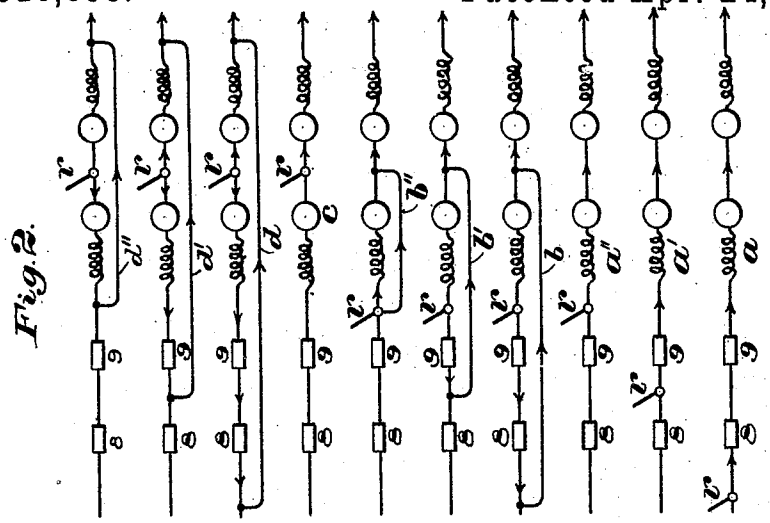
(No Model.) 2 Sheets—Sheet 1.

P. LANGE & B. G. LAMME.

CONTROLLING SWITCH FOR ELECTRIC RAILWAYS.

No. 518,693. Patented Apr. 24, 1894.

Fig. 2.



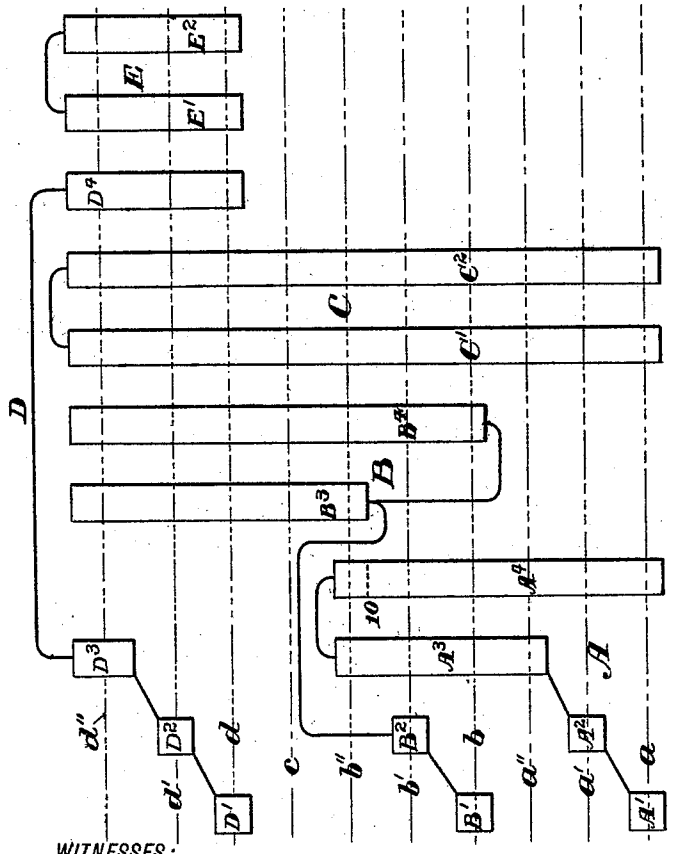
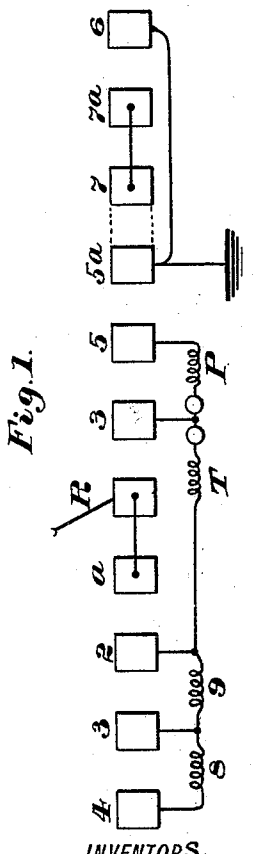


Fig. 1.



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(No Model.) 2 Sheets—Sheet 2.

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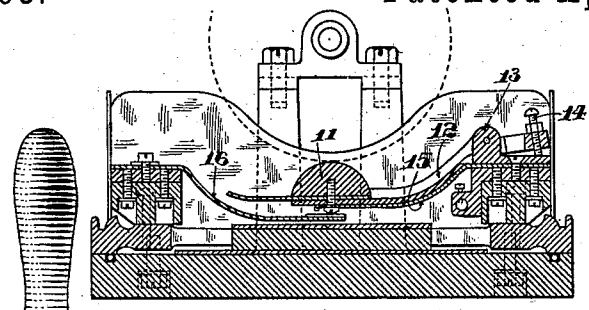

Fig. 3.

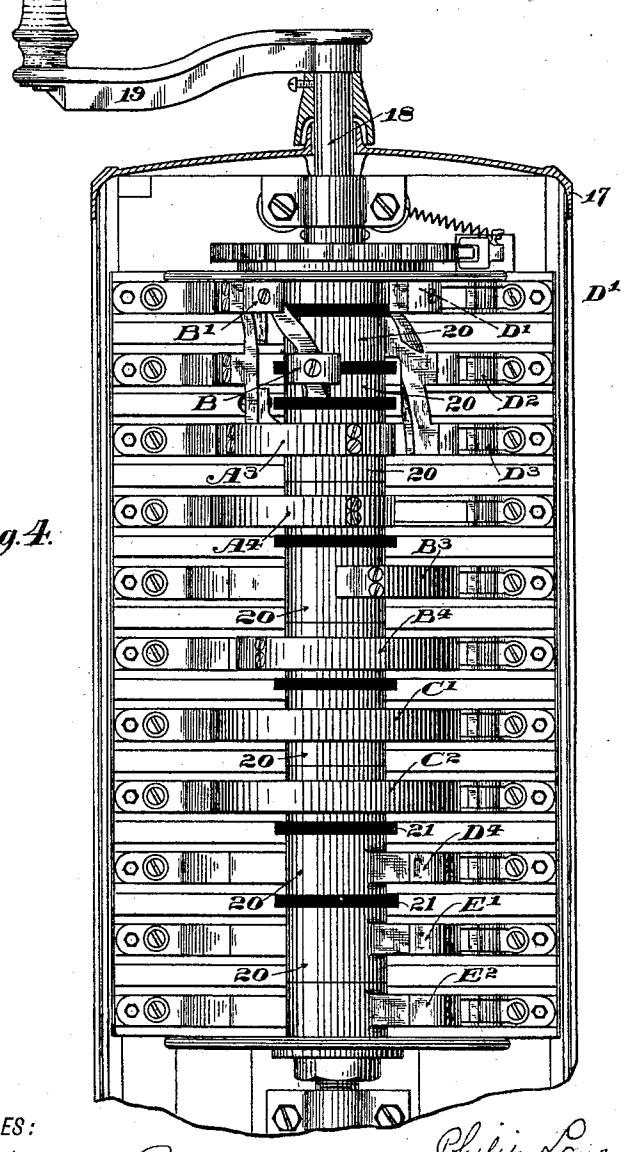

Fig. 4.

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UNITED STATES PATENT OFFICE.

PHILIP LANGE, OF NEWARK, NEW JERSEY, AND BENJAMIN G. LAMME, OF PITTSBURG, PENNSYLVANIA, ASSIGNORS TO THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, OF PITTSBURG, PENNSYLVANIA.

CONTROLLING-SWITCH FOR ELECTRIC RAILWAYS.

SPECIFICATION forming part of Letters Patent No. 518,693, dated April 24, 1894.

Application filed February 25, 1893. Serial No. 463,781. (No model.)

To all whom it may concern:

Be it known that we, PHILIP LANGE, residing in the city of Newark, county of Essex, State of New Jersey, and BENJAMIN G. LAMME, residing in the city of Pittsburg, county of Allegheny, State of Pennsylvania, citizens of the United States, have invented certain new and useful Improvements in Controlling-Switches for Electric Railways, (Case No. 539,) of which the following is a specification.

Our invention has relation to means whereby electric car motors may be controlled from either end of the car.

One object of our invention is the production of a controller having provision for the diminution of arcs when the same is operated.

Another object of our invention is the provision of a method of commutation whereby the driving motors may be changed from series to multiple arc connection without sudden jerks which might endanger the machinery; and may be restored thereafter from multiple arc to series connection without causing the violent arcing hitherto so frequently experienced.

Another object of our invention is the provision of means whereby the above ends may be reached with motors which are connected permanently in a series with any necessary resistances and at no time disconnected from each other at any point; thus when one motor is damaged, its use may be discontinued without employing any auxiliary devices for bridging said motor. By simply cutting the damaged motor out, the second motor may be utilized for driving the car.

Another object of our invention is the provision of means whereby one set of resistances permanently connected in a series with the two motors may be utilized in various ways with relation to said motors.

Another object of our invention is the provision of means whereby gradual speed changes are attained as above set forth without changing the ratio of magnetic power of armature to field-magnet in either motor.

Another object of our invention is to so connect the motors as to bring the heaviest strain due to inductive discharge on breaking circuit upon the field-magnets, thus relieving the armatures.

Our invention is illustrated in the accompanying drawings, in which—

Figure 1 is a diagrammatic representation of the movable strips and stationary buttons in their relation when circuit is not made together with an indication of the permanent connections existing between the stationary buttons and the motors and resistances. Fig. 2 shows the course taken by the current when the switch is in different positions. Fig. 3 is a transverse section of a preferred form of stationary button; and Fig. 4 is an elevation of our drum as preferably mounted by us.

In Fig. 1 are shown five strip systems, A, B, C, D and E, and eleven buttons co-operating therewith. As far as the essential working of our device is concerned only six buttons are necessary where two resistances are used as illustrated. Four groups of dotted lines are shown extending across the systems of strips to indicate the four groups of relative positions of buttons and strips assumed in changing the motor circuits. The various members of the strip systems are electrically connected as indicated. The button 1 is permanently connected to the trolley as indicated by the line R.

In Fig. 2 the line *r* indicates the electrical position of the trolley in all cases. The button 1^a is electrically connected to button 1, and the two might, if desired, be replaced by one button spanning two strips. The buttons 2, 3 and 4 form the terminals of the two part rheostat 8, 9. There might be any desired number of these resistances, which may be of any well known character. The button 2 is connected to one end of a permanently connected series composed of the field magnet and armature of the temporary motor T and the armature and field-magnet of the permanent motor P. If desired, the other end of this series might be permanently grounded, but such a form is not illustrated, as we prefer to use an arc dividing system which requires additional connections.

The temporary motor T is so called herein,

because it is not always in circuit during the time the car is being driven; the permanent motor is that which is so in circuit.

Of the remaining buttons shown, the button 3 is connected between the armatures of the motors, the button 5 is connected to the ground end of the motor series, the button 5^a is grounded and is electrically connected with button 6, while the buttons 7 and 7^a lie between 5^a and 6, and are electrically connected. These might indeed form a single button spanning two strips. It will thus be seen that the sole function of the strip systems is that of bringing the different buttons in connection with the trolley R in different orders, none of said strips being permanently connected to any outside apparatus. By sliding the strips over the buttons, or the buttons over the strips, they are brought into various relative positions, producing the desired changes; and, while in our drawings we have shown stationary buttons and movable strips, sliding over the same; we wish it understood that our invention comprehends broadly the relative movement of the buttons and strips, whichever remains stationary. In any case, all permanent exterior connections are made with the buttons.

We will first describe our method of commutation and then the application of our switch thereto.

In Fig. 2, ten different connections are shown, but the number may be increased or decreased by use of a greater or less number of resistances 8, 9. The essential changes reduce themselves to four, indicated by *a*, *b*, *c* and *d* in Figs. 1 and 2. Beginning with *a*, at the bottom of Fig. 2, the current enters at *r* and passes through both resistances and the two motors in series. The car is thus started with a small current. Positions *a'*, and *a''* are essentially the same, the resistances being dropped out one by one. The problem now arises, how to change the motors from series to multiple arc relation with one another. If this be done suddenly, the rush of current will cause danger to the armature and a violent jerk of the gears. One method of reducing this jerk is to weaken the field and then cut out the armature of the temporary motor, preparatory to putting it in multiple arc with the permanent motor. This, however, causes dangerous sparking at the commutator. Our method is to leave the two motors still in series, and maintain the ratio of field-magnet power to armature power constant in the temporary motor, but to gradually decrease the current flowing through said motor by introducing a shunt around the same, as shown in position *b*. In this position, the shunt includes both resistances 8, 9, in *b'* one is cut out, and at *b''*, the temporary motor is shown short-circuited. The next change is shown at *c*, where the motor T is entirely cut out, and only the motor P is driving the car. The motor T is being driven as a dynamo, and now tends to drive current in the opposite direction. In position *d*, this tendency is satisfied, and for the first time the two motors are in parallel. But both resistances are in series with the motor T, and the current taken by it is small. Position *d'* shows one resistance cut out, and position *d''* shows all resistances out, and the two motors in multiple arc with each other. The motors being series motors, the reversal of current in motor T will not affect the direction of its driving effect. It will thus be seen that by my method of changing there is no sudden change of effort in going from series to multiple arc, and correspondingly small tendency to create arcs at brushes and switches during the reverse change. The maximum tendency to this arcing is found between positions *c* and *d*, and we have made provision in our controller for further reducing all danger from this cause.

On inspecting the strips in Fig. 1, they will be found to be divided into five systems, the members of which are electrically connected. These systems we term herein the temporary series system A, used for carrying current to the temporary motor when in series; the permanent motor system B, used for conveying current to the permanent motor without passing through the motor T; the grounding system C, composed of two strips as shown, but which might be made in one broad strip, spanning two buttons; the temporary shunt system, conveying current to the motor T, when in parallel; and the arc dividing system E for obviating the difficulties attendant upon the arcs which may occur in passing from position *c* to position *d*. This last system is, of course, merely auxiliary and not essential. When not used, the buttons 6 and 7^a would also be suppressed. Indeed the grounding system C is also an arc dividing system for the arc which may occur on breaking circuit altogether at the controller; and by simply bringing strip D^4 in line with button 5, and removing strips C' and C^2, the grounding system may also be done away with.

If the relative position of strips and buttons indicated by the dotted line *a* be assumed, the circuit will be as follows: from trolley R to buttons 1 and 1^a, thence through system A to strip A', button 4, through 8, 9, T and P to the grounding system C and to ground by button 5^a. Through the positions in the *a* group the same connections will be made, save that the resistances will be gradually thrown out by contact first with A^2 at 3 and then with A^3 at 2. When position *b* is reached the permanent motor system first comes in play, to carry current to motor T, around motor T, while the system A still remains in play. The current, then, will divide at button 2, part going through both motors in series as before, and part going through the resistances 9 and 8, the strip B', by system B to button 3 and through motor P, only. Strip B^2 acts in position *b'* to cut out resistance 8; and finally, in position *b''* the current divides at the trolley buttons

1^a and 1, the motor T being then, however, short-circuited by system B, and practically all the current passing through motor P. If desired the plate A^4 need not overlap plate B^3, as shown, but may be cut off at dotted line 10. Position *b''* in Fig. 2 will then only occur during the short interval when the buttons, owing to their width, bridge between A^4 and B^3. Position *c* will carry current from trolley to button 1, thence through system B, to 3, through P to ground. Position D will then occur, when the current will divide at 3, most of it going through P to ground, and a less portion reversely through T, 9, 8, D', system D to D^4, 7, 7^a, E', E^2, 6, and to ground. Thus it will be seen that two extra contacts will be made at E' and E^2. It is for this reason that we have called E the arc-dividing system. It provides two extra breaks in moving from parallel connection to position *c*, and distributes the arc over so many more points, thus greatly diminishing its intensity and destructive effect. In position *d'*, strip D^2 cuts out resistance 8, and finally in position *d''*, the strip D^3 affords a path through T of no more resistance than that through P.

It will be seen that in systems A, B and D, a portion of the system is simply resistance strips, and there will be as many in each system as there are sections 8, 9 of resistance.

It is evident that wherever, in our switch contiguous strips are shown electrically connected, they might be made in one, and so broad as to cover two buttons. If the arc dividing system were done away with, buttons 6 and 7^a would be unnecessary, and buttons 7 and 5^a could be made one, as indicated by dotted lines. Indeed system C might, if desired, be taken out as above mentioned.

Although our invention contemplates the use of a drum or other sliding switch wherein either the buttons or strips are movable, we prefer to make the latter movable as shown in Figs. 3 and 4. Fig. 3 shows the form of button preferably constructed by me, wherein 11 is the contact piece or button proper. This is supported upon an arm 12, pivoted at 13, and provided with a stop, preferably a screw 14, whereby the forward movement of the button may be limited. The two springs 15 and 16, attached on opposite sides, bear on the button to press it against its proper strip, indicated in dotted lines in this figure. The proper number of buttons is supported in a line on the inside of a case 17, set preferably vertically at one or both ends of the car, and the shaft 18 may be turned by a handle 19, axially within this casing. Upon this axle are mounted sleeves 20, carrying offsets as shown, curved to a cylindrical surface as shown, and acting as strips, as indicated by lettering agreeing with Fig. 1. This construction is preferred to a solid drum, as it is lighter, but of course a drum carrying peripheral strips would be within our invention, and we will in our claims, use the term drum as including the construction shown in Fig. 4.

The various strip systems are insulated from each other by insulating washers 21.

In this specification and in the claims hereinafter we have used the term "connected permanently in a series" to indicate that the parts so connected are supplied with permanent conducting wires or parts which maintain a constant electrical connection of such a nature that if the terminals of a generator were applied at any two points in the system, the parts of the system between such points would be in series with the generator. The term "a series" is thus differentiated from the simple use of the word "series," which latter is ordinarily understood to imply some relation to a generator. The term "permanently connected in a series" relates to an arrangement of parts in a system of motors and resistances having no necessary relation to a generator, but coming under the definition above given.

Various obvious changes in detail may be made in this construction without departing from our invention.

What we claim is—

1. The method of controlling electric vehicles provided with two motors, which consists in the following steps:—connecting said motors in series; establishing a shunt around one of said motors; decreasing the resistance in said shunt, until said motor is short-circuited; cutting out said short-circuited motor; and finally putting said motors in multiple arc with each other, substantially as described.

2. The method of controlling electric vehicles provided with two motors, which consists in the following steps:—connecting said motors in series; establishing a shunt around one of said motors; decreasing the resistance in said shunt until said motor is short-circuited; cutting out said short-circuited motor; putting said motors in multiple arc with a resistance in series with one of them; and finally withdrawing said resistance, substantially as described.

3. The combination in an electrically propelled vehicle of two motors for propelling the same permanently connected in a series, and a series of resistances permanently connected in a series with said motors; with a series of buttons permanently connected with said resistances and motors, and a group of strips adapted to connect said buttons in various groups, substantially as described.

4. In an electrically propelled vehicle, a permanent motor and a temporary motor, permanently connected in a series, and resistances permanently connected in a series with said motors; in combination with a row of buttons, some of said buttons being connected to said motors and resistances, and some being connected to a source of current, means for grounding one end of said permanent series, and groups of switch strips cooperating with

said buttons to connect them in various groups, substantially as described.

5. In an electrically propelled vehicle, a permanent and a temporary motor, means for grounding one end of the circuits thereof, and a row of switch buttons, connected to said motors and to a source of current; in combination with a temporary series strip system, a permanent motor strip system, and a temporary shunt strip system, all cooperating with said buttons to connect them electrically in various groups, substantially as described.

6. In an electrically propelled vehicle, a permanent and a temporary motor, and a row of switch buttons, some of which are connected to the circuits of said motors, some to a source of current, and some to ground; in combination with a temporary series strip system, a permanent motor strip system, a temporary shunt strip system, and a grounding strip system, all cooperating with said buttons to connect them electrically in various groups, substantially as described.

7. In an electrically propelled vehicle, two motors for propelling the same, permanently connected in a series, in combination with a series of buttons permanently connected with said motors, and a group of strips adapted to connect said buttons in various groups, substantially as described.

8. In an electrically propelled vehicle, a permanent and a temporary motor for propelling the same, and a row of switch buttons, some of which are connected to the circuits of said motors, some to a source of current, some to ground, and some adapted simply for spanning arc-drawing strips; in combination with a temporary series strip system, a permanent motor strip system, a temporary shunt strip system, a grounding strip system, and an arc-drawing strip system, all cooperating with said buttons to connect them electrically in various groups, substantially as described.

9. In an electrically propelled vehicle, two motors for driving the same, permanently connected in a series and having their armatures next each other in the series, substantially as described.

10. In an electrically propelled vehicle, a permanent and a temporary motor permanently connected in a series, and switch buttons permanently connected with the circuits of said motors; in combination with switch strips comprising a temporary series system, and a permanent motor system, the two systems overlapping, substantially as described.

11. The combination in an electrically propelled vehicle of two motors for propelling the same, permanently connected in a series, and a series of resistances permanently connected in a series with said motors; with a row of buttons permanently connected with said resistances and said motors, and a group of switch strips cooperating with said buttons to place said resistances in various relations to said motors and to each of them, substantially as described.

12. In a controller for electric cars, a row of pivoted arms carrying buttons, and two springs, fastened at opposite sides of said buttons, and pressing them outward; in combination with switch strips cooperating with said buttons, substantially as described.

13. In a controller for electric cars, a rotatable axle, a series of conducting sleeves carried thereby, said sleeves being insulated from each other and from the axle, and a curved conducting strip carried by each sleeve; in combination with a row of switch buttons, adapted to cooperate with said strips, substantially as described.

14. In a controller for electric cars, a rotatable axle, a series of sleeves carried thereon, and curved projecting strips carried thereby; in combination with a row of switch buttons, adapted to cooperate with said strips, substantially as described.

In testimony whereof we have hereunto subscribed our names this 21st day of January, A. D. 1893.

PHILIP LANGE.
BENJ. G. LAMME.

Witnesses to signature of Philip Lange:
WILBUR B. EVEREST,
LOYALL A. OSBORNE.

Witnesses to signature of Benj. G. Lamme:
JAMES WM. SMITH,
HAROLD S. MACKAYE.