(No Model.)

2 Sheets—Sheet 1.

# C. S. BRADLEY.

## CONVERTER SYSTEM FOR ELECTRIC RAILWAYS.

No. 508,807. Patented Nov. 14, 1893.

Fig. 1.

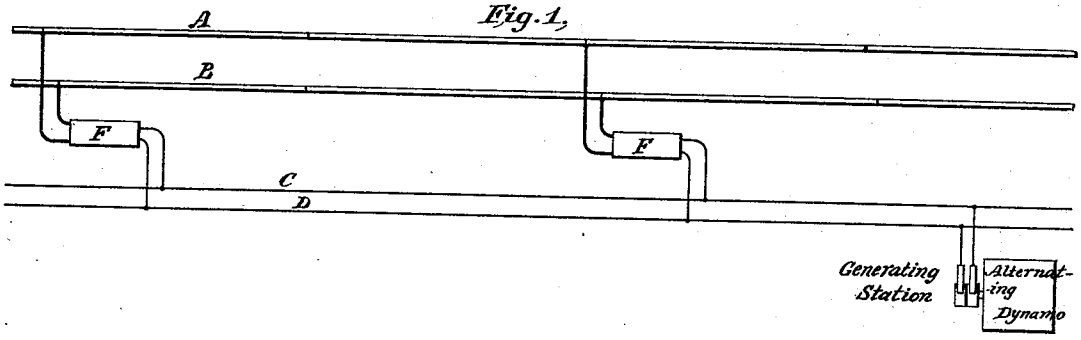


Fig. 2.

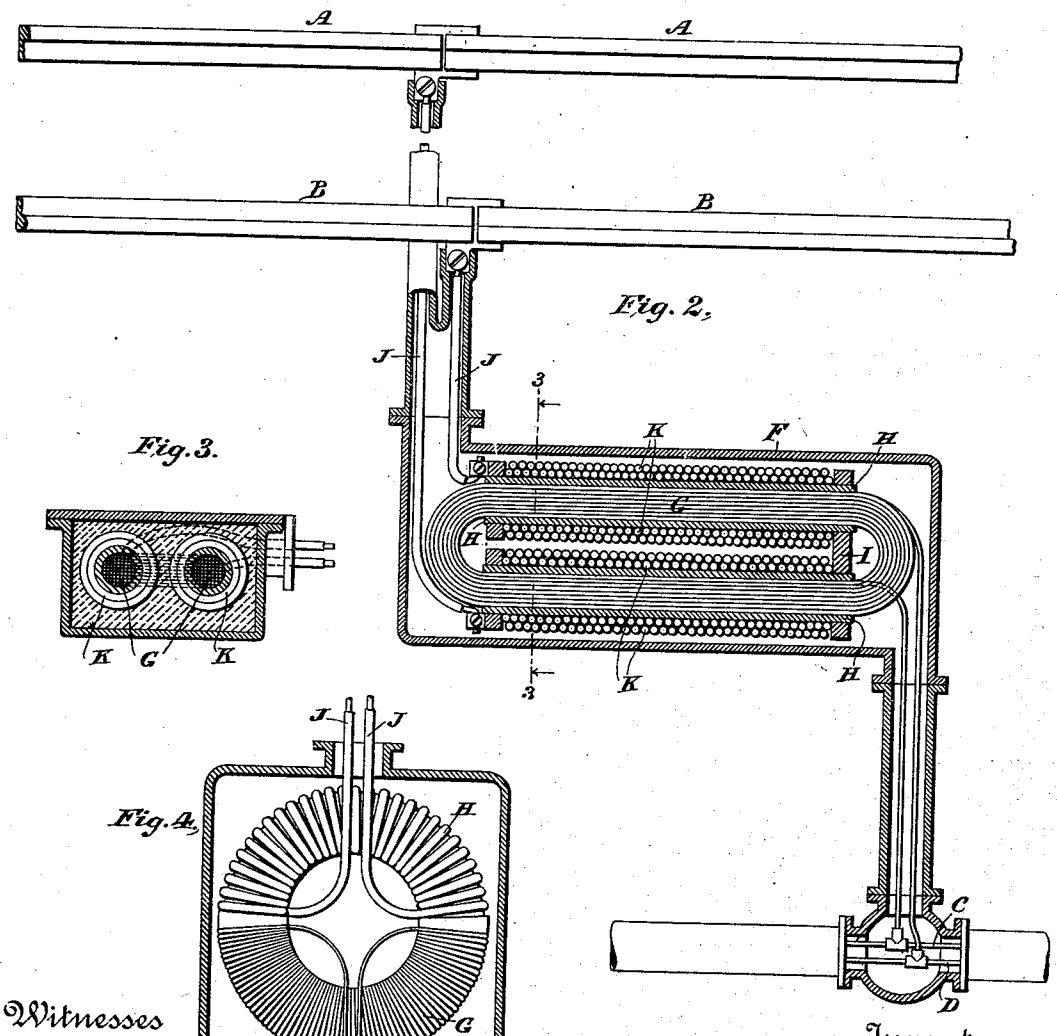


Fig. 3.




Fig. 4.




Witnesses

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Chas. J. Maguire

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(No Model.) 2 Sheets—Sheet 2.

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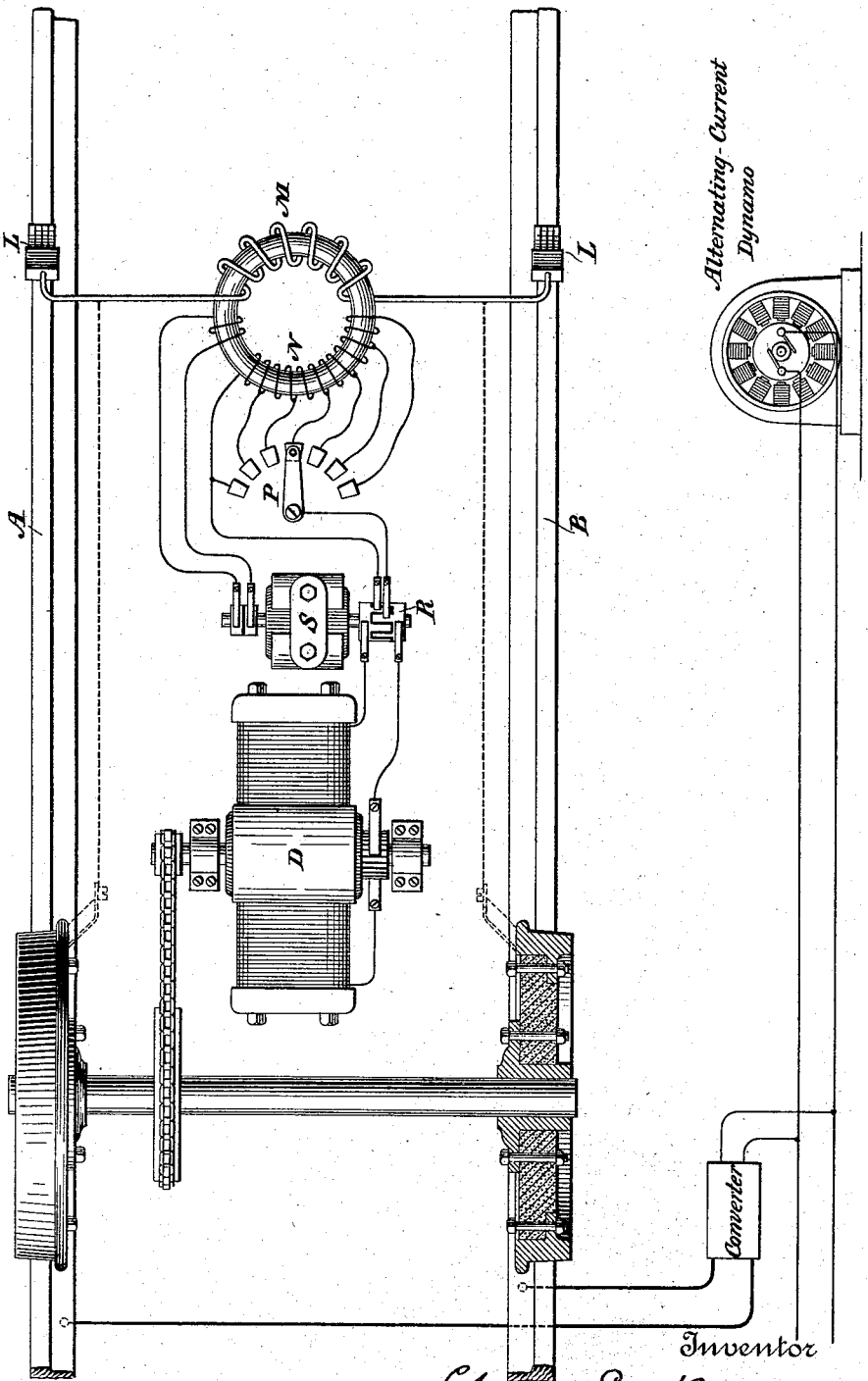


Fig. 5.

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# UNITED STATES PATENT OFFICE.

CHARLES S. BRADLEY, OF YONKERS, NEW YORK.

## CONVERTER SYSTEM FOR ELECTRIC RAILWAYS.

SPECIFICATION forming part of Letters Patent No. 508,807, dated November 14, 1893.

Application filed May 31, 1887. Serial No. 239,786. (No model.)

*To all whom it may concern:*

Be it known that I, CHARLES S. BRADLEY, of Yonkers, Westchester county, New York, have invented a new and useful Improvement in Electric Railways, of which the following is a specification.

The object of this invention, which is especially applicable and important in ordinary street or surface railways, though applicable to electric railways of all kinds, is to enable the ordinary rails of the track on which the car travels to supply the current for driving the cars, by feeding the rails with a current of such low electro-motive force that the danger of shock to animals, and the loss by leakage in wet weather or otherwise is avoided; and accidental short-circuiting between the rails becomes a matter of less importance; and to accomplish this without involving very large copper or other conductors to convey the necessary electrical energy from the station where it is generated to the moving cars.

By my invention I am enabled to make use of the rails of ordinary horse-car or other street roads now in use to supply the driving current to the cars without the necessity of tearing them up or changing them in any material way. To accomplish this I have devised a system in which the cars or vehicles running on the track take their supply of current directly from the ordinary track rails in the form of a current of very low electro-motive force, and the electrical energy is conveyed from the generating station or source of supply in the form of a current of comparatively high electro-motive force and converted at points along the track into the low electro-motive force current which is fed to the rails. The low electro-motive force current taken up from the rails by the moving cars or vehicles is then used either directly to drive the car, or is reconverted into a current of comparatively high electro-motive force, which is used to drive the car.

I will describe my invention by reference to the accompanying drawings, in which—

Figure 1 is a plan view of a track, showing the conductors and apparatus for supplying the rails with the current, according to my invention. Fig. 2 is a detail view of the same, showing an improved form of converter which I have devised to convert the high electro-motive force current into a low electro-motive force current. Fig. 3 is a view in section of the converter on the plane 3, 3. Fig. 4 is another form of converter; and Fig. 5 is a plan view of the track and the driving machinery of the car, constructed according to my invention.

A and B represent the rails of a track, which may be any kind of track - the ordinary iron or steel rails of a horse-car or other railroad, for example. Alongside or between the rails of the track I lay current-conveying conductors, C D, which extend to and are connected with the generating station or source of supply of electric current. These conductors may be arranged overhead or alongside of the track, but preferably underground alongside of or between the track rails, or under the pavement in a proper conduit. They are fed with a current of high electro-motive force from a suitable dynamo-machine or source of supply at the generating station. I have shown them connected with an alternating current dynamo machine, so that they are fed with an alternating current of high electro-motive force,—say a thousand or several thousand volts. These conductors may be made of copper or of any other material of the necessary conductivity, and need only be large enough to carry the required amount of electrical energy of the given volts to operate the cars without too much loss of current due to resistance, and without overheating; the necessary size depending of course upon the electro-motive force of the current used, and the amount of power required to operate all the cars at any one time. The higher the electro-motive force of the current used the smaller can these conductors be made, both on account of the less ampères they will be required to carry to supply a given power, and on account of the less loss of current in them due to resistance. By using a current of quite high electro-motive force,—say over a thousand volts—I am enabled to convey the required amount of electrical energy to operate the number of cars in the form of a current of so few ampères, that only a very small copper conductor, or a mere wire, will be required. For example, if there

are—say ten cars to be supplied from the same set of conductors requiring five horse-power each, with an efficiency of sixty per cent., and an electro-motive force of twelve hundred volts to be used, the capacity of the conductors need only be sufficient to carry fifty ampères in order to furnish the required fifty horse-power. At points along the track I arrange converters F F, or transforming apparatus, which are connected with and fed from the conductors C D, and may be placed at any desired points above or below the ground. The primary coils or circuits of these converters are connected, as stated, with the feeders C D, and their secondary coils or circuits are connected directly with the rails from which the cars take up the current. If the ordinary rails of the track be used for this purpose, the secondary coils of the converters are connected, one end with one rail, and the other end with the other rail, as clearly shown. The connections with the rails may be made at any desired points along the track, and as frequently as desired, depending upon various conditions; but in order to avoid the necessity of carrying any current through the joints of the rails, I provide connections at every second joint of the rails, as shown, making the connection with the rails on each side of the joint, so that the current passes both ways, and the same connection feeds the rail for the length of one rail either way, as clearly shown. The ordinary track rails being thirty feet long, this would make the connections to the rails about sixty feet apart, and no current would be required to pass through the ordinary joints in the rails. Otherwise a special provision would have to be made to connect the rails with each other, which would be very difficult, if not impossible, with the use of such extremely low electro-motive forces as can be used in my system. If desired a separate converter may be used at each point where connection is made to the track rails, as I have shown in Fig. 1; or several connections may be taken from the same converter. The converters or transforming apparatus F F are constructed so as to convert the high electro-motive force current supplied to them by the feeders C D into currents of extremely low electro-motive force; and it is these very low electro-motive force currents which are supplied to the rails of the track, and taken up therefrom by the moving cars. By properly constructing the converters in the well-known manner, the electro-motive force of the original current may be reduced to any desired extent,—to only a very few, say five volts or less—so that the electro-motive force between the two rails of the track is so low that no material loss results by leakage between the rails, even in wet weather, or from other causes, short-circuiting between the rails becomes a matter much less serious, and all danger of shock to animals is avoided. If the rails themselves were used to convey the current from the generating station, the current would have to pass through the joints of the rails, and special connections would have to be made between the abutting ends of the rails for this purpose, and the loss of electrical energy resulting from the resistance of the joints and the rails themselves, provided a current of comparatively low electro-motive force were used, would be too great for practical use, besides which the ampère-carrying capacity of the rails and their joints would be far too limited, and the joints would be in danger of overheating, due to an increase in their resistance, whereas by my invention I am enabled to supply the cars directly from the rails of the track with a current of such a low electro-motive force as to be unobjectionable in streets and other localities; to avoid the necessity of passing the current through the joints of the rails; and to convey the current from the generating station to the tracks in a way which does not require large and expensive copper conductors, and with only a small and permissible loss of electric energy.

In Fig. 2, I have shown a more detailed view of the track rails and connections, and a very simple and inexpensive form of converter which I have devised, applicable to this purpose. G is the primary coil or conductor of the converter, which I make in the form of an oblong coil composed of the proper number of turns to suit the electro-motive force of the primary current which is fed to it from the feeders C D. The two straight parts of this coil are surrounded by copper or other metal tubes H H, which are connected together at one end by a copper collar I, so that the tubes are electrically in series. These two copper tubes in series form the secondary conductor of the converter, and are connected at their ends by heavy copper conductors J J with suitable chairs or connecting devices which make proper electrical connection with the track rails A B, as shown. These copper tubes H H are made of a sufficient length to give the required electro-motive force for the rail current, and of a sufficient cross-section to carry the required number of ampères. Surrounding the copper tubes or envelopes are shells or tubes of iron K K for concentrating the lines of force, which should of course be laminated at right angles to the length of the tube, and may conveniently be formed of iron wire wrapped around the tubes, as shown, and having its convolutions insulated from one another. The alternation or change of the current in the primary coil G induces an alternating current in the tube or secondary conductor H H, the electro-motive force of which is extremely low compared with that of the primary circuit; the amount of reduction being determined, as is well-known, by the relative lengths of the primary and secondary conductors acting upon each other in the converter. The converters may

well be inclosed in water-tight cast iron boxes, as I have shown, so that they can be placed under ground.

In Fig. 4 I have shown another form of converter, in which the primary and secondary conductors consist of two coils of relatively coarse and fine wire, H and G, wound upon the same laminated iron ring.

Fig. 5 shows the apparatus upon the car, which I have devised for taking up the low tension current from the track rails and applying it to the work of propelling the car. The current may be taken up from the track in various ways. I have shown for this purpose brushes L L which are mounted upon the car and slid along in constant contact with the clean surface of the rails. These brushes or sliding contacts may be made of copper sheets or wires, and finely divided so as to bear upon the rail surface and make contact over a considerable area, and in snowy or wet weather they may be preceded by scrapers or sweeping devices which clean the surfaces of the tracks, or the necessary connections with the rails may be obtained by means of special rollers or by the wheels of the car itself, which latter plan of taking up the current I have also represented, the tires of the driving wheels on the car axle being insulated from one another and the current being taken from the wheels by suitable brushes bearing thereon, and mounted upon the car, as I have indicated by dotted lines. The current taken up from the track rails may then be conveyed either through an electric motor of a proper construction to be operated by such a low volt circuit current, or it may be passed through the primary circuit M of a converter carried by the car itself, and there reconverted into a current of higher electro-motive force, whatever it is desired to operate the motor with, as I have shown in the drawings. To accomplish this and to enable the speed or power of the motor to be easily and efficiently controlled, I construct the converter so that its secondary coil or circuit is divided up into a number of sections, which are respectively connected with the points of a switch P, and which may be arranged in series, as shown, so that the turning of the switch throws more or less of the sections into the motor circuit in series, thereby varying the electro-motive force of the current supplied to the motor. This secondary controllable current may be fed either directly to a motor capable of being operated directly with an alternating current, or it may be first rectified and then fed to an ordinary continuous current electric motor Q, which drives the car, as I have shown.

In an application filed by F. B. Crocker and C. G. Curtis April 25, 1887, Serial No. 235,990, there is described an electric motor adapted to be operated directly by an alternating current, and such a motor as that may be employed to drive the car, and fed directly from the secondary of the converter; but it may be desirable to employ a continuous current motor, and feed it by rectifying the alternating current obtained from the secondary of the converter. To accomplish this, any suitable means for rectifying the current may be employed. I have shown for this purpose a rectifying switch or commutator R, operated by a little constant speed alternating-current motor S, which is fed from an independent secondary coil on the converter, as shown. This little motor which requires only power enough to turn the commutator R, is provided with a permanent-magnet field, and being operated by an alternating current will only run, as is well-known, at a certain speed, and will preserve exactly that speed. By making the sections of the commutator R of the proper number and in the proper positions to agree with the reversals of the secondary current, the commutator R will work in unison with the alternations of the current and operate to reverse the connections with the motor synchronously with the reversals of the secondary current, so that the current always passes through the motor Q in the same direction. The motor Q being mechanically connected by a sprocket belt, for example, or in any other satisfactory way with the driving wheels, the motive power for propelling the car is thus supplied.

In my system of conveying the electrical energy from the generating station or source of supply to the moving cars or vehicles, a continuous or intermittent or any other form of electric current or energy may be employed instead of the alternating current to convey the power from the generating station to the point or points where it is converted into a current of different electro-motive force which is supplied to the rails or conductors from which the traveling vehicles take their current; and the conversion of the electric current from a current of high electro-motive force into a current of low electro-motive force can be effected by various forms of converters or transforming apparatus and in various ways. It may be preferable under some conditions to employ a continuous current to convey the electrical energy from the generating station to the converters, and the conversion may be effected among other ways by varying the current or producing intermittent changes in it.

My invention is also applicable to cases where the moving cars or vehicles, instead of taking their supply of current from the track rails, take their supply of current from overhead or other conductors or rails extending parallel with the track in which cases such overhead or extra conductors would be supplied from the converters in the same way as I have shown the ordinary track rails supplied. For example my invention may be applied to electric railways in which the cars take their supply of current from overhead suspended naked wires or conductors. These wires or conductors being exposed or in danger of having something come in electrical

contact with them, can be supplied with the comparatively low tension current by the converters, according to my invention.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The combination of a generating station or source of supply of electric energy, electric feeding conductors supplied thereby and extending along the line of a railway, track rails formed of jointed sections or lengths in the usual way, cars adapted to travel thereon and provided with electric propelling apparatus and means for taking the supply of current from the track rails, and electric connections at every second joint of the rails on each side of the joint for supplying the current furnished by the feeding conductors to the rails at these points, thereby avoiding the necessity of passing the current through the ordinary rail joints.

2. In an electric railway system, the combination of a stationary source of electricity, a track or roadway insulated feeding conductors extending along the latter and supplied from said source with an alternating or intermittent current of high electro-motive force, secondary or working conductors also extending along the roadway, electrical transforming devices arranged at intervals along the roadway and having their primaries in circuit with said feeding conductors and their secondaries connected to said working conductors, an electric motor on a vehicle, and a second transformer carried by said vehicle and having its primary and secondary in circuit respectively with the working conductors and the said motor, substantially as set forth.

3. In an electric railway system, the combination of a stationary source of electricity, a track or roadway, insulated feeding conductors extending along the latter and supplied from said source with an alternating or intermittent current of high electro-motive force, secondary or working conductors also extending along the roadway, electrical transforming devices arranged at intervals along the roadway and having their primaries in circuit with said feeding conductors and their secondaries connected to said working conductors, an electric motor on a vehicle, and a second transformer carried by said vehicle and having its primary and secondary in circuit respectively with the working conductors and the said motor and having a switch for varying the resistance of the secondary of said transformer, substantially as set forth.

CHARLES S. BRADLEY.

Witnesses:
CHARLES G. CURTIS
CHAS. J. MAGUIRE.