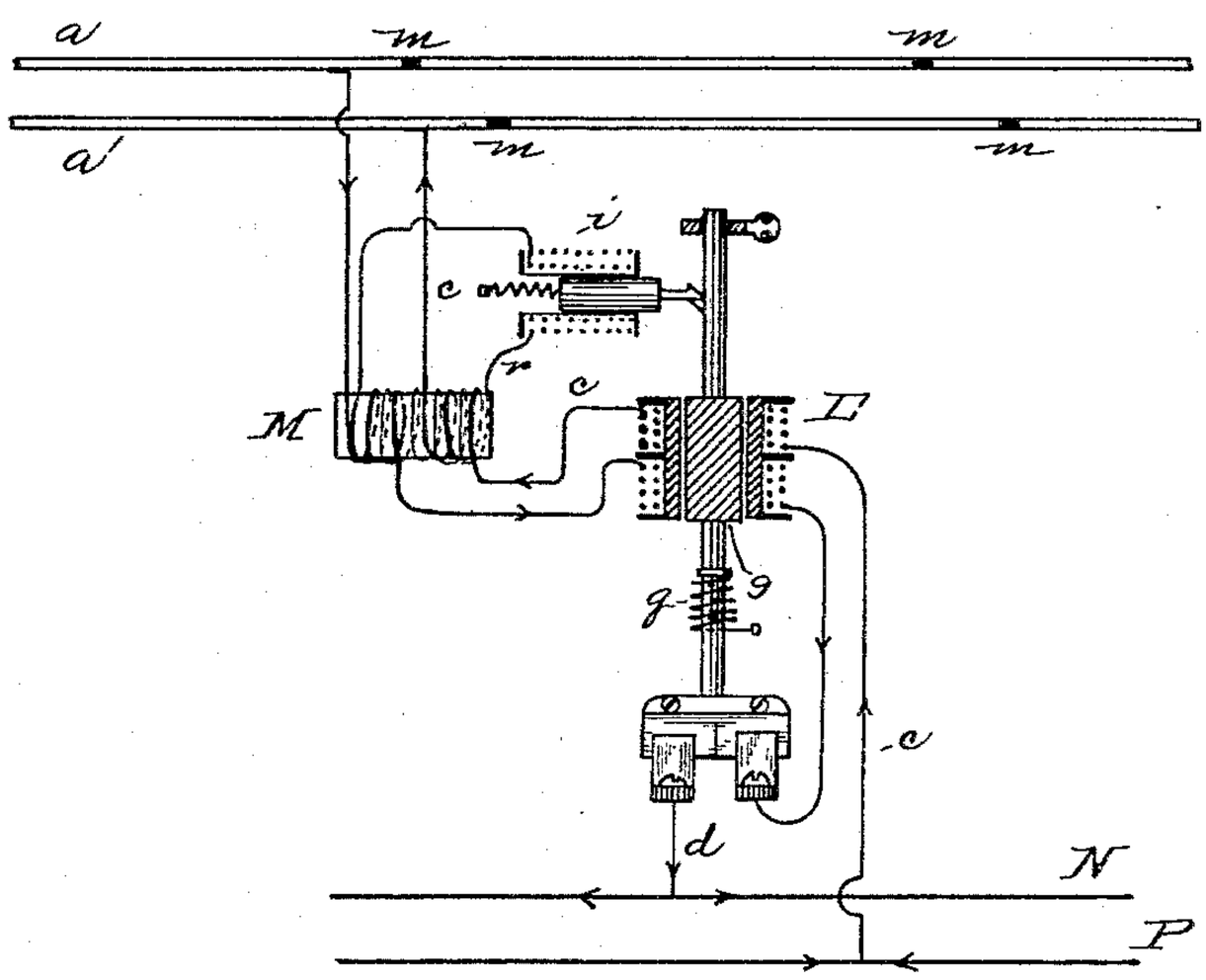


Fig. 7.



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UNITED STATES PATENT OFFICE.

FRANK J. SPRAGUE, OF NEW YORK, N. Y., ASSIGNOR TO THE SPRAGUE ELECTRIC RAILWAY AND MOTOR COMPANY.

ELECTRIC-RAILWAY SYSTEM.

SPECIFICATION forming part of Letters Patent No. 323,459, dated August 4, 1885.

Application filed January 19, 1885. (No model.)

To all whom it may concern:

Be it known that I, FRANK J. SPRAGUE, of New York, in the county and State of New York, have invented a certain new and useful Improvement in Electric-Railway Systems, of which the following is a specification.

The invention relates to those systems for electric railways in which continuous main conductors are employed, and working-conductors, from which the motors derive current, divided into sections, each section being connected with the continuous main conductors; and more especially said invention relates to apparatus controlled by the position of the motors for making and breaking the connections between the main conductors and the working-conductors, whereby each section is placed in circuit when the train approaches it, and remains in circuit while the train is upon it, whether the motor of the train is using a greater or less quantity of current, or none at all; and as soon as the train has left the section its circuit is broken, that of the next section in advance having been previously closed. Further, by the use of my invention, when the train is on one section the working-conductors of the next section may be crossed or joined together electrically at almost any point without producing a short circuit, it being possible to short-circuit such conductors only at a very small portion of their length, while on other sections than those next adjacent it is impossible to produce a short circuit at all.

In carrying out my invention each working section has preferably two connections to the main conductors—one permanent, the other through a switch controlled partially by the current of said permanently-closed conductor and partly by its own current. The motors and working-conductors are so arranged relatively that the motor closes the permanent connection of a section before it is fully on that section, and the switch is thus operated to close the other or electrically-controlled connection. At the same time one connection of the section which the motor is leaving is broken, but current passes through the other one and through one of the conductors of the advanced section to propel the motor completely upon the latter, which breaks the remaining connection of the circuit just left.

An electro-magnetic device for controlling branch circuits must be independent of the strength and continuity of the current, or of the direction of the current through the motor, because there are several different conditions which may arise when a motor is on a section. Such conditions are as follows:

First. If the motor is doing work, it is taking current from the main conductors, but not a uniform current, in which case the electro-magnetic devices in circuit will be energized with a variable magnetic movement.

Second, If the motor is being driven by the momentum of the train, as in descending a downgrade or slowing down, it becomes a generator and gives back current to the line, and so will reverse the current in the electro-magnetic switching devices.

Third. When the motor is in the transitional stage of just changing from doing work as a motor to doing work as a generator, its electromotive force is just sufficient to supply its own field without taking from the line or giving to it. In this case there will be no current in the electro-magnetic switching devices.

Fourth. A motor may be at rest on a section without using any current at all.

It is evident that a motor on a section may pass through all these conditions in rapid succession, or may remain in any one of them for a considerable time.

My invention is illustrated in the accompanying drawings, in which Figure 1 is a general plan view and diagram of an electric-railway system embodying said invention. Figs. 2, 3, and 4 are diagrams illustrating modified arrangements. Fig. 5 is an enlarged view in elevation of the preferred form of electro-magnetic switching device; Fig. 6, a view of the same, with the magnets in section; and Fig. 7, a view of a modified form of the device.

A railway-line is shown in Fig. 1, having two tracks, A A and B B. Each track has two intermediate rails, *a a'* and *b b'*, which are the working-conductors from which the motors C and C' derive current. The working-conductors may, however, be of any other suit-

able form and placed in any convenient situation, so that the motors can receive current from them; or, in some cases, the grounded rails of the track form one side of each working-circuit. Only a portion of the motor C′ is shown, there not being sufficient space to show the whole of it in the position in which it is placed. The connections and local circuits of the motors are not shown. They may be of any suitable character.

P N are continuous main conductors extending the whole length of the line. Both tracks are supplied from these main conductors by means of branch conductors *c c′ c²*, &c., and *d d′ d²*, &c.

The feature of supplying a double track from a single main circuit is not claimed herein, being claimed in another application for Letters Patent.

D D′ represent the dynamo-electric machines at the generating-stations, of which there are any suitable number, according to the length of the line and the power required. They are connected with the main conductors by supply conductors *p n*.

The electro-magnetic circuit-controlling apparatus (shown in detail in Figs. 5 and 6) consists of electro-magnet or solenoid, E, having two sets of coils wound in the same direction, one set being included in the branch conductor *c*, (or *c′ c²*, &c.,) the other in branch conductor, *d*, (or *d′ d²*, &c.) Conductors *c* are continuous permanent connections between a main conductor and the working-conductor of the same polarity. Each conductor is broken and closed at a switch, which preferably consists of two upright stationary contact-plates, *e e′*, which are bridged to close circuit by the contact-plate *e²*, which makes a rubbing-contact with both of them. The rod *f*, which supports plate *e²*, is carried by the movable core *g* of the solenoid or hollow electro-magnet E, which, when energized, draws its core downward. Another magnet or solenoid, *i*, is also included in both conductors; but on this magnet the two sets of coils are wound differentially and equally, so that when both are in circuit the magnet is inactive. The core *k* of magnet *i* carries a catch, *l*, and the rod *f* has upon it a projection, *n*, with which said catch engages, and from which it is withdrawn when the magnet is energized.

The working-conductor-sections 1, 2, and 3 are formed by interposed short sections of insulation, *m m*. The ends of the sections preferably overlap, as shown, so that the motor leaves one working-conductor of a section before the other.

The operation of these devices is as follows: The arrows by the sides of the tracks indicate the direction of movement of motors thereon. When the motor C crosses the insulating-section *m* of conductor *a*, which lies next in its path—that is, when it reaches the position *x x* relative to the working-conductors—a circuit is at once closed from main conductor P by branch conductor *c′*, working-conductor *a*, through the motor to working-conductor *a′*, and by branch conductor *d²* of section 3 to main conductor N. One coil of magnet E of section 2 is thus closed and its core is attracted downwardly, closing circuit at *e²*; but as yet no current passes at this contact. At the same time branch conductor *e²* of section 3 is cut out of circuit, the motor having left the working-conductor with which this branch conductor is connected, and the remaining coil or magnet *i* of section 3 draws back the core of said magnet and unlocks the switch of that section. The switch is still, however, kept closed by the current in *d²* so long as the motor is still in connection with the section; but as soon as the motor passes over the insulating-section *m* of conductor *a* the circuit of section 2 is closed through *c′* and *d′* and the motor, both coils on the locking-magnet *i* of section 2 become equal, that magnet becomes inactive, and the spring on its core throws the core and the catch out and locks the switch. At the same time the circuit through *d²* of section 3 is broken and the magnet E of that section becomes inert, and the spring *q* throws rod *f* and plate *e²* up and breaks the switch-contact. The motor having already broken the current in conductor *d²*, there is no sparking at the switch. Circuit to section 3 is thus broken, and that of section 2 is closed and remains positively locked until the train approaches the end of section 2, when the same operations are repeated in the switching devices of sections 1 and 2 as have just been described for sections 2 and 3. The lower track is similarly equipped. On this track is shown the motor *c′* on the overlapping portion of two working-sections, showing the arrangement of the switches and locking devices under these circumstances, which, however, has been already described with reference to motor C.

It will be seen that it is impossible to short-circuit any section except at the part where the conductors overlap, and at this part it is possible only when a motor is on the next section. When a motor is on a section, circuit is constantly maintained to it. Variation in the current upon the section, due to a change in load on the motor or to any other cause, or an entire cessation of current through the motor, has no effect on the switching devices.

In my application Serial No. 150,899 is set forth a method of braking trains by converting the motor into a generator giving current to the line. If a motor is in this condition when passing from one section to another the switching devices operate just the same, their action not being dependent upon the direction of the current; or if a train is receiving no current, but running only on its own momentum, when it reaches the end of a section I can operate the switching devices from the motor by changing it into a generator in the manner set forth in the application last above referred to.

It is possible in some cases to dispense with the locking device and let the switch be held closed by the motor-current. I prefer, how-

ever, to lock the switch positively while the motor is on the body of a section.

In the diagram, Fig. 2, the electro-magnetic switch of each section is placed at the farther end of the section from that at which the motor approaches it. The operation is substantially the same. When the motor indicated at C is on the overlapping part at the beginning of section 2, circuit is closed through conductor c' of section 2 and conductor d^2 of section 3, and pivoted armature o of the magnet E of section 2 is attracted and closes conductor d'. Section 2 is thus closed before the motor enters wholly upon it. At the same time conductor c^2 of section 3 is first broken, the motor being, however, supplied with current through c' d^2 until it is entirely on section 2, when d^2 is broken and armature o' is released.

The electro-magnetic switch in this and Figs. 3 and 4 is a simple form, with no locking device, shown merely for illustration.

In Fig. 3 each section has two switches, one at each end. On the motor entering section 2, branch conductors c^4 and c^5 are first closed and both magnets are energized, and afterward d^4 and d^5 are closed, completing the circuit of the section when the motor is on the body thereof.

In Fig. 4 the working-conductors do not overlap, but instead the motor has diagonal connections—that is, one front and one rear contact—so that it leaves one conductor of a section before it leaves the other. This is evidently the equivalent of the overlapping conductors.

A different mode of operating the locking device is shown in Fig. 7. An additional magnet, M, is employed, on which both conductors c d are wound differentially, and this magnet has a third coil of fine wire, r, which is wound in series on the locking-magnet i. When the motor is fully on the section, magnet M is inert, its coils c d being equal and differential; but when the motor leaves one working-conductor of the section, the sudden change of current in one of said coils c d induces a current in the fine-wire coil r and energizes the magnet, so that the latter attracts its core and unlocks the switch.

In Figs. 2, 3, and 4 only one set of working-conductors is shown in each figure. I prefer, however, to use two sets, as in Fig. 1.

Safety-catches u u are preferably placed in the branch conductors, so that if a short circuit should accidentally occur on the overlapping portion of a section the system will be protected.

It is desired to keep the same potential at the terminals of all the generating-stations, and to this end I provide an indicating-circuit, s s, in which an electrical indicator, t, is placed at each station, whereby the relative potentials are observed, and the generators can be regulated accordingly by means of the adjustable resistances v in their field-circuits. This feature is, however, not claimed herein, being claimed in another application.

What I claim is—

1. In an electric-railway system, the combination of the main conductors, the working-conductors divided into sections, two branch conductors for each section, and an electro-magnetic switch for a section affected by the current in both said branch conductors, substantially as set forth.

2. In an electric-railway system, the combination of the main conductors, the working-conductors divided into sections, a permanent connection from one main conductor to a working-conductor of a section, and a connection from the other main conductor to the other working-conductor affected by the current of said permanent connection, substantially as set forth.

3. In an electric-railway system, the combination of the main conductors, the working-conductors divided into sections, two branch conductors—one permanently, the other electro-magnetically, connected, and the electro-magnetic controlling device included in the circuit of both said branch conductors, substantially as set forth.

4. In an electric-railway system, the combination of the main conductors divided into sections, two branch conductors, each connecting a main and a working conductor, a switch controlled by the current in both said branch conductors, and a locking device for said switch controlled by the current in both said branch conductors, substantially as set forth.

5. In an electric-railway system, the combination, with the main conductors and the sectional working-conductors, and the motors so arranged relatively that a motor-contact in passing from one section to another leaves one of said working-conductors before it leaves the other, of the permanent connection between a main and a working conductor of a section situated first in the path of the motor and including an electro-magnetic switching device, and a connection from the main to the other working conductor of the section controlled by the said switching device, substantially as set forth.

6. The combination, in an electric railway, of continuous main conductors, two sets of working-conductors supplied from said main conductors, each of said sets being divided into sections, and devices controlled by the movement of the trains or motors for controlling the circuit of each section, substantially as set forth.

This specification signed and witnessed this 12th day of December, 1884.

FRANK J. SPRAGUE.

Witnesses:
T. G. GREENE, Jr.,
E. C. ROWLAND.