

No. 766,381.

PATENTED AUG. 2, 1904.

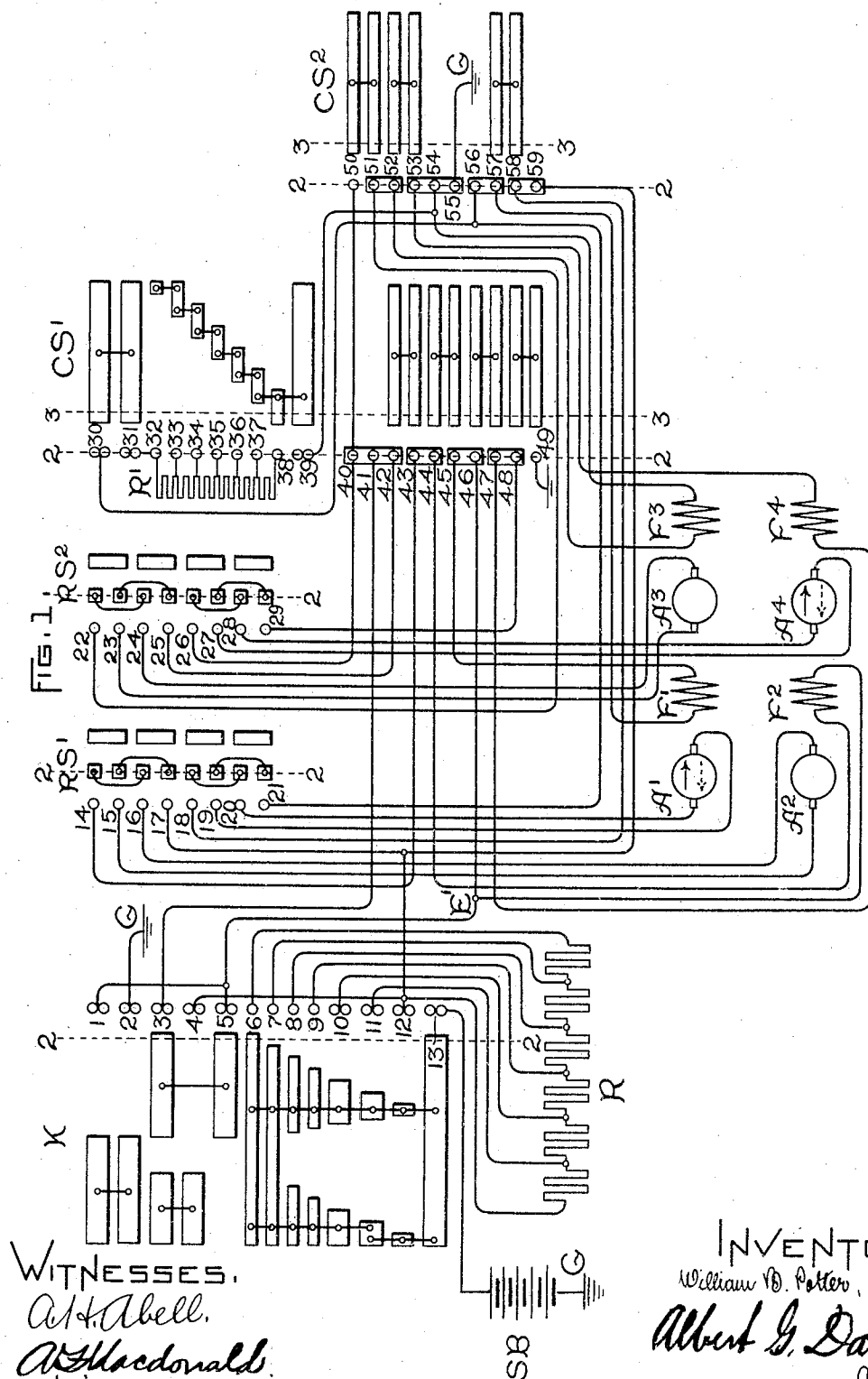
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APPLICATION FILED MAR. 3, 1898.

NO MODEL.

2 SHEETS—SHEET 1.



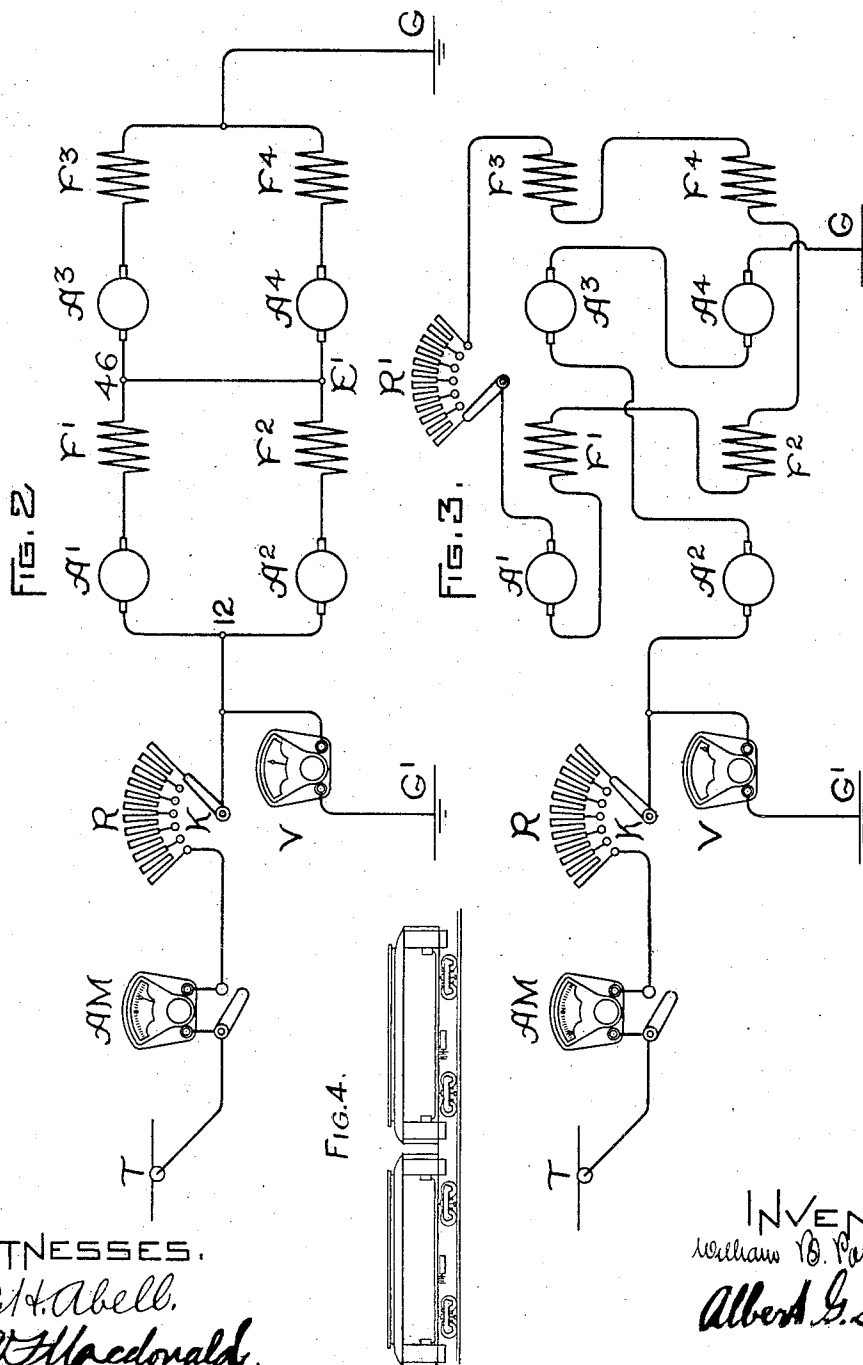
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UNITED STATES PATENT OFFICE.

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ELECTRIC RAILWAY AND CONTROLLING DEVICE THEREFOR.

SPECIFICATION forming part of Letters Patent No. 766,381, dated August 2, 1904.

Application filed March 3, 1898. Serial No. 672,348. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM B. POTTER, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Electric Railways and Controlling Devices Therefor, of which the following is a specification.

In the normal operations of electrically-equipped vehicles, and particularly in modern high-speed trainwork in which rapid acceleration and frequent stops are required, it has become necessary to employ after each stop enormous starting-currents, so as to secure the maximum permissible speed as rapidly as possible and thereafter to drift nearly to the point where the next stop is to be made and then to suddenly apply the brakes. The result of this practice, a practice rendered necessary by commercial requirements, is that each car or train takes at starting from the generating-station an amount of energy much more than sufficient to carry it past the next stop. A large part of such energy is therefore necessarily wasted in the brakes whether they are of the electrical or mechanical type. In addition any car or train which descends an appreciable grade receives thereby an inconveniently large amount of energy, which must be wastefully absorbed by the brake-shoes. In addition to the wastefulness of this practice it frequently becomes inconvenient and sometimes impossible to dissipate this energy with sufficient rapidity to keep the brake-shoes cool enough to run. It is obvious that these inconveniences would be avoided and great economy would be secured if the energy absorbed in retarding the car or train could be returned to the line. Various attempts have been made to accomplish this result; but they have been uniformly unsuccessful, for the reason that they have one and all involved the use of shunt-wound motors, which are not adapted to traction-work. My invention aims to return to the distributing system the energy absorbed, as above described, and though I have described it particularly in connection with electric traction systems it is not restricted thereto, but

is applicable as well to electric elevators and to other uses. One of its features consists in connecting motor-armatures in series when it is desired to return energy, so that their electromotive forces act to supply current to the line at a voltage in excess of that impressed thereon by the main generator or generators.

Another feature of my invention consists in converting the ordinary motors actually employed for traction-work into separately-excited generators when it is desired that they should return energy. Their voltage is thus made independent of their output.

My invention also consists in various connections and combinations to be hereinafter more particularly described and claimed.

The accompanying drawings show in Figure 1 a controlling device in which the connections for the practice of my invention have been embodied. Fig. 2 shows in diagram the first power-point of the controller. Fig. 3 shows the first point in which my invention is applied, and Fig. 4 shows a train of cars provided with motor equipments and supply-circuits and operated as indicated in the preceding figures.

The motors are shown as divided into two groups of two each. These two groups are operated as units in series or in parallel. The controlling device shown is one of the type in general known in the art as the "K" type—that is, one in which the step from the series position to parallel is taken by first shunting a part of the motors. This type is in general so well known that no extended description of the controller will be found necessary. In Fig. 1 this controller is shown developed at K. The contacts are divided into two general groups. The upper part of the controller contains contacts for grouping the motors. The lower part is a resistance-switch. The contacts on the right of the upper part of the controller arrange the motors in series. When the fixed brushes 1 to 5 pass the center of the developed contacts, they make contact with the plates on both the right and left side of the controller, and in this position one pair of the motors is shunted, and when the contacts on the right have passed so far as to be

out of circuit the motors are in multiple. In the same figure there is shown a reversing-switch RS' RS², and in addition I have shown a regulating-switch CS' CS². In the drawings this switch is developed in two parts; but it is to be understood that the part marked CS² may be on the same cylinder as CS', being arranged on the back of the cylinder. Other equivalent mechanical connection may be made. The first running position of the controller, as shown in Fig. 2, may be traced as follows, it being premised that the ammeter marked in Fig. 2 AM and the voltmeter marked V are not shown in Fig. 1, their application being too well known to require illustration. In this position the brushes of the switches K, CS', and CS² stand on the line 2 2 and the brushes of the reversing-switch RS' RS² stand on the left-hand line of contacts. Current enters the switch K from the source SB at contact 13, passing through the cross connection to the contact 6. Thence it flows through resistance R to contact 12. At this point the current divides, a portion passing from the contact 12 to the contact 59 on the switch CS², thence to contact 58, then back to contact 18 on RS', thence by cross connection to contact 20, to the armature A', to contact 19, by cross connection to contact 21, to contact 56 on the switch CS², thence through contact 57 to the field-magnet F', to the contact 45, and to contact 46. 46 is a point on the equalizer-wire 46E'. (Shown in diagram in Fig. 2.)

Returning now to contact 12 on the switch K it will be seen that a second path leads to contact 17 on RS', thence by cross connection to contact 15, through the armature A², to contact 16, thence by cross connection to contact 14, to contact 43 on the switch CS', to contact 44, through the field-magnet F² to the equalizer-point E'. Starting again at equalizer 46E', the current divides, a portion flowing through the contact 5 on the controller K, thence by cross connection to contact 3, to contact 41 on the switch CS', thence to contact 42, to contact 25 on the second portion RS² of the reversing-switch, by cross connection to contact 23, through the armature A³, back to the contact 24 on the reversing-switch RS², by cross connection to the contact 22, to contact 51 on the switch CS², to contact 52, thence through the field-magnet F³ to contact 54 and to ground at G. Returning now to the equalizer 46E', the second path is as follows: from E' to 5, to 3, to contact 41, thence to contact 40 and to contact 26 on the reversing-switch RS², thence by cross connection to contact 28, through the armature A⁴, back to contact 27, by cross connection to contact 29, to contact 48 on the switch CS', thence to contact 47, through the field-magnet F⁴, to contact 53 on the switch CS², through contact 55 to ground. It will be seen that the motors are thus connected in the position shown in Fig. 2 in two multiple

groups of two each, the two groups being arranged in series with the equalizer between. Further rotation of the controller K acts to cut out step by step the resistance R to shunt one motor and finally to connect the two multiple groups of motors in parallel, as already mentioned above. These changes form no part of my present invention and need not be more fully considered herein, since my invention may be applied to any preferred type of controller.

Suppose now that the controllers are in the position above described and that it is desired that the car shall begin to return energy. The controller K is thrown to the off position, thus breaking all the circuits, the regulating-switches CS' CS² are thrown to the line 3 3, and the switch K is again closed. The connections are then as shown in Fig. 3. With this arrangement it will be seen that the armatures A², A³, and A⁴ are connected in series across the line and that the armature A' acts solely to furnish current to the field-magnets of all four motors, the magnitude of this current, and therefore the excitation of the motors, being controlled by the resistance R', connected to the upper portion of the switch CS'. It thus appears that the three motors A² A³ A⁴ will act as separately-excited generators to return energy to the line. The voltage at which the current is returned to the line may be controlled by manipulation of the switch CS', while the amount of current returned may also be regulated by the resistance R of the controller K. It will be noted that the armature A' has been reversed. This is done as in any case in which it is desired that a series motor shall be turned into a series generator and shall continue to have current flow through its armature in the same direction as before.

It will be noted that upon closing the switch CS' for the generating position the switch K has first been opened. The result is that the field-magnet F' has been deprived of current and must build itself up by its residual magnetism, as in the case of any series-wound machine. The switch K should not again be closed to return energy to the line until the voltage of the three armatures A² A³ A⁴, connected in series, as indicated by the voltmeter V, is greater than the line-voltage. In the first braking - point the circuit may be traced as follows, remembering that the controller K stands on the line 2 2 and that the reversing-switch RS' RS² bears on the left-hand contacts and that the switches CS' CS² are thrown to the line 3 3. Starting from the left-hand brush of the armature the current passes to contact 20 on the reversing-switch RS', to contact 18, to contact 58 on the switch CS², to contact 57, then through the field F' to contact 45, to contact 44, through the field F², contact 46, contact 47, through field F⁴, contact 53, contact 52, through the field F³, con-

tact 39, contact 21, contact 19, and back to the other side of the armature A'. This is the circuit of the four field-magnets and the armature A'. It will be apparent that the further motion of the switches CS' will gradually cut out the resistance R.

The circuits of the three generating-armatures may be traced as follows: Starting from the left-hand brush A⁴, current passes to contact 28, to contact 26, to contact 50, contact 51, contact 22, contact 24, through the armature A³ to contact 23, contact 25, contact 42, contact 43, contact 14, contact 16, through the armature A², contact 15, contact 17, through the resistance R to contact 6 upon the controller K, to contact 13, to the source SB, returning from ground at contact 49, then to contact 48, contact 29, contact 27, and so to the other side of the armature A⁴. Any further rotation of either the switch K or the switch CS' will now affect the amount of energy returned to the line, as above explained. The control of output is thus rendered perfect, inasmuch as the strength of the fields and the resistance of the line-circuit may be independently regulated. By this means the best results from my invention may be obtained, it being for this purpose desirable to keep the voltage at just such a point as will return the maximum current to the line without undue retardation of the train.

It is of course to be understood that when the speed of the car has been so reduced that the electromotive force of the armatures A², A³, and A⁴, with the highest possible field excitation, is too low to permit the further return of energy the switch K will be opened.

While of course the line conductor or trolley system, as indicated conventionally at T in Figs. 3 and 4, is the specific system to which the invention is commercially applied, a storage battery may be used as the source of current, and such a source is intended to be comprehended by the representation at SB in Fig. 1.

When the car is to run backward, the reversing-switch RS' RS² is thrown to the right-hand row of contacts. In this position manipulation of the controller K will control the speed of the car, while the proper manipulation of the regulating-switches CS' CS² will cause the motors to return energy, as above described.

In the use of my invention the voltmeter V and the double-scale ammeter AM (shown in the diagram in Figs. 2 and 3) should be carefully watched by the operator. It is obvious that the main circuit should be kept open when the switches CS' CS² are in the generating position before the motor A' has built up its own field and the fields F² F³ F⁴ sufficiently to cause the electromotive force generated by the three armatures in series to be sufficient to return energy, or after the

speed of the motors has decreased to such an extent as to render the returning of the energy impossible. This may be accomplished by intelligent use of the switch K.

So far as I am aware, I am the first in the electric-railway art to combine motors acting as generators so that their electromotive forces act summatively to return current to the line at a voltage equal to or in excess of that supplied by the power-generators. I am also the first to combine motors as momentum-driven separately-excited generators or as generators having independent field and armature control, so that both voltage and output may be regulated.

In the use of my invention it will be found that the current requirements of a long line operating where grades or stops are frequent will be materially reduced, as the trains or cars which are coming to a station or running downgrade will supply a considerable percentage of the power needed in operating other trains which are still running at speed or are just starting.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. The combination of a number of electric motors, adapted to act as momentum-driven generators, and means for connecting them to the supply-circuit so that their electromotive forces may act summatively to supply current thereto.

2. The combination of a number of electric motors, with a controlling device having contacts for connecting some of the motors in series in the supply-circuit, and for regulating the voltage of the current supplied by their armatures.

3. The combination of a number of electric motors acting as momentum-driven generators, with means for supplying all the fields from one of the armatures, and means for connecting the other armatures in series to the supply-circuit.

4. The combination with the armature and field-magnet of a dynamo-electric machine, of means for connecting the field and armature to line, and for connecting the armature to line and the field to a separate source of current, at will.

5. In an electric railway, the combination of a number of electric motors acting as momentum-driven separately-excited generators, with means for regulating the field and armature currents.

6. In an electric-supply system, the combination of a number of electric motors acting as momentum-driven separately-excited generators, having some of their armatures connected in series in the supply-circuit, with means for simultaneously regulating the fields of the motors.

7. In combination, a number of motors acting as momentum-driven generators having some of their armatures connected in series

in the supply-circuit, a source of current energizing all the motor-fields, a regulating resistance in the field-circuit, and a regulating resistance in the line-circuit; whereby the voltage and output may be independently controlled.

8. In combination, in an electric-supply system, a number of motors acting as momentum-driven generators, a switch for connecting all of the fields to one of the armatures and for connecting the remaining armatures in the supply-circuit, a regulating resistance for regulating the fields controlled by the switch, and means for regulating the resistance of the armature-circuit.

9. The combination of a plurality of electric motors geared to the axles of a moving vehicle or vehicles, and a circuit including the field-windings of all the motors and the armature of one of them.

10. The combination of a line-circuit, a plurality of series-connected dynamo-electric machines geared to the axles of a moving vehicle or vehicles, and adapted to be electrically connected with said line-circuit, and means dependent upon the speed of said vehicle or vehicles for exciting the fields of said dynamo-electric machines.

11. The combination of a line-circuit, a moving vehicle or vehicles, a plurality of dynamo-electric machines geared to axles of said vehicle or vehicles and all receiving energy derived from said line-circuit, means for exciting the fields of all the machines by current derived from the armature of one of them.

12. The combination of a plurality of dy-

nämo-electric machines and a circuit-changing device for adapting some of them to act either as series-wound motors or as separately-excited generators.

13. The combination of a plurality of dynamo-electric machines and means for adapting some of them to act as separately-excited generators, or all of them to act as series-wound motors.

14. In an electric-railway system, the combination of a line-circuit extending along the railway, a railway-vehicle, a direct-current dynamo-electric machine geared to wheels of said vehicle, electrical connections between said line-circuit and the armature of said direct-current dynamo-electric machine, and other electrical connections between the field of said direct-current dynamo-electric machine and a source of current other than said line-circuit.

15. In an electric-railway system, the combination of a source of direct current, a railway-track, a line-circuit connected to said source of direct current and extending along the track, railway-vehicles on said track, dynamo-electric machines carried by said vehicles and geared to wheels of said vehicles, and another dynamo-electric machine driven through motion of said vehicle for exciting the fields of said dynamo-electric machines.

In witness whereof I have hereunto set my hand this 2d day of March, 1898.

WILLIAM B. POTTER.

Witnesses:

B. B. HULL,
G. HAYNES.