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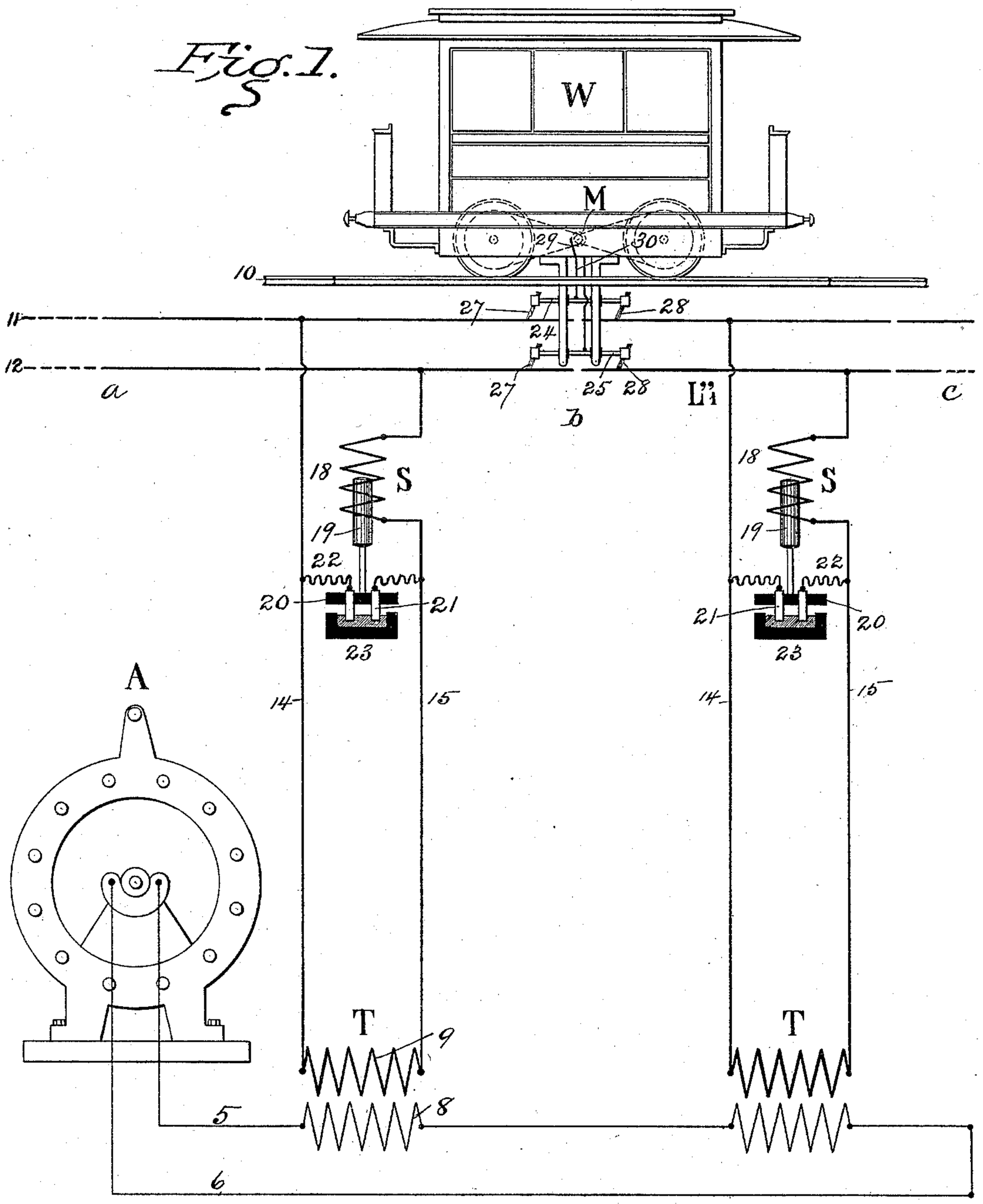
A. DU BOIS-REYMOND.

CONVERTER SYSTEM FOR RAILWAYS.

No. 493,914. Patented Mar. 21, 1893.

Fig. 1.



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(No Model.) 4 Sheets—Sheet 2.

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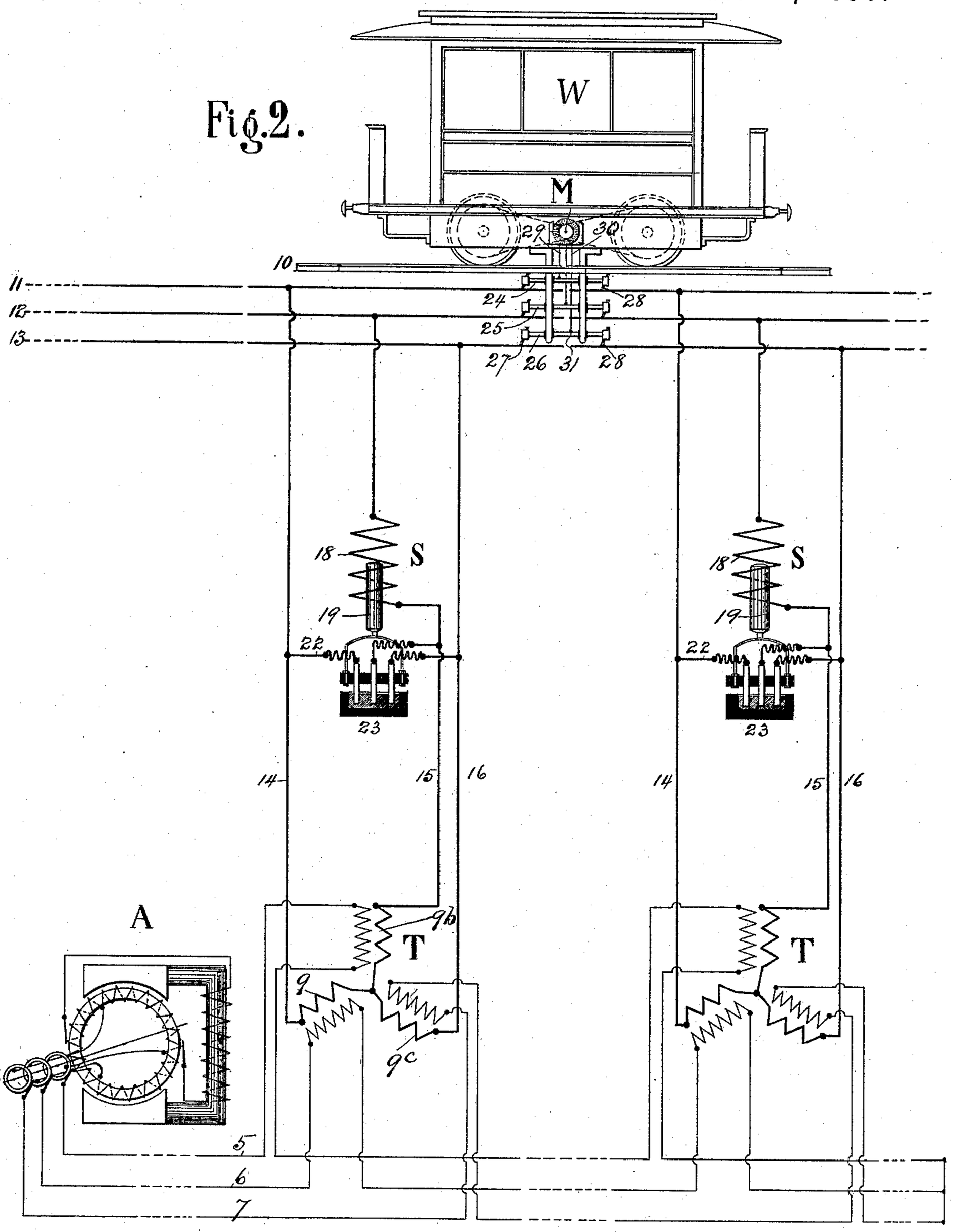
CONVERTER SYSTEM FOR RAILWAYS.

No. 493,914. Patented Mar. 21, 1893.

Fig. 2.



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CONVERTER SYSTEM FOR RAILWAYS.

No. 493,914. Patented Mar. 21, 1893.

Fig. 3.

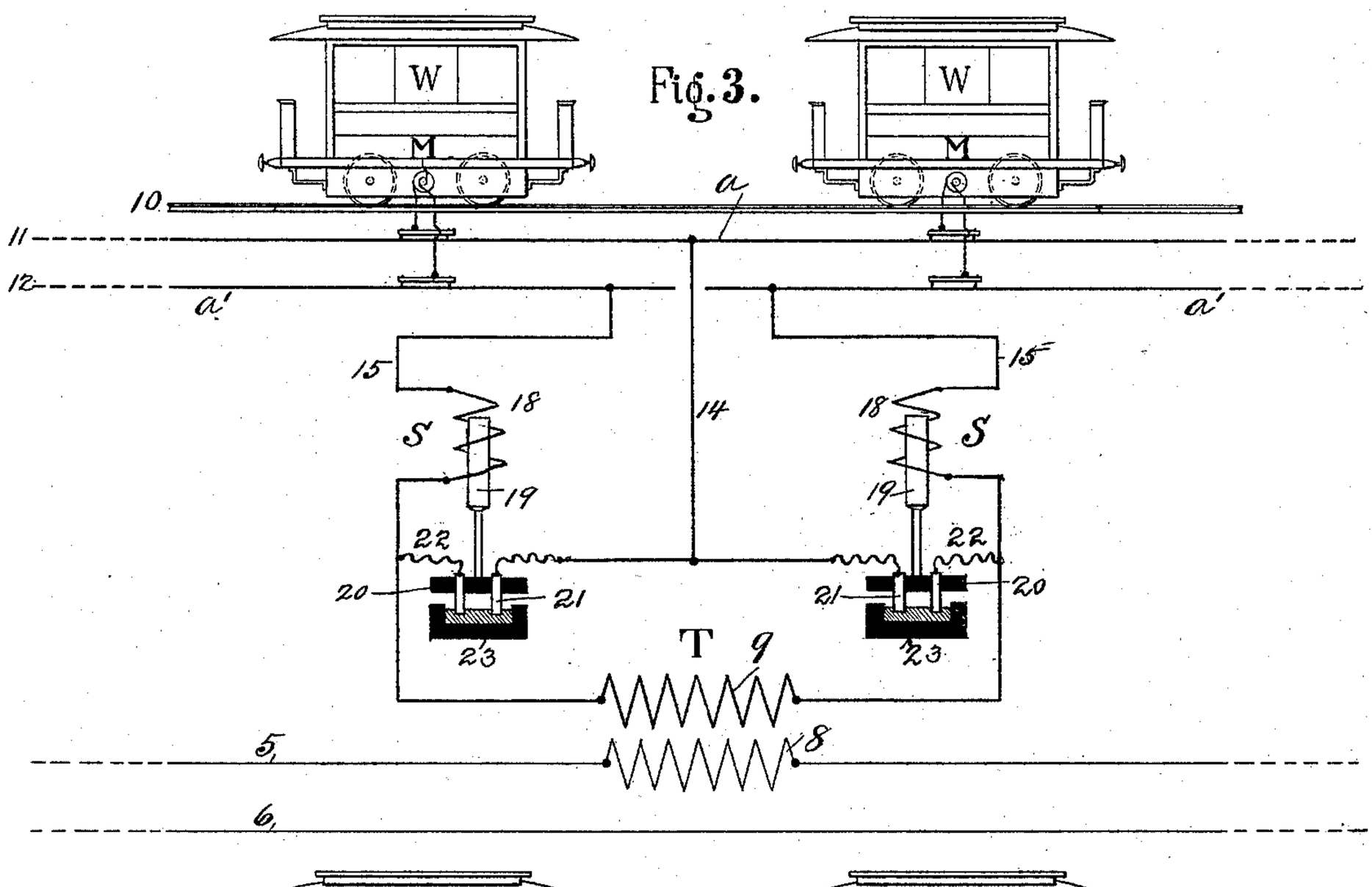
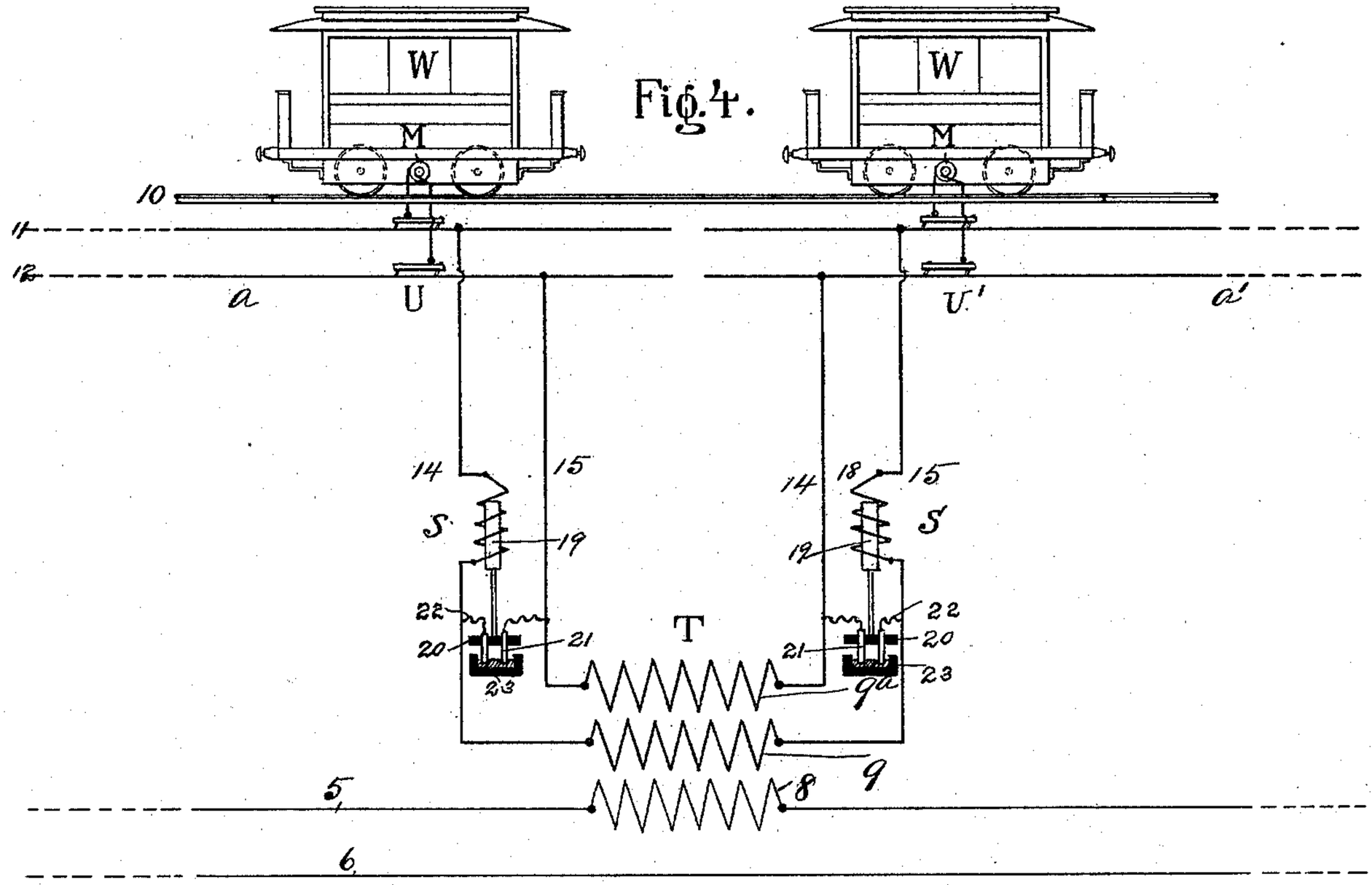


Fig. 4.



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A. DU BOIS-REYMOND.

CONVERTER SYSTEM FOR RAILWAYS.

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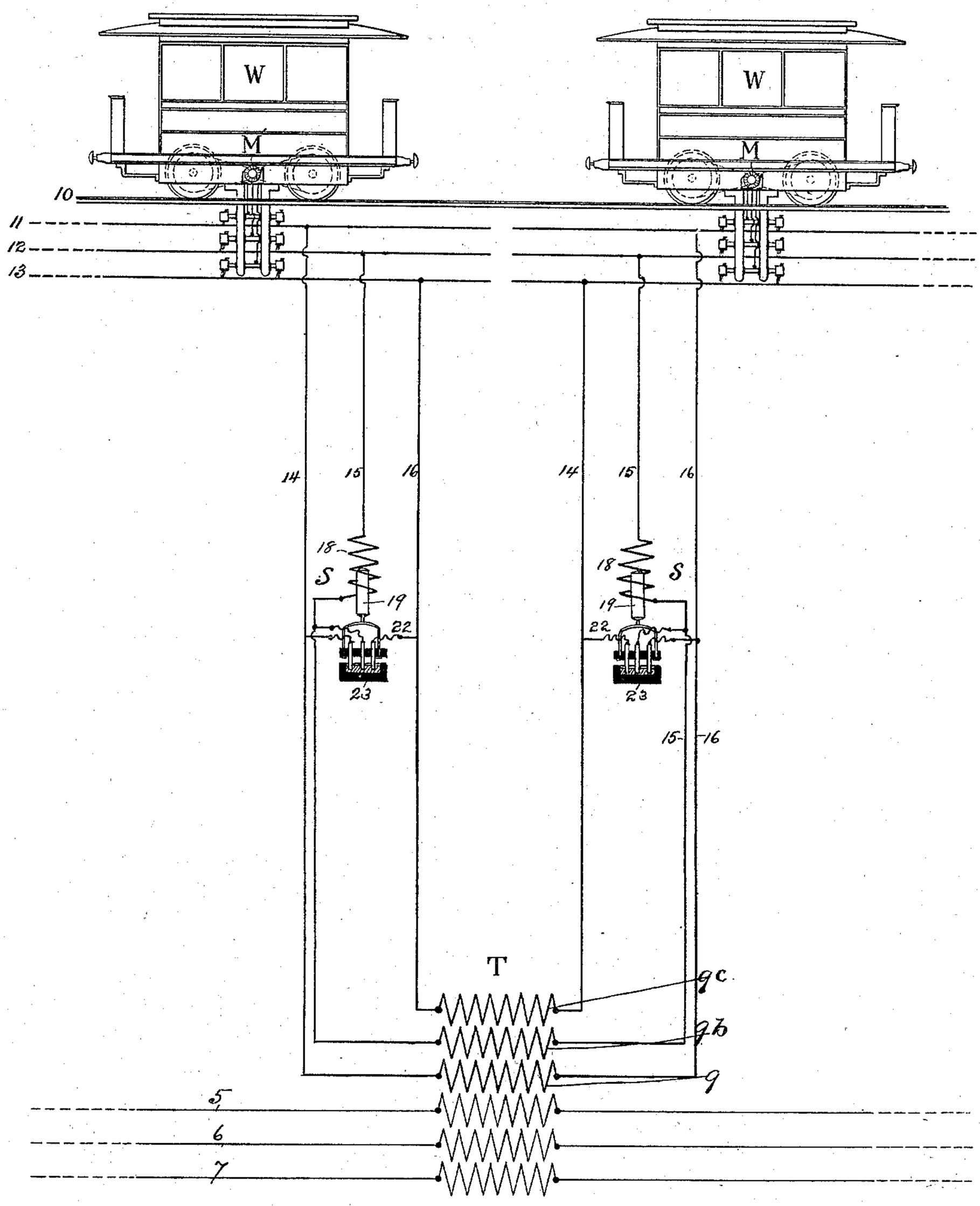
Fig 5.



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UNITED STATES PATENT OFFICE.

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CONVERTER SYSTEM FOR RAILWAYS.

SPECIFICATION forming part of Letters Patent No. 493,914, dated March 21, 1893.

Application filed February 3, 1892. Serial No. 420,148. (No model.)

To all whom it may concern:

Be it known that I, ALARD DU BOIS-REYMOND, a subject of the King of Prussia and German Emperor, residing at the city of Charlottenburg, Prussia, Germany, have invented certain new and useful Improvements in Electrical Tramways Operated by Means of Transformators; 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 to an electric railway system, in which the energy employed is alternating currents of electricity generated at a distance and transmitted through suitable feeder conductors to a number of independently located current transforming devices, which serve to modify the primary current transmitted to them, and distribute it as secondary currents through working conductors so located relatively to the road or railway that the vehicle or vehicles thereon may be brought into conductive connection with such conductors through the instrumentality of suitable contact making devices.

My invention further relates to the method and means employed for automatically causing the current to flow in only such portion of the working conductors as are at the time in conductive connection with the vehicle or vehicles upon the road or railway.

The object of my invention is a system of electric locomotion by which is avoided the great leakage of current and danger from accidental contact present in all electric railway systems where the working conductors are constantly charged with the energizing current.

In the accompanying diagrams which illustrate my invention, similar letters and figures of reference indicate like parts.

Figure 1 illustrates my improved system as designed to be operated by a single phase alternating current. Fig. 2 shows the construction employed with the tri-phase alternating current. Figs. 3 and 4 illustrate the construction adapted to be energized by a single alternating current, with the vehicles in series, and the transformer in Fig. 4 provided with two secondary coils, and Fig. 5 illustrates two vehicles in series, and a construction such as is required by the three-phase alternating current.

In the diagrams A indicates a generator of alternating currents;—the generator may be of any well known type adapted to transmit to a suitable transformer, a single phase or a multiphase alternating current,—it being understood that the separate connections in each case will be such as are adapted for the class of generator employed. The generator may be located at any required distance from the point or points of distribution, and the current generated may be of any determined electro-motive force. The current from the source of energy A is conveyed by the feeder conductors 5 and 6 (Figs. 1, 3 and 4) and 5, 6 and 7 (Figs. 2 and 5). In the case of a single alternating current, as well as in a two-phase system, two conductors will be required from the source of energy to the point or points of distribution;—with the tri-phase or multiphase system, as many conductors as there are phases of the currents transmitted will be employed.

At the point or points of distribution are arranged transformers T. The transformers may be of any well known type, and located at any distance from the generator A,—but preferably near to the districts to be supplied. The transformers employed must be such as are required for the system with which they are used. In Figs. 1, 3 and 4, the transformers have each a single primary coil 8, arranged in series in the conductor 5. In Figs. 2 and 5 there is a primary coil in each of the conductors 5, 6 and 7. If more conductors than three are used, there will be a corresponding number of primary coils, and the primary coils, in every case, will be arranged in series. The transformers shown in Figs. 1 and 3 are each provided with a single secondary coil 9: in Fig. 4, the transformer has two secondary coils 9 and 9^a, for the purpose which will hereinafter be more fully described. In Figs. 2 and 5 each transformer has as many secondary coils 9, 9^b, 9^c, as there are primary coils. I prefer that each transformer shall be provided with a laminated core.

I wish it understood that I do not limit myself to any particular construction of trans-

former to be employed with a single alternating, a two-phase or a multiphase system,—providing the device used will accomplish the results of those shown and described.

10 represents traffic rails or a road-way upon which the vehicle or vehicles to be operated moves or move, said traffic rails being upon the street surface, elevated above it or otherwise located, as may be deemed desirable.

11 and 12 are the working conductors (Figs. 1, 3 and 4) and 11, 12 and 13 (Figs. 2 and 5). In the diagrams, these conductors are shown as located below the street surface, as for instance in a sub-way, but it will be obvious to those skilled in the art to which this invention belongs, that the working conductors may be located at the side or above the road or track, as is usual in electric railway systems now in use; or the working conductors themselves may be dispensed with, and the traffic rails 10 take their place,—in which case the traffic rails must be insulated from each other and from the earth, and should this construction be carried out, it will be necessary to insulate the wheels on the opposite sides of the motor from each other.

W represents a vehicle adapted to move upon the roadway or rails.

M is a motor located upon the vehicle. The motor may be of any suitable type adapted to be energized by the currents transmitted, and which will give motion to the vehicle upon which it is placed.

The working conductors are divided into sections of their length. The length of the sections will, as a rule, depend upon the tension of the current employed in the motor. Each section of the working conductors is insulated from the neighboring sections *i. e.* the section *b* is insulated from *a* and *c*:—this will also be true if the track rails 10 are used in place of the distributing conductors 11 and 12.

The current from the prime source A is conveyed to the working sections *a*, *b*, *c*, as follows: 14 and 15 (Fig. 1) and 14, 15 and 16 (Fig. 2) are secondary conductors connected at one end to the respective terminals of the secondary coils 9 of the transformer T, and at the other end to the working conductors 11 and 12. The currents therefore which traverse the primary coils 8 of the transformers, induce currents in the secondary coils 9,—which currents are conveyed by the conductors 14 and 15, or 14, 15 and 16, to the working conductors 11 and 12, or 11, 12 and 13, arranged as successive insulated sections *a*, *b* and *c*;—that is to say, the sections *a*, *b*, *c*, &c., are supplied with current when it is desired that these sections shall be energized. It is, however, desirable in practice that only such of the working sections *a*, *b*, *c*, &c., shall be energized as are in conductive contact with the vehicle or vehicles at the moment,—all the other sections of the road being out of circuit, *i. e.* when only one vehicle is in use upon the road. If more than one vehicle is in use, only such sections will be in conductive connection with the source of energy as are engaged at the moment in furnishing current to the vehicle or vehicles in electric connection therewith.

I will now proceed to describe how the sections *a*, *b*, *c*, are automatically thrown into and out of circuit with the source of energy A: Included in the conductors 15 is an electro-magnetic device S which consists of a solenoid 18, core 19, fastened to the end of which core is a plate 20 of insulating material, from which project the vertical conducting plates 21. These plates (21) are connected through the conductors 22 to the conductors 14 and 15, (Fig. 1) or 14, 15 and 16 (Fig. 2). 23 is a mercury bath. The operation of this device is very simple. Normally the plates 21 of the device S are immersed in the mercury bath 23, hence the secondary coil or coils 9 of the transformer or transformers are short-circuited through the conductors 22, and no current will flow to any of the sections *a*, *b*, *c*, &c., of the working conductors 11 and 12, or 11, 12 and 13. When, however, connection is made by any suitable means between two of the contiguous sections *a*, *b*, *c*, in successive order, as for instance sections *b* and *c*, supposing the vehicle to be traveling toward *c*, the current will flow in conductor 15 of section *b*, and will energize the core 18 of the solenoid, which will attract its core 19 and break the circuit previously established through the conductors 22 and the mercury cup 23. The current will thus flow from the secondary of the transformer 9 to the working conductors 11 and 12, or 11, 12 and 13 of section *b*. This result will also be brought about when working conductors 11 and 12 or 11, 12 and 13 are brought into conductive connection.

The means by which the working conductors are brought into conductive connection with each other and with the motor upon the vehicle, consists of a contact device, shown in the diagrams as depending from the bottom of the vehicle. The device consists of two or three parallel rods 24 and 25 (Fig. 1) and 24, 25 and 26 (Fig. 2) of conducting material, on the ends of which are brushes 27 and 28. The brushes on the ends of the separate rods are electrically connected together. These rods are connected through suitable conductors 29 and 30 (Fig. 1) and 29, 30 and 31 (Fig. 2) with the motor M upon the vehicle W. The length of the rods 24, 25, &c., should be sufficient to permit the brushes 27 and 28 on their ends to lap the openings between the sections *a*, *b*, *c*, of the working conductors.

Instead of using the apparatus described for short-circuiting the secondary coils of the transformer, I may use any other suitable device for the purpose.

Referring to Fig. 2, the current from section *b* is taken up by the brushes 27 and 28.

Instead of having the device which connects the motor upon the vehicle with the

working conductors, depending below the bottom of the vehicle, a suitable device may be affixed to the side or to the top of the vehicle, such for instance as a trolley arm or a contact bar, as is now used in electric railway systems,—provision being made for lapping the openings of the working conductors arranged overhead, as in the case above described.

I have thus far described my improved system as carried out with a single track railway and with but one vehicle upon a working section, such as *a*, *b*, or *c*. It will be evident, however, that two or more vehicles may be operated upon a single section, and that the system can be applied to a double track road. The connections for such system I have illustrated in Figs. 3, 4 and 5.

In Fig 3, the working section (*a*) is divided into two sub-sections *a' a'*, that is to say, I divide one of the conductors,—say 12—into two equal parts and connect them by the conductors 15 to the secondary terminals 9 of the transformer T. The conductor 11 I connect to the conductor 14 and include between it and the conductors 15, on each side, a short-circuiting device S, which is in all respects similar to that described with reference to Fig. 2. It will be understood that the short-circuiting device S, on the left of the figure, will serve to short-circuit one sub-section and that upon the right of the figure the other sub-section, when there are no vehicles moving over these sub-sections.

In Fig. 4, the working sections *a* are shown as disposed parallel, in which case the secondary of the transformer consists of two coils 9 and 9^a, and the usual short-circuiting devices S are included in the conductors 15. The application of the system shown in Fig. 5 is the same, only carried out with a multiphase system.

Instead of placing one motor upon a vehicle, two motors may be placed thereon, but they should in any case be connected in series. In the construction shown in Figs. 3, 4 and 5, it will be observed that the motors upon the vehicles are in series.

The operation of my improved system is as follows: The primary generator A sends a current of constant energy into the primary conductors and thence through all of the primary coils of the transformers arranged in series,—which primary coils induce secondary currents in the secondary coils of the respective transformers, and these secondary currents are conveyed separately to the working sections, which sections are successively brought into electrical connection with the vehicle or vehicles upon the road or railway, as the vehicles pass over them. That is to say, when the vehicle is, for instance, in section *b*, the secondary current from the transformer of *b* section is carried by the contact making devices to the motor M upon the vehicle and motion is imparted thereto. As the vehicle moves forward, the brushes 27 and 28 bridge the interval between the sections *b* and *c*; at this moment the magnet 18 of the short-circuiting device S of *c* section is energized, lifts the armature 19 and breaks the short-circuit between the conductors 14 and 15: the secondary current from the *c* section transformer then energizes the *c* section working conductors and the contact making devices are carried over, as the vehicle advances, on to the *c* section. As soon as the brushes 27 leave the *b* section, there will be no current in conductor 15 of the *b* section, and the short-circuiting device S of *b* section, will short-circuit the conductors 14 and 15 of the *b* section. In other words, the vehicle, as it moves along, energizes the working section in advance of it as it enters it, and cuts out of circuit the working section which it has just passed, as it leaves it, so that a single vehicle never has included with the motors thereon, more than two of the working sections of the system. The operation, so far as the other disposition of the system described is concerned is the same, and will be readily understood without further explanation.

As before stated, I wish it understood that so far as the substance of my invention is concerned, it does not make any difference whether a simple alternating, a two-phase or multiphase alternating current is employed. Further, that I do not limit myself to any special construction of generator, transformer, or motor, or to the device or means employed for cutting the separate working sections into or out of circuit with the source of energy, or to the device employed for conveying the current to the motor or motors upon the moving vehicles, as many changes may be made therein.

Having thus described my invention, I claim—

1. The method of operating electric railway systems, having working conductors sectionally fed from secondary circuits, the primaries of the transformers of which are supplied with an alternating current, the said method consisting in short-circuiting the secondary circuits of such sections as are not in operative relation to a moving motor, substantially as and for the purpose set forth.

2. In an electric railway system, the combination with an alternating current generator and feeder conductors therefrom, sectional working conductors, a plurality of transformers having their primary circuits connected to said feeder conductors, and their secondary circuits to independent sections of the working conductors, and means for automatically short-circuiting the secondaries of said transformers, substantially as set forth.

3. In an electric railway system, the combination with an alternating current circuit and generator therefor, working conductors including a series of independent insulated sections and connected with the secondary circuit of a transformer, together with a circuit-closing device in each secondary circuit

for short-circuiting the current in said secondary circuit, as the vehicle passes from the end of the current charged section, substantially as described.

4. In an electric railway system, the combination with an alternating current circuit and generator therefor, of a series of transformers, and working conductors including insulated sections, each connected with the secondary circuit of one of the transformers, together with circuit closing devices included in said secondary circuits, and each adapted to close and short-circuit the secondary circuit of the insulated section from which the vehicle is passing and open the short-circuiting device of the secondary circuit of the insulated section to which the vehicle is passing, substantially as described.

5. In an electric railway system, the combination with a plurality of transformers, of sectional working conductors connected to the secondaries of said transformers, and a circuit closing device in said secondary conductors, adapted to short-circuit said secondary conductors when no current is required in the sections of the working conductors to which they are connected.

6. In an electric railway system, the combination with a generator of alternating currents of electricity, of feeder conductors leading therefrom, a plurality of transformers having their primaries in series of said feeder conductors, working conductors divided into sections insulated from each other, and each of said sections connected to the secondary terminals of one transformer, a moving vehicle or vehicles and a propelling motor or motors located thereon, and means whereby the said sections are automatically cut into and out of circuit with the source of energy.

7. In an electric railway system, the combination with a generator of alternating currents of electricity, of a plurality of transformers in operative relation with said generator of electricity, working conductors divided into sections insulated from each other and each of said sections connected to the secondary terminals of one transformer, a moving vehicle or vehicles and a propelling motor or motors thereon, a device upon the vehicle or vehicles for establishing electrical contact between said section or sections, vehicle or vehicles, and means whereby said section or sections are automatically energized or de-energized without making or breaking their mechanical connection with the source of energy.

8. The combination with the secondary coils of two transformers, of two adjacent sections of working conductors insulated from each other, two transformers, two circuits of conductors connecting the secondary coils of said transformers with the respective sections of working conductors, a vehicle with a propelling electro-motor or motors mounted thereon, a device for bringing said electro-motor or motors into operative relation with one or both of said sections of working conductors, and short-circuiting devices in said secondary circuits from said transformers, which act to open said normally closed short circuits, when the contact device on the vehicle closes the circuit between the adjacent sections of the working conductors, but which will automatically close said short circuits when the sections of the working conductors are no longer in circuit with the motor or motors upon the vehicle.

9. An electric railway divided into a number of successive sections insulated from each other, each section comprising a current transformer, the primary coil of which is in series with the primary coils of the other transformers in the system, and connected to the source of energy, a pair of supply conductors fed from the secondary coil of the transformer, and a device for short-circuiting the said secondary coil when no current is required in the supply conductors.

10. An electric railway divided into a number of successive sections insulated from each other, each section comprising a current transformer, the primary coil of which is in series with the primary coils of the other transformers in the system, and connected to the source of energy, and means for de-energizing the working conductors without rupturing their mechanical connection with the source of current.

11. An electric railway divided into a number of successive sections insulated from each other, each section comprising a current transformer, the primary coil of which is in series with the primary coils of the other transformers in the system, and connected to the source of energy, and means whereby the current flowing in the working conductors of one section will actuate a device in the next section and thereby permit the supply conductors of that section to be energized.

12. In an electric railway system, the combination with a source electricity, a plurality of independently located transformers, working conductors arranged as successive sections, insulated from each other, and each of said sections connected to the secondary terminals of a transformer, a vehicle and a propelling electro-motor thereon, and means for energizing and de-energizing said working sections, without altering their mechanical connection with the source of current actuated by apparatus carried on the vehicle.

13. In an electric railway system, the combination with a source of electricity, of a plurality of independently located current transformers, the primaries of which are coupled in series, working conductors arranged as successive sections, insulated from each other, and each of said sections connected to the secondary terminals of a transformer, a vehicle and a propelling electro-motor thereon, and means for energizing said motor from said working conductors, substantially as described.

14. An electric railway divided into a number of independent distributing stations, each station comprising a current transformer, a sectional working conductor, a pair of supply conductors interposed between the section of the working conductor and the secondary terminals of the transformer, and a device for automatically short-circuiting the secondary coil of the transformer, at such times as when the working current is not required in the section of the working conductor supplied by it.

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

ALARD DU BOIS-REYMOND.

Witnesses:
JOHN B. JACKSON,
MAX WAGNER.