(No Model.)

4 Sheets—Sheet 1.

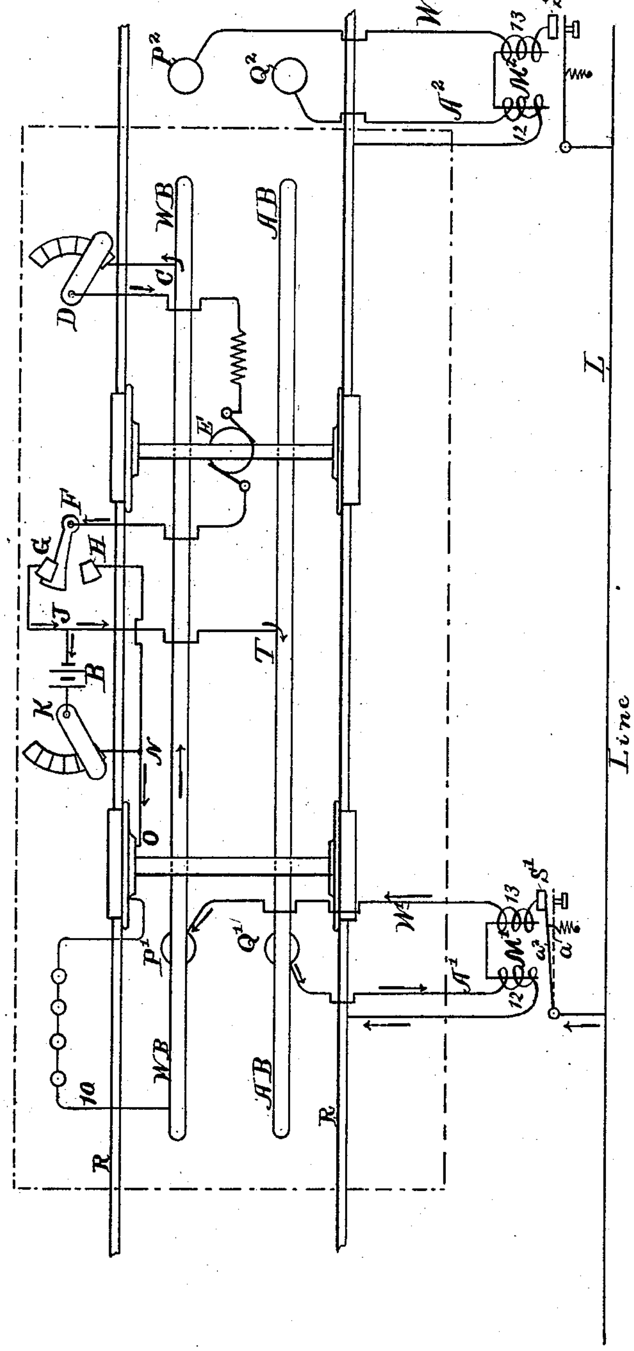
A. C. CREHORE.

ELECTRIC RAILWAY SYSTEM.

No. 523,396.

Patented July 24, 1894.

Fig. 1.



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(No Model.) 4 Sheets—Sheet 2.

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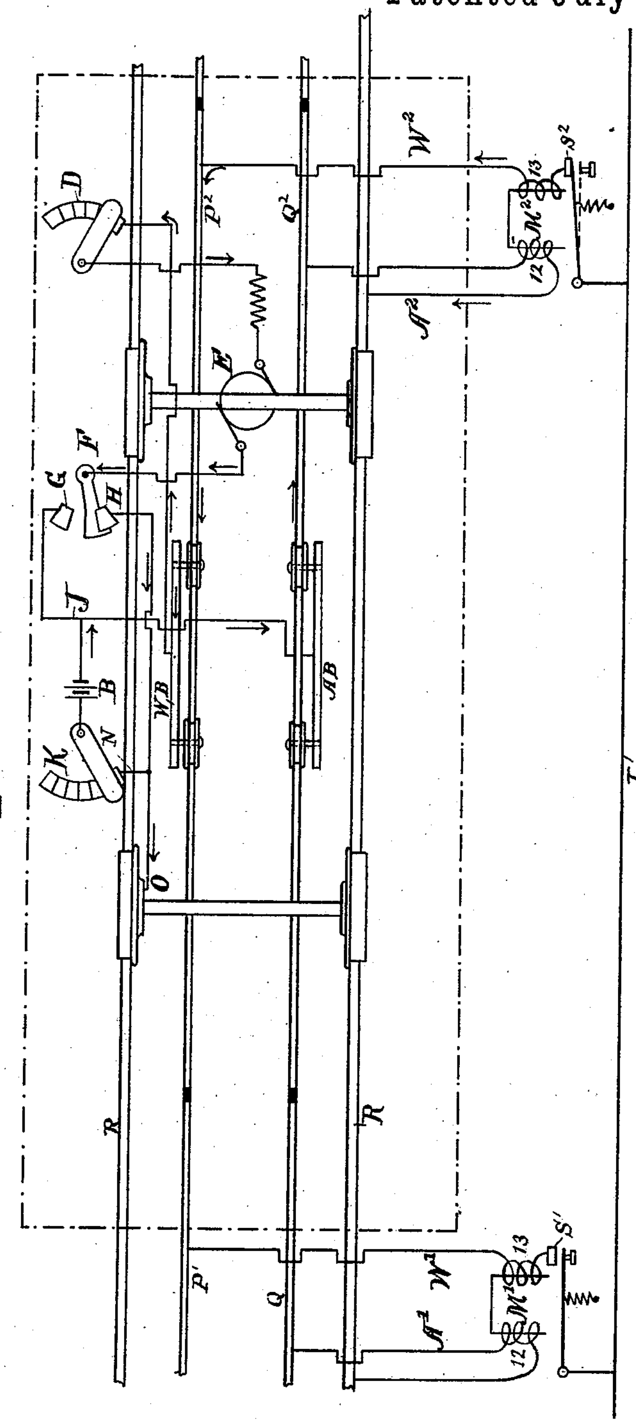
Fig. 2.



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ELECTRIC RAILWAY SYSTEM.

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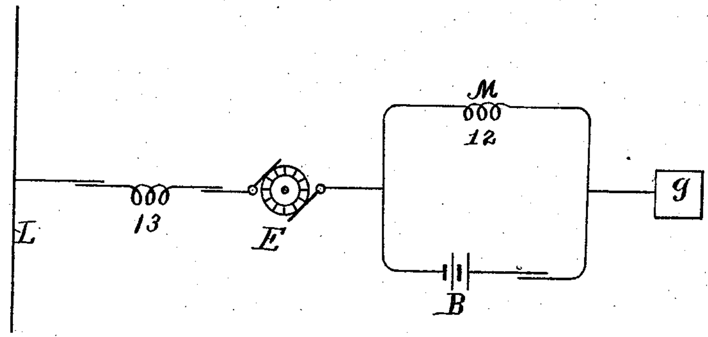

Fig. 3.

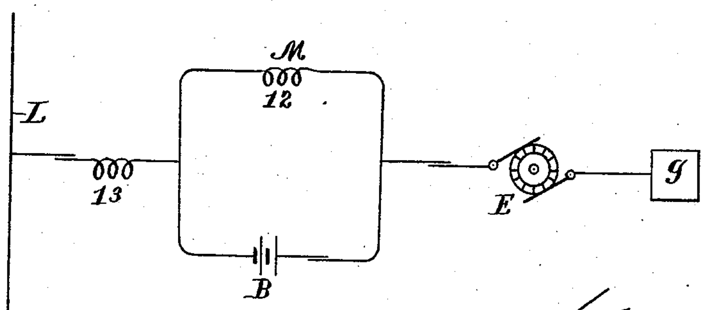

Fig. 5.

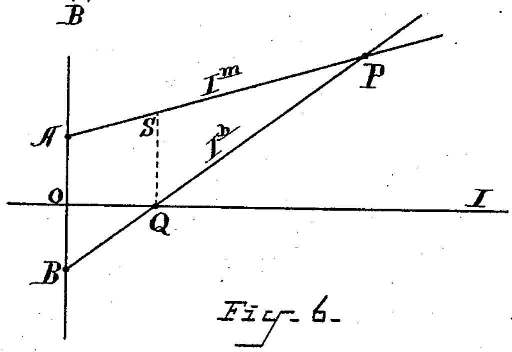

Fig. 6.

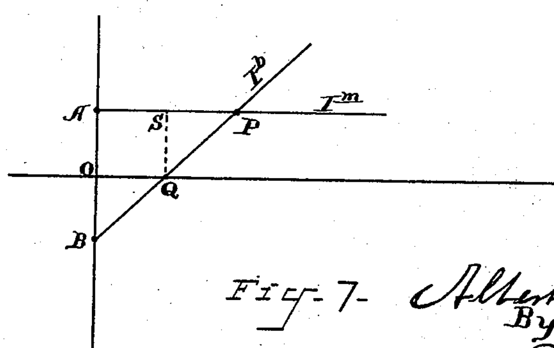

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Fig. 7.

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A. C. CREHORE.

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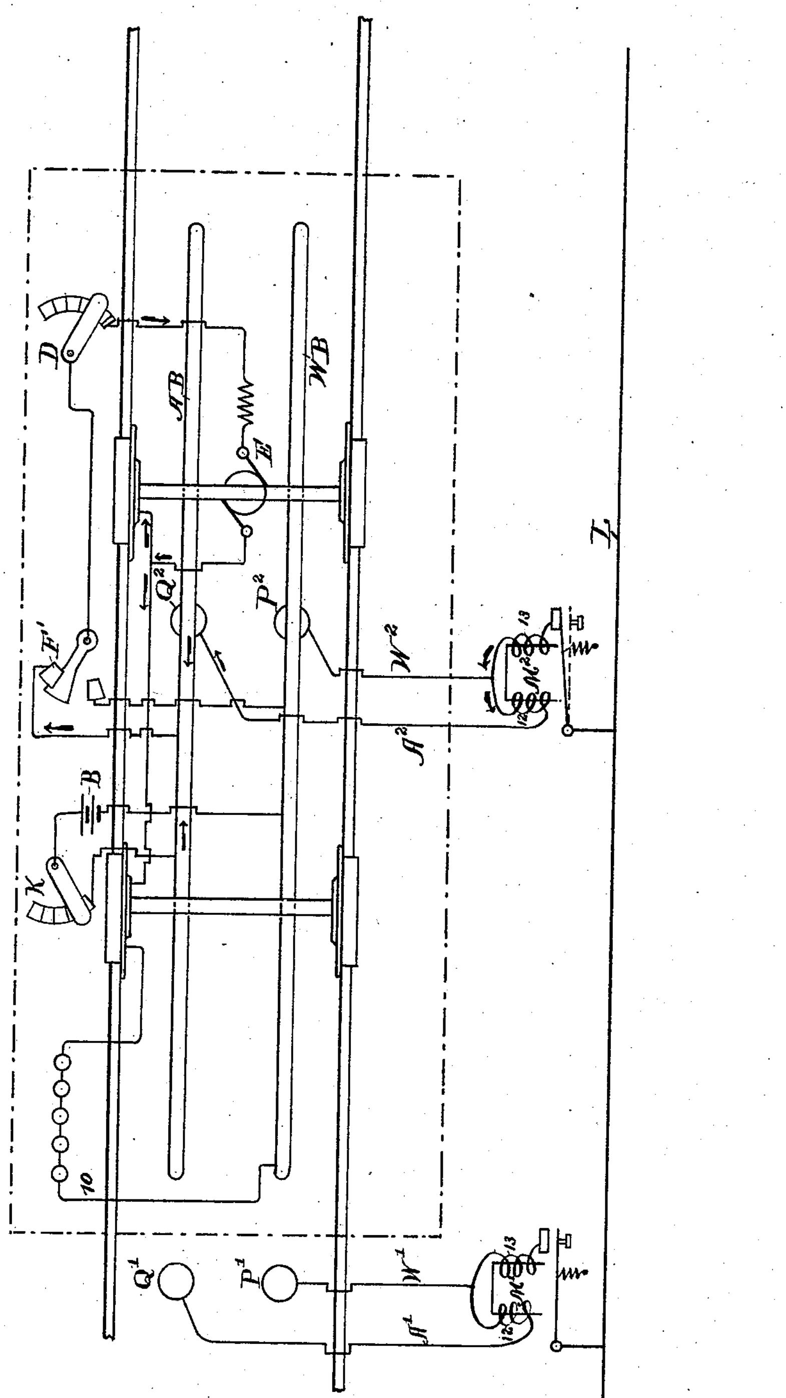
Fig. 4.



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UNITED STATES PATENT OFFICE.

ALBERT CUSHING CREHORE, OF ITHACA, NEW YORK.

ELECTRIC-RAILWAY SYSTEM.

SPECIFICATION forming part of Letters Patent No. 523,396, dated July 24, 1894.

Application filed July 20, 1893. Serial No. 481,067. (No model.)

To all whom it may concern:

Be it known that I, ALBERT CUSHING CREHORE, a citizen of the United States, and a resident of Ithaca, in the county of Tompkins and State of New York, have invented a certain new and useful Electric-Railway System, of which the following is a specification.

My invention pertains to an electric railway system in which a main conductor (hereinafter called the "line") supplies current from a stationary source to secondary conductors (hereinafter called "working conductors") suitably disposed along the line of travel; and in which the working conductors convey the current to a motor or motors upon a moving vehicle or car.

The object of my invention is to provide a practical method of operating electrical railways where the motive power is supplied from a stationary source to a moving vehicle or car, without necessarily resorting to the overhead wires with the unsightly poles which usually accompany them, and without having the element of danger connected to its operation which to-day exists where the overhead trolley wires are used.

My invention relates more particularly to systems wherein the moving vehicle or car derives its current successively from working conductors, each of which is automatically connected to the line as the car passes, and disconnected from the line when it has passed by the operation of a magnetic switch. It has heretofore been proposed in this art to use on the car a storage battery which should act, under certain conditions, to operate the magnetic switches and to provide means for charging said battery by current taken from the main line. It has also been proposed to use what I term auxiliary conductors which provide a path for the current energizing the switch magnets.

My present invention relates to a system in which these features are employed and consists, among other things in charging the battery with a shunted portion of the main or power current which circulates in the motor instead of with a current shunted around the motor, whereby I am enabled to use a low potential battery and keep the same charged without the use of wasteful resistance to cut down the main line potential as would be necessary if the battery were in a shunt around the motor.

In my invention, the battery, instead of being in a shunt around the motor is in a branch around the magnet.

My invention consists further in the combination with the series of working conductors, of a contact or contacts adapted to move from one section to another without break of circuit, a series of magnetic switches for connecting said section to a line, an auxiliary conductor over which the magnetic switches may be operated, and a storage battery in a branch of the power circuit on the car around said auxiliary conductor branch.

My invention consists also in the combinations of circuits and devices involving a storage battery charged from the circuit on the car for operating the switch magnets and an auxiliary conductor over which said magnets are energized either by the storage battery or by the power current as more particularly hereinafter described and claimed.

The working conductors may take a variety of forms. The essentials are that they have such forms and are so situated along the line of travel that one of the working conductors at least may be continually maintained in electrical connection with a conductor upon the moving car. For example, each of the working conductors may be a short conductor terminating at one end in a contact piece so situated as to engage a conductor upon the car as it passes over it, and terminating at the other end in an electro-magnetic switch, the purpose of which is to connect the working conductor, normally insulated from the line, to the line as the car passes. If the working conductors do thus terminate in contact pieces situated at intervals along the line of travel, a continuous conductor or brush (hereinafter called the "working brush") should be provided upon the car, so that of the line of contact pieces, one at least, may be continually in electrical communication with the car. Again, the working conductors may terminate in a series of insulated rail sections, each section constituting the terminal of one working conductor, the other terminal being in the electro-magnetic switch as before described for the purpose of connecting the working conductor to the line as the car passes on to that rail section.

In case the working conductors have the rail form it is sufficient that a trolley wheel or trolley wheels or short brushes (hereinafter called the "working trolley") be used upon the car for the purpose of continuously engaging one of the working conductors instead of using the long brush before described. In either case, whether the contact points are at intervals along the track and a continuous conductor upon the car to engage these contact points, or whether the continuous sectional conductor is along the track and contact points upon the car, the same purpose is subserved in maintaining a continual connection between the car and working conductors, and the same plan of making the electrical connections in the track and on the car may be used with each method.

It is immaterial where the "line" is placed with relation to the line of travel. It may be overhead or beside the vehicle or car but it is preferably buried within an insulating sheath or cable underneath the ground. In any position it must be insulated from the ground, or the conductor carrying the return current, and normally from the working conductors.

In addition to the line and working conductors I, by preference, employ a third set of conductors to go with the track construction, suitably arranged along the line of travel, and normally insulated both from the line and the working conductors. This third set of conductors I term the "auxiliary conductors." The auxiliary conductors may have different forms as is the case with the working conductors. For example, each auxiliary conductor may have one terminal in a contact piece somewhere along the line of travel so situated as to engage a conductor (hereinafter called the "auxiliary brush") upon the moving car; or each auxiliary conductor may terminate in one rail section so situated as to engage a trolley wheel or trolley wheels, or a short brush or brushes (hereinafter called the "auxiliary trolley") upon the moving car. It is important in my present invention to have this auxiliary brush or trolley upon the car insulated from direct contact with the working brush or trolleys upon the car. I say "direct contact" because there may be an indirect connection between them through the motor or motors upon the car. The object of this set of auxiliary conductors is to provide an independent path for the electric current from or to the car through the electro-magnetic switch situated in the track.

The use of the storage battery in the manner proposed by me makes it necessary to provide at least three distinct paths for the electric current; one from the line to and through the working conductors and thence to the car by any suitable trolley or collector; a second from the power circuit (either the line or its return) through the magnet of the switch; and the third directly to the ground or return from the car, and hence it is necessary to use at least one additional rail besides the ordinary rails on which the car runs. If one additional rail only be used, it is necessary to insulate one of the ordinary rails from the ground, and I hence prefer to employ a fourth rail in which case both the ordinary rails may be used as a return and neither need be insulated from the other.

In a simple form of my invention, the main motor current would first pass through the motor or motors on the car and suitable rheostat, and thence to a switch where the main current has either of two paths according to the position of the switch, one a divided path, in a branch including a storage battery to the return circuit, the other brach leading to the brush of the auxiliary conductor or rail and thence through the switch magnet to the return, the battery being, as will be obvious, in a branch around the magnet and being charged by a portion of the current which flows in the motor; the other path which is established by throwing the switch would be from the motor to the ground or return circuit, the storage battery being then left to work alone on the magnet by discharge through the same, until such time as the motor or power circuit may be again established through the auxiliary conductors. By this method of connecting the circuits it will be found that not only does the storage battery not become discharged so as to be rendered unavailable, but in addition the line may be continually kept in contact with the car when at rest as well as in motion, so that in case it is desired to light the car by electricity, the lights may be run from the working trolley as they are at present.

As will be hereinafter described the working or power circuit might be branched between the line and the motor instead of between the motor and return, the battery being in one branch and the switch magnet and auxiliary conductor in the other; the battery then, as before, being charged by a current due only to the difference of potential at the terminals of the branch containing the switch magnet.

In the accompanying drawings:—Figure 1, is a diagrammatic view illustrating a plan of a short portion of a road, having contact pieces placed at intervals along the road, and having a car thereon carrying the long conductors which are to engage the contact pieces, and showing the electrical circuits, connections, &c., made according to my plan. Fig. 2, is a diagrammatic view illustrating a short portion of road having rails divided into sections and having a car thereon carrying trolley wheels which are to roll upon these rail sections, and showing the electrical circuits, connections, &c., similar to Fig. 1, made according to my plan. Fig. 3, illustrates the same simplified. Fig. 4, illustrates diagrammatically the modification in which the power current which runs the motor is branched through the battery and switch magnet between the line and motor. Fig. 5, illustrates the same, simplified. Figs. 6 and 7, are diagrams illustrating the current and potentials under different conditions.

Referring to the drawings—R, R, represent the track rails—L, the line which is intended to be maintained at a constant potential difference with the rails R, R, or with the ground by means of the generators situated in the stationary power house or power houses—L, may be situated either above or below the surface of the ground.

W′, W², represent the independent sections of the working conductor terminating at one end in the contact pieces, P′, P², Fig. 1, or in the rail sections, P′, P², Fig. 2, situated at intervals along the road, and at the other end at the points S′, S², in the electro-magnetic switches M′, M².

M′, M², represent any kind of an electro-magnetic switch whereby one circuit may be opened or closed by means of the magnetic action of the current flowing in another circuit. The switch is normally open, as at M².

A′, A², represent the auxiliary conductors terminating at one end in the contact pieces Q′, Q², situated at intervals along the road, and at the other, after passing around the magnet of the electro-magnetic switch M′, or M², in the rails R, R, or what is the same thing in the ground.

WB, is the working brush or trolley carried by the car so as to engage the working conductors P′, P².

AB, is the auxiliary brush or trolley carried also on the car for the purpose of continuously engaging the auxiliary conductors Q′, Q².

Both of the brushes WB, and AB, are made long enough so that before one contact piece is left the next is reached, and thus there is never a time when no piece engages the brush.

From the working brush WB, a conductor leads to a rheostat D, or ordinary regulator for the motor, and thence to the motor and its field E, and next to a switch F. This switch may be set so as to turn the current from the motor off by either of two paths beginning at contacts G or H. The path from H, leads directly to the ground through N, and O, to the wheels of the car and the rails R, R; the path from G, immediately divides into two paths at J; one of these paths leads from J to T, and thence along the auxiliary brush AB, to contact piece Q′, and from Q′, to ground *via* A′, and the electro-magnetic switch M′; the other of these paths leads from J, through the storage battery B, to the switch and rheostat K, and thence to the ground through N and O. The rheostat serves to adjust the current of the battery. Although the rheostat is represented at K, in the storage battery branch, I do not limit myself to this method of adjusting the ratio of the currents in the two branches, viz. the storage battery branch, and the electro-magnetic switch branch. Either branch may include an adjustable resistance. In order that the action of this arrangement of the circuits may be more clearly set forth, I will describe the whole cycle of operations as they may occur, subject to the control of a man upon the car, while the car starts from any desired position.

Suppose the car is at rest in the position indicated in Fig. 1, and the connection between the line L, and the car is broken, the armature of the electro-magnetic switch being in the position *a′*, represented by the dotted line. The rheostat and switch at D, are set open, no current passing into the motor. The switch at F, is set as indicated, and the switch at K, is open. The first thing to do in order to start the car is to close the switch K. This closes a circuit through the storage battery B, and magnetic switch M′, allowing the current to flow as follows, discharging the battery:—from B to J and thence to T and Q′; from Q′ to the ground *via* A′ and M′; from the ground up at O, thence to N, to K, and back to B, again. The action of this current upon the electro-magnetic switch M′, is to close the circuit between the line and W′, moving the armature from the position *a*, to *a*². This puts the point P′, in connection with L, but no current will yet flow through W′, until there is some connection made between P′, and the ground. But the brush WB, is now charged to the potential of the line and will furnish a current to the motor when the switch D, is turned. Next the switch D, is set so as to allow the current to flow through the motor. At J, the motor current finds two paths by which it may go to the ground; so the motor current divides, part of it going through the storage battery in such a direction as to charge it, viz, from J to B to K to N to O, and part going through the magnetic switch M′, in the same direction in which the storage battery furnished the current before, viz:—from J to T to Q′, through A′ to M′ to R. The car now proceeds and at each section of working conductor the switch will be operated by the current flowing over the auxiliary conductor, and consisting either of a portion of the power current flowing from the motor, or in some cases of the power current reinforced by the current from the battery. As will be seen, however, the trolley or brush being constructed to preserve the connection in passing from one section of the working conductor to the next, the action of the switch magnet is normally caused by the main current and the battery is an auxiliary which will operate at any position, and it is not necessary, as in some prior plans, that the main line or power connection should break in order to establish a connection for the battery through the switch magnet.

Since the amount of current that flows in the branches of a divided circuit is determined by the relation between the resistances and the electro-motive forces in those branches, the following will make it apparent that this arrangement of circuits is extremely advantageous. Suppose, for instance, the resistance of the storage battery branch is R^b, and of the magnetic branch is R^m, and that the total current passing through the motor is I. If E, is the electro-motive force of the battery and I^b represents the current flowing through the battery and I^m, the current through the magnet switch, then a simple calculation shows that—

$$(1) \quad I^m = \frac{R^b}{R^m + R^b} I + \frac{E}{R^m + R^b}$$

and

$$(2) \quad I^b = \frac{R^m}{R^m + R^b} I - \frac{E}{R^m + R^b}.$$

If I is considered as the independent variable in these equations, I^m and I^b being dependent variables, all other quantities being constants, it is evident that each of the equations represents a straight line, as in Fig. 6. This figure shows how the branch currents change when the total or motor current varies. When the main current comes to be so small as that represented by the abscissa O Q, Fig. 6, then the current I^b, through the battery ceases, the total current passing through the magnetic switch. If the main current falls below the value O Q, the storage battery begins to discharge, the current going in the opposite direction through the battery, so that it keeps up the current through the magnetic switch even though the main motor current stops altogether or even reverses and the motor runs as a dynamo.

According to the equations (1) and (2) if R^b is small compared with R^m, the coefficient of I in equation (1) representing the tangent of the angle the line makes with the axis of abscissas, approaches the value zero; and the coefficient of I in (2) approaches the value unity, so that the lines of Fig. 6, are modified as in Fig. 7. This shows that the current I^m, operating the magnetic switch M, may be maintained constant independent of any variation of the main motor current.

As the current curve of a railway motor is usually of an extremely variable nature, it is probable that the current through the storage battery will frequently be reversed, but the system may be so designed that the battery will be charged as much as it is discharged, and thus is always ready for use. The switch at F, is provided so that in case the battery ever becomes overcharged the main motor current may go by the path H, to N, to O, directly to the ground. When this is the case the storage battery alone is used to operate the magnetic switch M, through the path B, J, T, Q′, A′, M′, R, O, N, K, B.

As illustrated in Figs. 4 and 5, the power current might be branched in its passage from the line to the motor instead of branching after passing the motor, one branch taking in coils of the switch magnet which operates said switch so as to close the connection between the line and working conductor, the other taking in the storage battery. The one branch which operates the switch is from the brush WB, which is normally charged with the main line potential being always in connection with a working conductor, to the contact P^2, when the car advances to connection therewith, thence through coils 12, on the magnet to the auxiliary contact and brush Q^2, AB, and thence through the switch F′, in the position shown to motor and to the return; the other branch is from WB, through a storage battery B, which is charged as before by a current due to the difference of potential at the terminals of the branch including the magnet coils; a switch K; thence to AB, and through the motor to the return. The two branches which start or diverge from WB, reunite in AB, and thence the current of both passes by way of the motor. This is more clearly seen in Fig. 5. As will be obvious the battery does not have to take a current corresponding to the whole difference of potential between the line and the return. The charging current may be determined by the resistance given to the switch magnet coils. Suitable switches and rheostates may be provided as before described. The switch F′, when turned from the position shown to the other contact opens the common return for the two branches just described and connects the motor directly to WB. The battery is left in connection across the brushes WB, AB, and may obviously operate in the manner before described.

Each switch magnet may have an additional coil 13, which will take the current flowing direct from L, through any working branch W′ or W^2, and hold the switch up, but this additional coil may be dispensed with.

As illustrated in Fig. 2, the working and auxiliary brushes of the car may consist of trolley wheels in pairs so as to preserve contact in passing joints, said trolleys running on lines of rails. The trolley wheels of WB, and AB, are so placed one in advance of another that the forward wheel may give the switch magnet of the advance section time to act before the rear wheel leaves its rail. The connections are the same as in Fig. 1.

A method of running lights on the car is indicated in Fig. 1. One terminal of the light circuit 10, connects to the working brush WB, the other to the return by way of the car wheels.

What I claim as my invention is—

1. In an electric railway system, the combination, substantially as described, of a series of working conductors, a series of electro-magnetic switches for connecting the same to the line normally operated by current taken from the power line, an auxiliary conductor over which the magnets for operating said switches are energized, and a storage battery in the car placed in a branch around the

switch magnet, and charged by a portion of the line power current which flows in the motor.

2. In an electric railway system, the combination, substantially as described, of a series of working conductors normally disconnected from the line, a series of electro-magnetic switches, an auxiliary conductor or conductors, electro-magnets for said switches connected to the auxiliary conductors, a power circuit through the motor, a branch of the power circuit completed over said auxiliary conductor, and a branch from the power circuit around the switch magnets containing a storage battery, as and for the purpose described.

3. The combination, substantially as described, in an electric railway system, of a sectional working conductor, electro-magnetic switches for connecting the same to the power line, an auxiliary conductor over which said switch magnets are initially energized, as the car progresses by current taken from the power circuit, a power circuit through the motor, a storage battery on the car charged in a branch from the power circuit, and connected to the auxiliary conductor, and switch devices for disconnecting said power circuit from the circuit of the auxiliary conductor and connecting it to the return direct, and leaving the storage battery connected to the auxiliary circuit.

4. In an electric railway system, the combination, substantially as described, with the series of working conductors, of a contact or contacts adapted to move from one section to another without break of circuit, a series of magnetic switches for connecting said sections to a line, an auxiliary conductor over which the electro-magnetic switches may be operated, and a storage battery in a branch of the power circuit on the car around said auxiliary conductor branch.

5. In an electric railway system, the combination with the sectional working conductor and magnetic switches therefor, of a car and its driving electric motor, a connection from one terminal of said motor to a circuit branched through a storage battery and the auxiliary conductor connection leading to a switch magnet, and a switch on the car placed in the motor connection and having two points as described, one connected to the branched circuit, and the other directly to the working circuit or its return, as and for the purpose described.

Signed at New York, in the county of New York and State of New York, this 14th day of July, A. D. 1893.

ALBERT CUSHING CREHORE.

Witnesses:
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THOS. F. CONREY.