(No Model.)

4 Sheets—Sheet 1.

C. J. VAN DEPOELE.

ELECTRIC RAILWAY SYSTEM.

No. 447,215.

Patented Feb. 24, 1891.

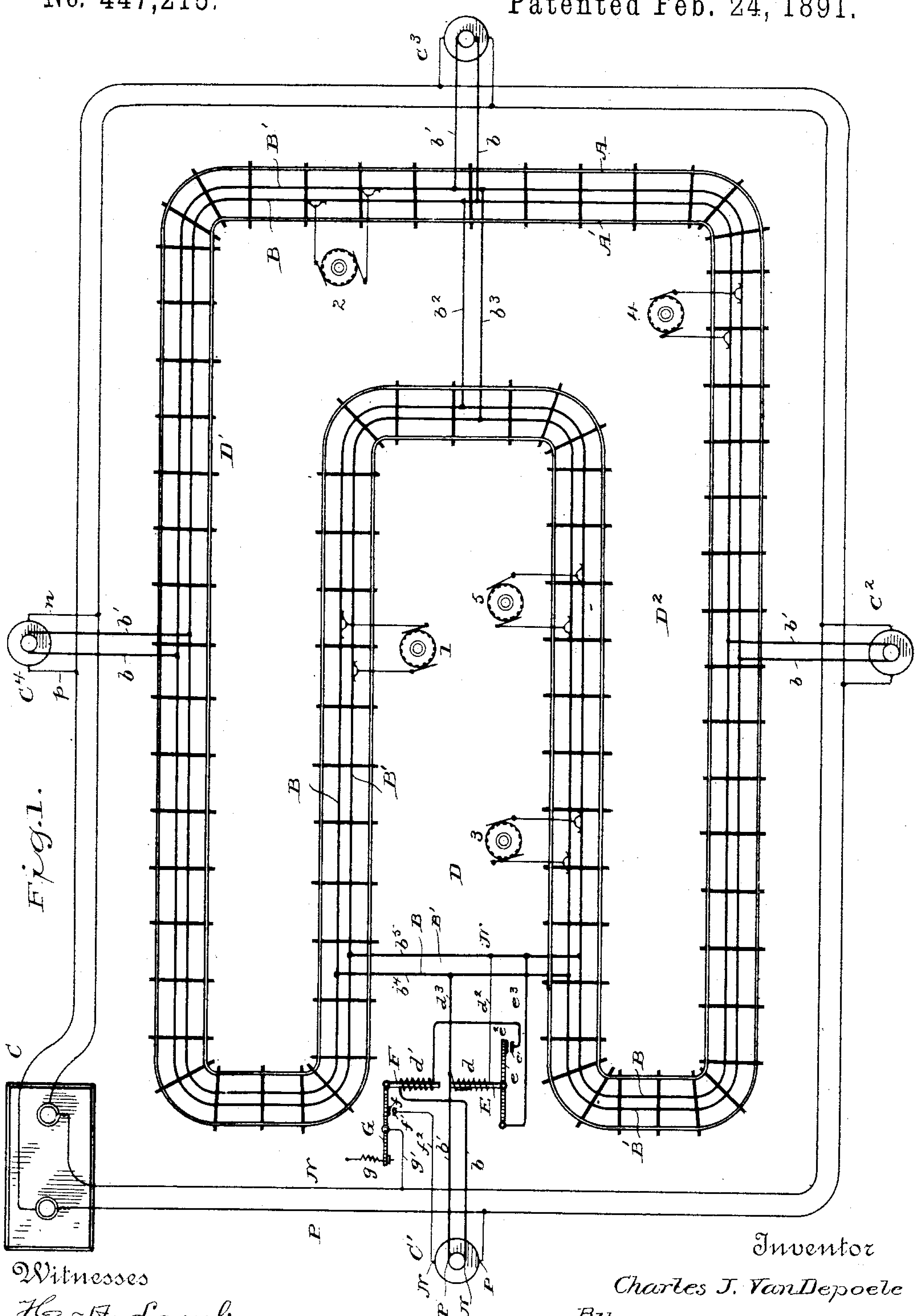

Fig. 1.

Witnesses

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(No Model.) 4 Sheets—Sheet 2.

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Fig. 3.

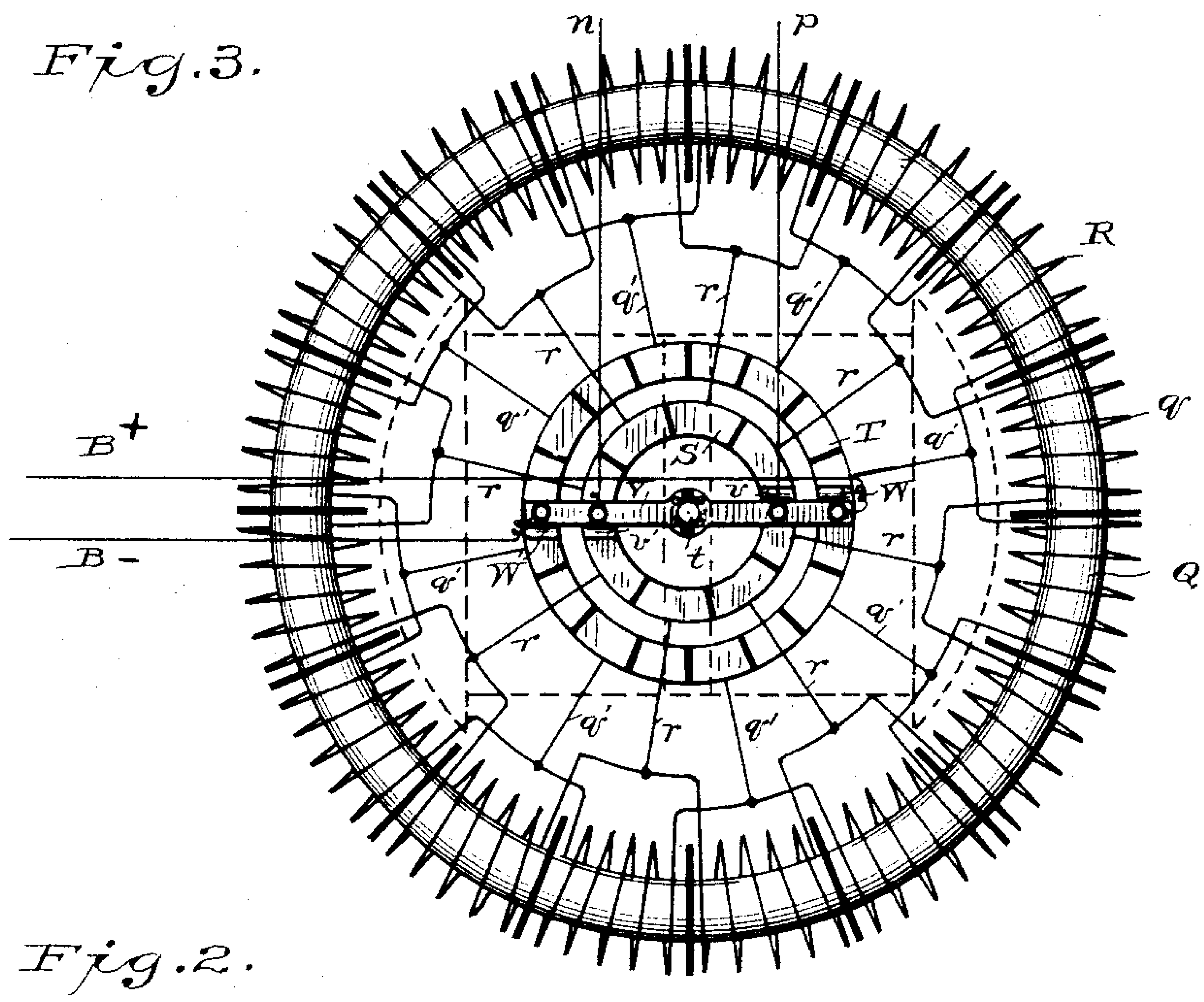


Fig. 2.

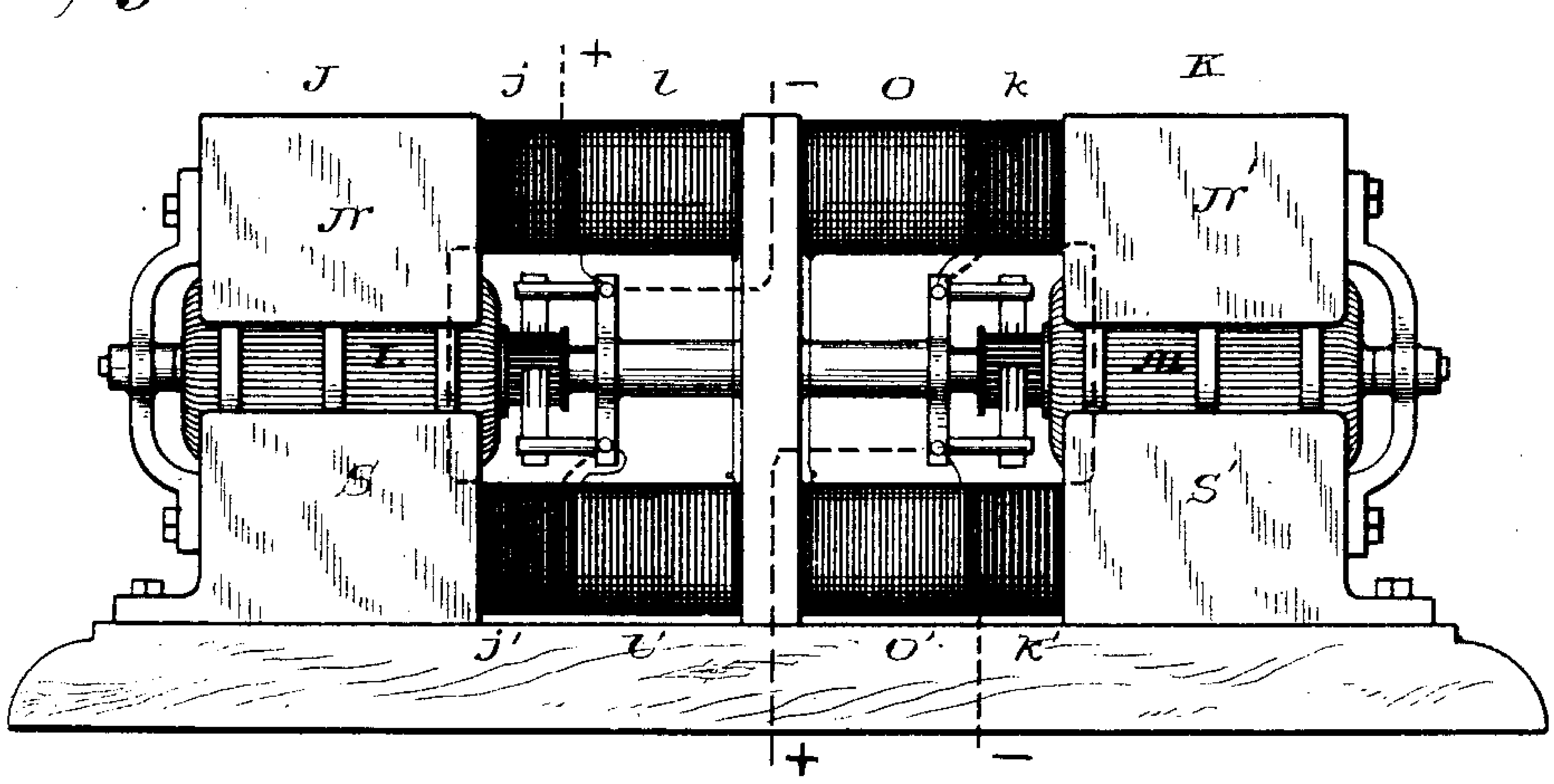
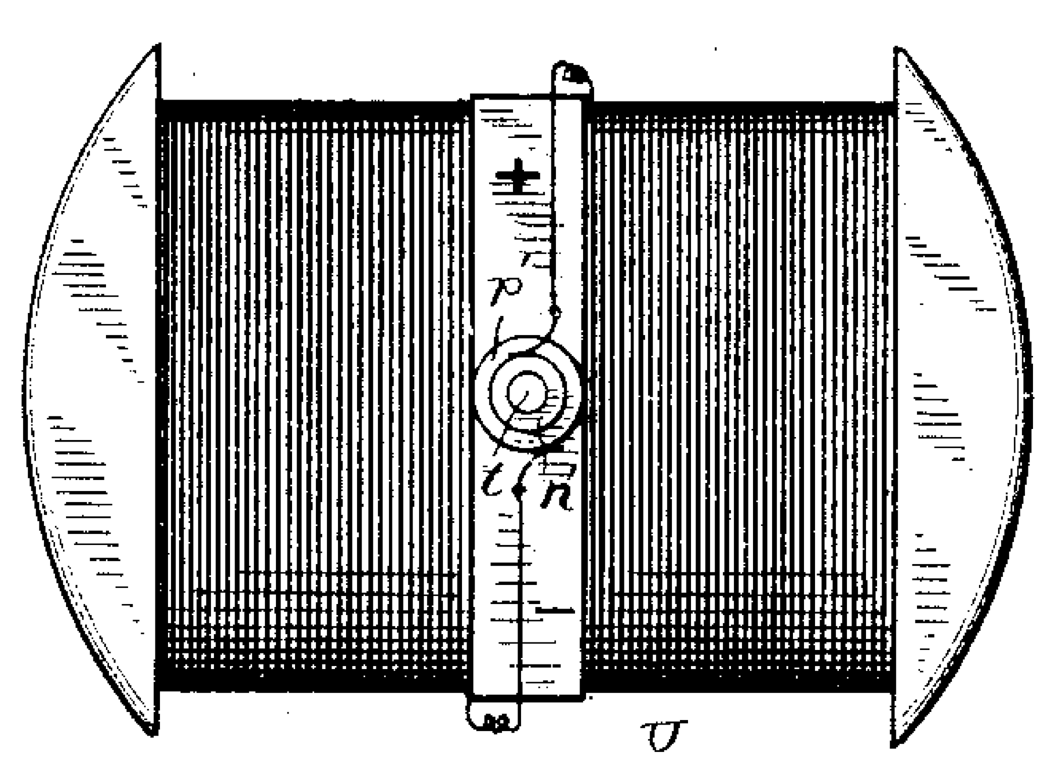


Fig. 4.



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(No Model.) 4 Sheets—Sheet 3.

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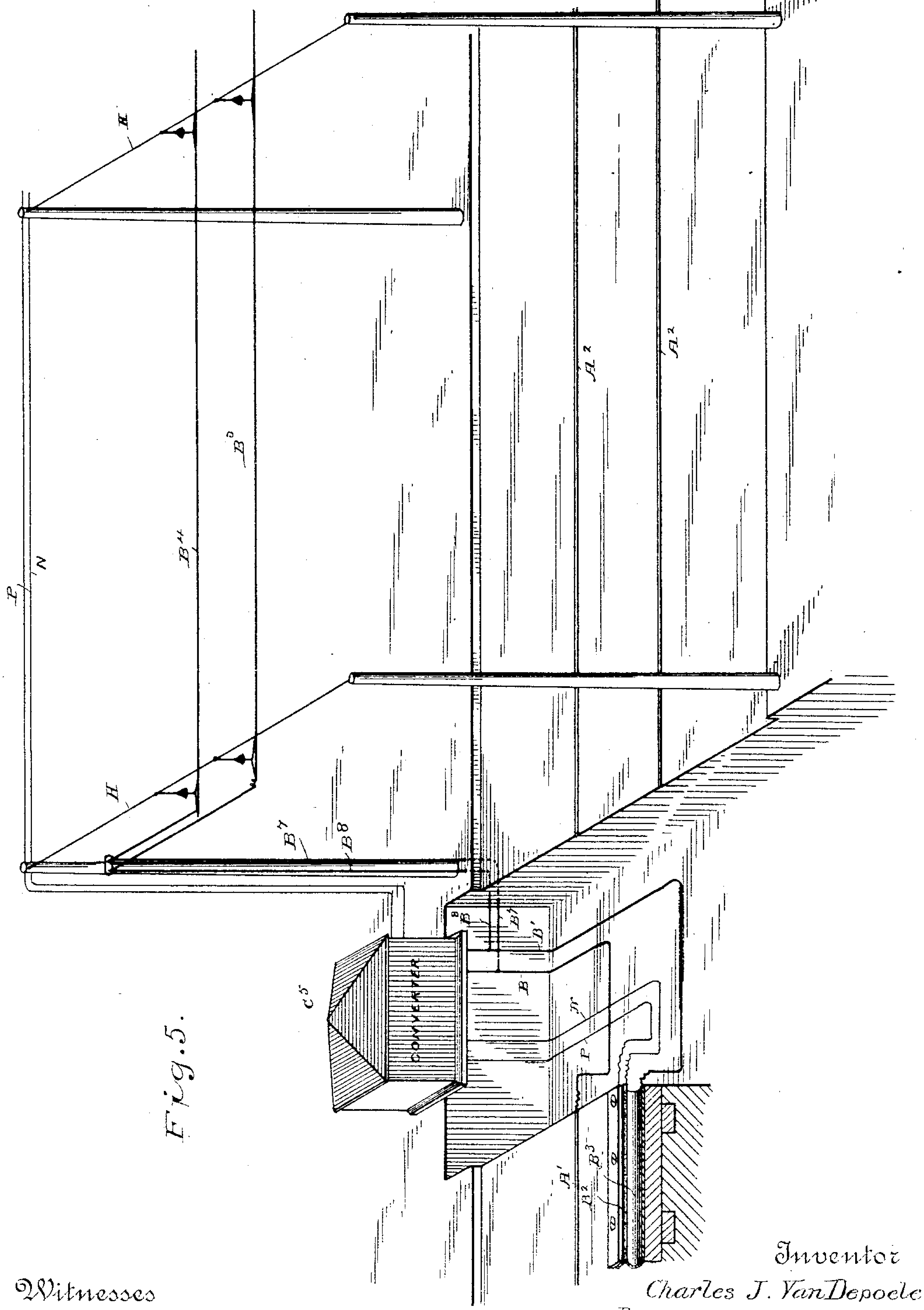

Fig. 5.

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C. J. VAN DEPOELE.

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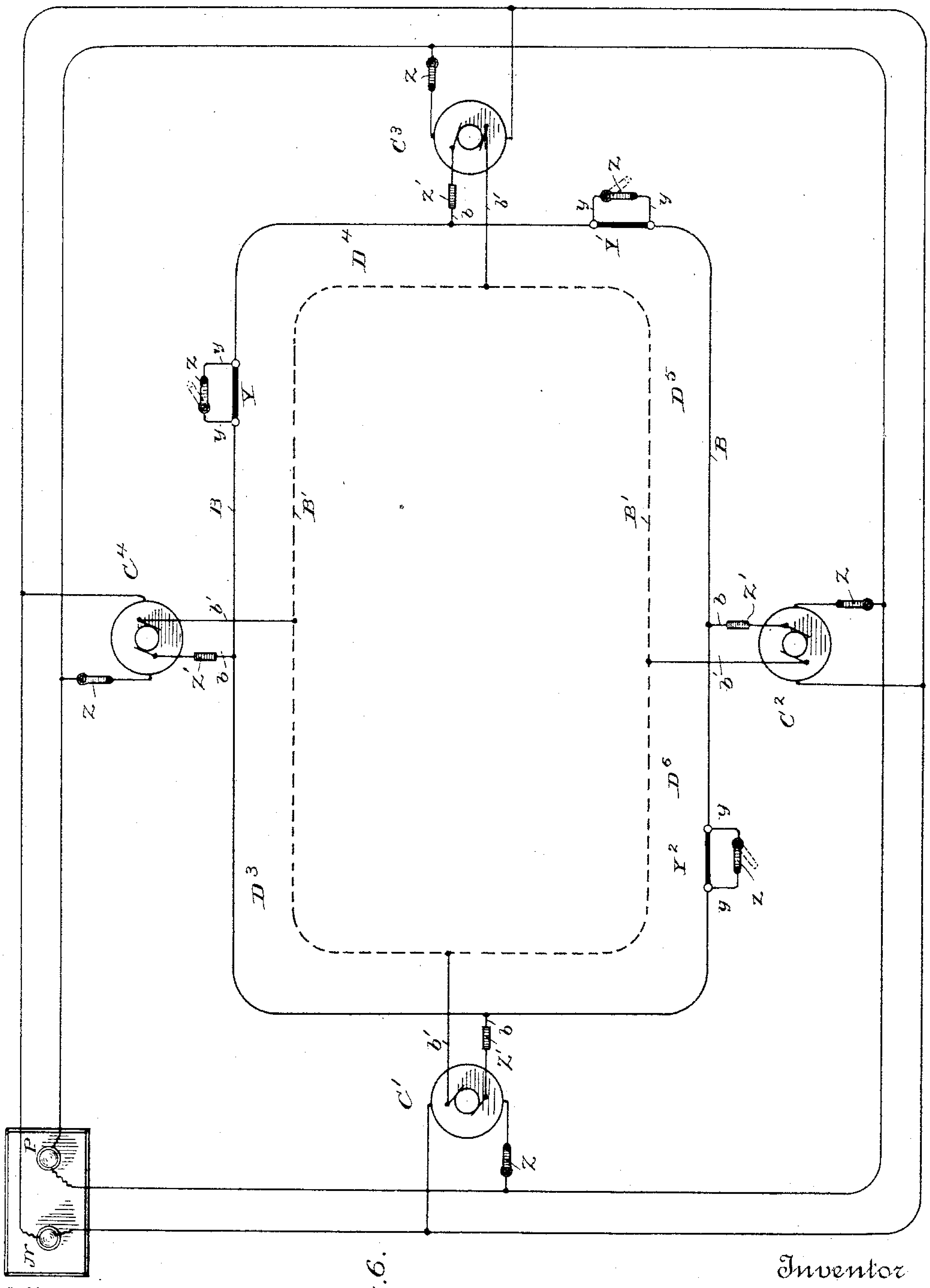

Fig. 6.

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UNITED STATES PATENT OFFICE.

CHARLES J. VAN DEPOELE, OF LYNN, MASSACHUSETTS.

ELECTRIC-RAILWAY SYSTEM.

SPECIFICATION forming part of Letters Patent No. 447,215, dated February 24, 1891.

Original application filed March 7, 1889, Serial No. 302,287. Divided and this application filed November 8, 1890. Serial No. 370,739. (No model.)

To all whom it may concern:

Be it known that I, CHARLES J. VAN DEPOELE, a citizen of the United States, residing at Lynn, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Electric-Railway Systems, of which the following is a description, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon.

My invention relates to electric railways, and comprises an improved system of supplying and distributing the current energy to the working-conductors thereof; and it consists in a system of supplying currents of low tension to long lines of conductors, which could not be accomplished economically by direct transmission from the generating-station, owing to the great size and cost of the necessary conductors and the large percentage of loss always attending the transmission of heavy currents of low potential over long distances. I accomplish the desired results by locating at desired intervals along the line of railways converters or generators adapted to be operated by currents of high tension, which may be economically transmitted from a generating station or stations located at the most favorable points for the economical production of current. In many instances it is undesirable or impracticable to so place the generating-station with respect to the line of the railway and its ramifications that economical transmission of current from the generator can be accomplished. By the use of a primary supply-current of relatively high potential traversing the line of the railway the said primary conductors can be thoroughly isolated and protected and suitable connections run therefrom to a sufficient number of tension-reducing devices located along the line of the railway and connected to the exposed working-conductors from which the traveling motors receive their current. Furthermore, I provide automatic means for starting and stopping the tension-reducing devices, so that the primary current will not be needlessly consumed. Assuming the potential of the primary current to be two thousand volts, it can be conveyed a long distance over small conductors without great loss. By using a sufficient number of tension-reducing devices, which are hereinafter referred to as "converters," the working-conductors can be supplied with current at a much lower potential than would be practicable if furnished direct from a generating-station. In practice I find that a pressure of one hundred volts between the working-conductors will greatly reduce the tendency to the formation of arcs between them when placed close together, as is necessary in sub-surface conduits, and furthermore a current of such or lower potential is much less liable to leak and be wasted. The system is equally applicable to the overhead and underground methods of distribution in electric railways, and while I show and describe the system as operating with converters of the continuous-current type it will be understood that substantially the same arrangements may be utilized in connection with an alternating primary or supply current, or with an alternating supply and distribution, or an alternating supply-current only with continuous current distribution from the converters to the working-conductors.

Means for carrying my system into effect are shown in the accompanying drawings and will be referred to in the following description and claims.

Figure 1 is a diagrammatic view of an electric-railway system embodying my invention. Fig. 2 is a view in elevation, showing a form of self-regulating converter. Fig. 3 is a diagrammatic view of a different form of converter. Fig. 4 is a detail view of the field-magnet of the converter seen in Fig. 3. Fig. 5 is a view in perspective, showing parts of an electric railway or railways with a converter and the line-connections of both primary and secondary circuits. Fig. 6 is diagrammatic view of an electric-railway system embodying certain features not shown in the other views.

As indicated in the drawings, A A′ are the tracks of an electric railway, and B B′ are the working-conductors thereof, which, though indicated as between the rails, may be either in that or adjacent position in an underground conduit or suspended above the line of way, or B′ may be represented by the rails themselves. (See Fig. 5.)

C is the generating-station, which may occupy any convenient position with reference to the railway.

C′ C^2 C^3 C^4 are the converters, receiving current by conductors *p n*, extending from the high-tension supply-conductors P N, extending from the generating-station and traversing the line of the railway or any other desired route with reference to the location of the converters. Connections *b b′* extend from the secondary circuits of the respective converters to the working-conductors B B′, supplying the current to the traveling motors.

The number of converters used in connection with any one system of railways will depend upon the length of the line, its arrangement, and the potential desired in the secondary or working current. A portion D of the railway is shown upon the outside of and running parallel with the portions D′ D^2 thereof, so that by connecting the secondary circuit of the nearest converter with all the adjacent lines of working-conductors fewer converters will be needed to supply the necessary working-current. Such cross-connections are indicated at b^2 b^3 b^4 b^5. The converters are shown as connected in multiple arc with the primary supply-circuit; but they may also be connected in series, if desired. They are also shown in multiple-arc relation with the working-conductors, so that the current from each converter will flow into the said working-conductors and travel in either direction from the point of connection. The converters are therefore to be arranged at such distances apart that their respective currents may traverse one-half the distance between the converters in either direction and be able to maintain the normal potential along such portions of the working-conductors. When the primary current is turned on, the converters will all be thrown into action until the current in the working-conductors reaches the desired potential, when, if no cars are running and no current consumed, the converters will stop and the consumption of primary and production of secondary currents cease until the potential falls, when they will be again rendered active. The converters are desirably provided with automatic means for being started and stopped, said means being actuated by the rise and fall of potential in the working-conductors.

As shown in connection with converter C′, two solenoids *d d′* are provided. The solenoid *d* is of relatively high resistance, and is permanently connected in derivation from the working-circuit by conductors d^2 d^3, and is provided with a suitably-laminated or subdivided iron plunger E, to the lower portion of which is attached a circuit-breaker *e*. The solenoid *d′* is of relatively low resistance, and is connected with the conductor *b*, extending from the secondary circuit of the converter, and its terminal extends to a contact *e′*, arranged in juxtaposition to a contact e^2, carried by the circuit-breaking lever *e*, the contact e^2 of the lever *e* being connected by conductor e^3 with the working-conductor B′ The solenoid *d′* is provided with an iron plunger F, also subdivided, connected to a pivoted lever G, provided at its opposite extremity with an adjustable tension-spring *g*. The lever G is connected with the primary supply-conductor N, as by conductor *g′*, and carries a contact *f*, adapted to engage with a contact *f′* upon a conductor f^2, to the negative primary circuit of the converter. The cores or plungers E F are mechanically connected so that they move together. The normal condition of the spring *g* is to raise its end of the lever and force down the plungers E F, closing both sets of contacts *e′* e^2 and *f f′*, thereby closing both circuits of the converter and causing it to become active. As the potential in the working-circuit increases or reaches the predetermined standard, the resistance of the solenoid *d* being appropriately adjusted, the said solenoid will at such point become sufficiently energized to raise its core E, and with it the core F, against the tension of the spring *g*, and by opening both the primary and secondary circuits of the converter stop its action. A fall of potential in the working-conductor, as on the consumption of current by a motor traveling within the limit of supply of said converter, will weaken the solenoid *d* to such an extent that the tension-spring *g* will force down the cores E F, close the contacts, and start the converter, the primary circuit closing first and secondary lastly. In practice it is, however, found desirable that one or more of the converters—say, for example, C^2 C^4—should be kept continuously in operation in order to furnish current to energize the solenoids *d* of the automatic controlling devices with which the automatic converters are provided—in other words, to maintain the potential of the line and prevent the starting of the converters upon the sections where no current is being consumed. These main converters may be provided with automatic controllers also, for use in case of accident; but when operating continuously the automatic devices are cut out of circuit and direct connections made. When current is consumed within the limit of supply of an automatic converter, the potential will at once drop, when the converter will start and feed into the working-circuit, as described.

Unless one or more converters are kept constantly in operation all the converters would start at once, raise the potential of the working circuit to the desired point, and then all stop. Therefore the working-conductors must be supplied continuously with current of sufficient strength to operate the converter-controlling mechanism, which will then automatically produce the described effects. In this manner great economy in the consumption and production of current can be effected; but at the same time any desired quantity can be supplied at any part of the line.

In the diagram Fig. 1 five motors are indicated, respectively, at 1 2 3 4 5, the said motors being in operative relation to the working-conductors. In the positions shown the motors 1 and 5 will receive their current mainly from the converter C^3, although some current may also be supplied from the converter C′. The motor 3 will receive its current almost entirely from the converter C′, motor No. 2 will receive its current from the converter C^3, and motor No. 4 will be supplied from the converter C^2 and partly from C^3. The respective motors therefore being supplied with current from the nearest converters, on passing beyond the limit of supply of one converter current will flow to them from the next adjacent one, the drop in potential caused by the proximity of the motor being sufficient to throw the converters into action automatically and as may be desired to keep up the necessary supply of current in the working-conductors. In the case of a railway running a large number of cars the converters will be made large enough to supply the necessary quantity of current within their limit, and the capacity of a railway can be readily increased or diminished by using converters of the desired capacity rather than increasing or decreasing their number.

In Fig. 5 I have shown a portion of an electric railway in which the supply conductor or conductors are suspended along the line of travel and a portion in which the working or supply conductors are inclosed within a sub-surface conduit, a converter being also shown with connections to both systems. In said Fig. 5, C^5 is a box or casing enveloping and protecting the converter. The casing is desirably a strong metallic box to insure immunity from unauthorized interference. The protective casing is lined with wood or some other non-conducting substance, which should be thoroughly insulated with a waterproofing compound, when it will serve as an insulating protection to the mechanism and also prevent the converter from being affected by heat, cold, or dampness. This is very desirable, for in many instances the converter-box will be located in positions where, if not thoroughly protected, it would be liable when stopped to receive the water of condensation from the atmosphere and its insulation be thereby rapidly injured. When protected as suggested, the heat generated by the machine will be retained in the box and serve to protect the apparatus from accumulations of moisture by condensation during its period of rest.

A′ represents one rail of the track, and B^2 a portion of the sub-surface conduit arranged along the line of travel and between or adjacent to the rails of the track. As indicated, the conduit contains one or more conductors B^3, the return or other side of the circuit being represented by the track A′. The conductors B B′, issuing from the converter-box, represent the secondary circuit of the converter and are connected, respectively, to the conductor B^3 in the conduit and the track rail or rails A. It will be understood that I may also use a conduit provided with two working-conductors, in which case the rails are not utilized as conductors in any form. I may also, as stated, suspend the working conductor or conductors along the line of travel instead of burying them in a sub-surface conduit. Such an arrangement is also shown in Fig. 5, B^4 B^5 being the suspended conductors extending above the line of way, of which A^2 A^2 are the rails. Conductors B^7 B^8, extending from the secondary circuit of the converter, are connected with the conductors B^4 B^5.

The suspended supply-conductors B^4 B^5 are sustained from cross-wires H H or equivalent means attached to poles I, arranged on opposite sides of the line of way. It will be obvious that a convenient disposition of the primary circuit will be to support the wires P N upon the poles I, where they may be conveniently disposed, and at such a distance from the ground and from adjacent buildings, &c., as to be very efficiently insulated and practically inaccessible. It may, however, be desirable, in order to provide against any possibility of accidental contact between persons or crossing telephone or telegraph wires, to carry the high-tension primary conductors underground, substantially as indicated with reference to the conduit portion of the railway seen in said figure. The particular means of insulating the said high-tension conductors and the exact manner of their disposition are not material, since they will be disposed of in the manner found to be the most desirable in practice.

As here shown, the converter is arranged and connected so as to feed into two separate railway systems, one represented by the sub-surface conduit, the other by the overhead conductors. While this is a perfectly practical arrangement where it is desired to use current of the same potential upon both lines, it will be understood that it is shown chiefly for convenience of illustration.

In many instances it will be found desirable to provide means for cutting out portions of the main working-conductors—for example, in case of fire, or where a portion of the roadway is blocked, the working-conductors damaged, or the railway otherwise rendered inoperative, when it would be extremely desirable to cut out that portion of the working-conductors, and thereby avoid the wasteful consumption of current flowing thereover and possible leakage on account of accident. Such an arrangement is indicated in Fig. 6, in which is seen a working-circuit B B′, supplied by four converters C′ C^2 C^3 C^4, placed for convenience at equidistant points upon the said conductors. The main conductor B is separated at points about equidistant between the several converters by insulated sections Y Y′ Y^2, the said insulation being bridged by conductors $y y$, connected with each set of which is a switch Z. When the switches Z are all closed, the several sections D^3 D^4 D^5 D^6 are all united through the switch-conductors y and switches Z. By opening any two of the switches Z the intervening section of main conductor will be cut out of the circuit. Switches z are also provided in the primary circuits of the converters, and it will be obvious that the action of any converter can be prevented by opening its supply-switch z, although unless its working-conductors are also cut out of circuit current might flow through the other sections into the converter. A fuse-box Z′ is placed in the working-circuit of each converter to prevent injury from the flow or production of excessive current.

As indicated in Fig. 6, no cut-out is provided for the main circuit between the converters C C^4, since the continued action thereof will be necessary to the operation of the line. Cut-outs will, however, be provided wherever desirable, since any portion of the line can be operated independently by its converter or converters. In case of accident to any portion of the line the desired number of converters, no matter where located, can of course be arranged to run continuously to provide the initial current, the remaining converters or those upon the remaining operative sections of the line being operated automatically, as described, and any desired arrangement of the working-circuits may be employed without departing from the invention. The fuse-boxes and another method of regulating and controlling the supply of the current to the working-conductors form the subject of a separate application filed April 13, 1889, Serial No. 307,131.

In Fig. 2 is illustrated a form of continuous-current converter or motor-generator suitable for use with my system. The machine comprises two sets of magnets J K and separate armatures L M, rotatably mounted between the polar extensions N S and N′ and S′ of the separate field-magnets. One armature acts as a motor and is supplied with current from the primary main conductors P N. The other being suitably wound acts as a generator, being driven by the motor-armature, and supplies current of the desired potential directly to the line through the automatic controlling devices and thence to line. The armature L is wound with a few turns of wire and may be connected in series with the primary circuit. Its field-magnet is wound with two sets of coils, one set j j' being in series with the main supply-conductors and sufficient in quantity to start the motor. The main body of the field-magnet coils is represented by the coils l l', which are connected in shunt relation to the motor-armature L, which is therefore practically a shunt-wound motor operated by a current of constant potential and will run at practically constant speed under varying loads. The field-magnets of the generator M may also be wound in shunt relation to the armature, although it may in many instances be desired, for more perfect regulation under the great variation of load under which it operates, to wind its field-magnets as a compound generator, and such winding is here indicated. The coils k k' on the cores of the field-magnets K represent a few turns of the main circuit supplied by the armature M, while the coils O O′ are connected in shunt relation thereto. With this arrangement a sudden drop in the potential of the main working-circuit, resulting from large demands for current by the traveling motors, will cause a greater flow of current through the series coils k k', tending to sustain and increase the strength of the field-magnet of the generating-armature and enable it to furnish the necessary current to its working-circuit.

In Fig. 3 a different form of converter or tension-reducing device is shown, in which an iron ring Q is wound with two separate circuits divided into separated insulated sections, the sections alternating around the ring. R are the coils of one circuit, and q of the other. The coils R represent the primary circuit, and each coil is connected by a terminal r with corresponding segments of a commutator S. The coils q are similarly connected by terminals q' with the segments of a second commutator T. Within the ring composed of the iron core and coils q R is rotatably mounted a central shaft t and field-magnet U. (Indicated in dotted lines in Fig. 3 and shown in full in Fig. 4.) Upon the shaft is secured a cross-arm or cross-arms V, provided with two pairs of commutator-brushes v v' and W W′. The respective commutator-brushes are insulated each from the other and bear upon the surface of the commutators S T. The main primary current is supplied to the primary coils R by the rotation of the arm V, and said primary current is led to the commutator-brushes v v' by suitable connections p n, leading from the main conductors. The field-magnet U is supplied with current from the same source, desirably in derivation therefrom, through conductors p' n', extending from the commutator-brushes v v' and making contact with insulated surfaces marked, respectively, + and —.

The commutator-brushes W W′ are connected with and deliver their current to the main conductors B B′ through branch conductors B B, connected in any suitable manner to the said commutator-brushes.

Many desirable forms of current-converter or tension-reducing apparatus may be utilized in connection with my improved system—as, for example, the apparatus shown and described in Letters Patent No. 298,431, granted to me May 13, 1884.

This application is a division of a prior application filed by me March 7, 1889, Serial No. 302,287. Being a divisional application, all matters shown and described but not hereinafter claimed continue to form part of the above-mentioned parent case.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. A system of supplying and distributing currents for electric railways, comprising working-conductors along the line of way, a circuit supplying currents of relatively high potential, main tension-reducing devices connected with the high-tension circuit and continuously supplying currents of lower potential to the working-conductors, and auxiliary tension-reducing devices distributed along the line of way and provided with automatic means for closing the circuits and rendering the auxiliary converters operative upon a fall of potential in the working-circuit, substantially as described.

2. A system of supplying and distributing currents for electric railways, comprising normally-continuous working-conductors along the line of way, a circuit supplying currents of relatively high potential, a plurality of tension-reducing devices distributed along the line of the railway and arranged to receive high-tension supply-current and to supply current of reduced potential to the working-conductors, the intervals between the converters being arranged in accordance with the electro-motive force of the working-current and the capacity of the circuit, and means for cutting out of the main working-circuit the portions thereof supplied by any of the converters without affecting the operativeness of the remainder of the system, substantially as described.

3. A system of supplying and distributing currents for electric railways, comprising normally-continuous working-conductors along the line of the railway, a supply-circuit carrying continuous currents of relatively high potential, a plurality of tension-reducing devices of the continuous-current type distributed along the line of the railway and connected in multiple arc with the work at intervals, connections between the high-tension supply-conductors and the primary circuit of the converters and between the secondary circuits of the converters and the working-conductors, and automatic means for opening the converter-circuits when the potential of the working-conductors is normal and for closing said circuits and opening the converter upon the fall of the potential in the working-circuit in the vicinity of the converter, substantially as described.

4. In a system of supplying and distributing currents for electric railways, a working-conductor extending along the line of way and having double or looped portions therein, a plurality of tension-reducing devices connected with said working-conductors at intervals therealong, cross-connections extending between and uniting adjacent portions of the working-conductors, a primary supply-circuit carrying currents of relatively high potential, and connections between the primary circuit and the primary circuit of the tension-reducing devices and between the secondary or current-generating portions of the converter and the working-conductors.

5. In a system of supplying and distributing currents for electric railways, the combination, with a tension-reducing or current-converting device, a primary supply-circuit therefor, and a secondary consumption-circuit in connection therewith, of means for automatically controlling the action thereof, comprising separable contacts in the primary circuit, separable contacts in the secondary circuit, means normally holding said contacts together, and a solenoid of relatively high resistance connected in the working-circuit and acting, when sufficiently energized, to move the contacts and open both primary and secondary circuits.

6. The combination, with a tension-reducing or current-transforming device, of primary and secondary circuits therefor, separable contacts in both circuits, a spring-actuated lever provided with a contact adapted to engage a second contact to close the primary circuit, a plunger connected with said lever and moving in a solenoid of relatively high resistance spanning the working-circuit, a second plunger also connected with said lever and moving in a solenoid included in series with the secondary circuit of the converter, a second contact-carrying arm connected with said plunger and controlling the working-circuit of the converter, and a tension-spring normally holding the levers and plungers in position to close both sets of contacts, whereby when the potential of the working-circuit is sufficiently high both plungers will be raised and both sets of contacts opened and upon a fall of potential in the working-circuit the tension of the spring will move the parts to close both sets of contacts, thereby completing the primary and secondary circuits of the converter and rendering the same active.

7. A continuous converter comprising an armature in circuit with the primary supply-current, an armature operated thereby and acting to generate currents of the desired potential, and field-magnets for both armatures, said field-magnets being provided, respectively, with energizing-coils connected in shunt relation to their respective armatures and with additional coils placed thereon and connected in series with said armatures and with their working-circuits, substantially as described.

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

CHARLES J. VAN DEPOELE.

Witnesses:
FRANKLAND JANNUS,
WM. D. POOL.