No. 610,445. Patented Sept. 6, 1898.

J. C. HENRY.

ELECTRIC RAILROAD.

(Application filed June 30, 1898.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1

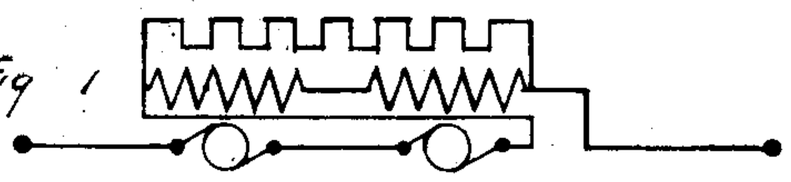


Fig. 2.

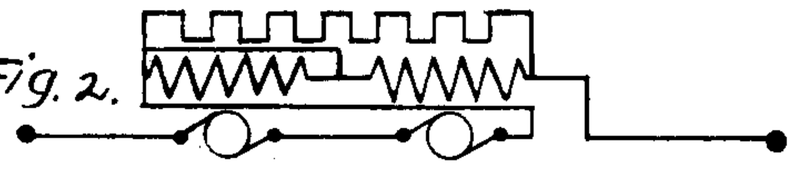


Fig. 3.

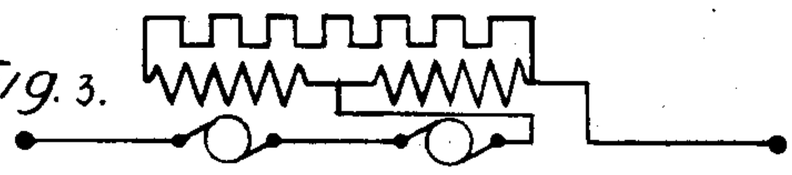


Fig. 4.

Fig. 5.

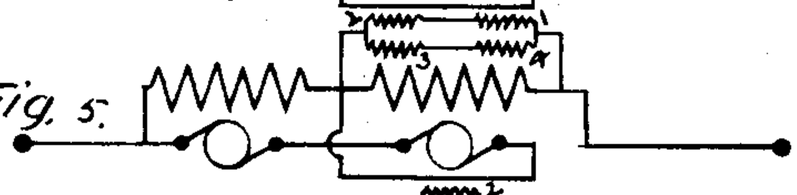


Fig. 6.

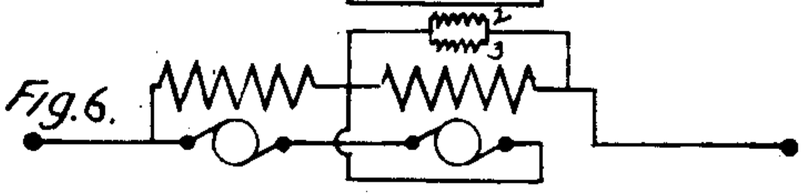


Fig. 7.

Fig. 8.

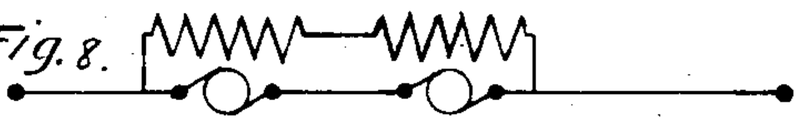


Fig. 9.

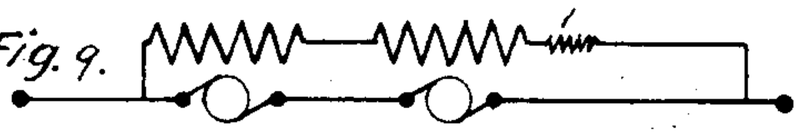


Fig. 10.

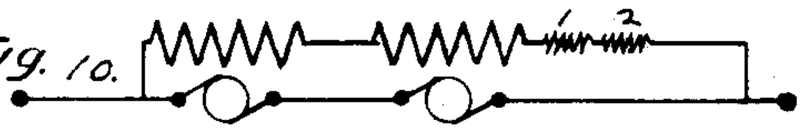


Fig. 11.

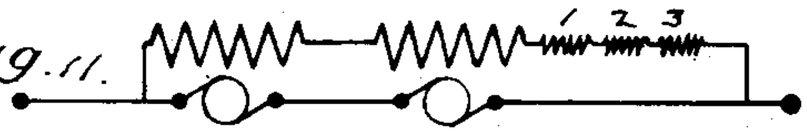


Fig. 12

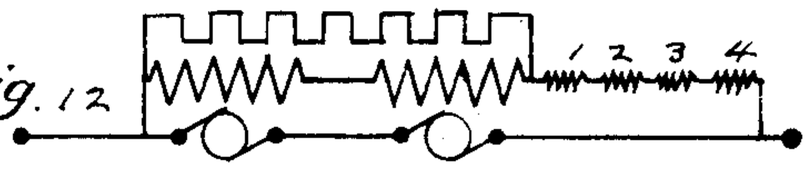


Fig. 13.

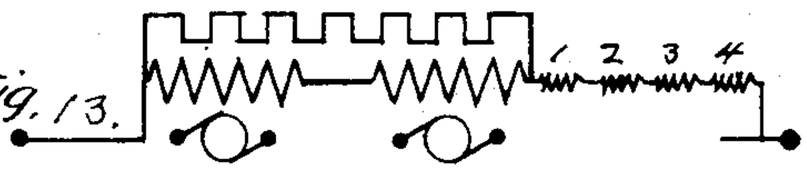


Fig. 14

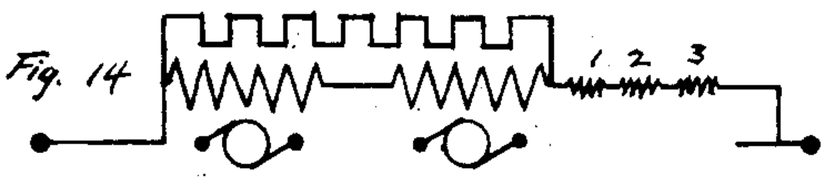


Fig. 15.

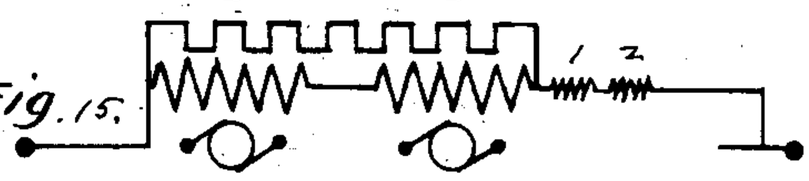


Fig. 16.

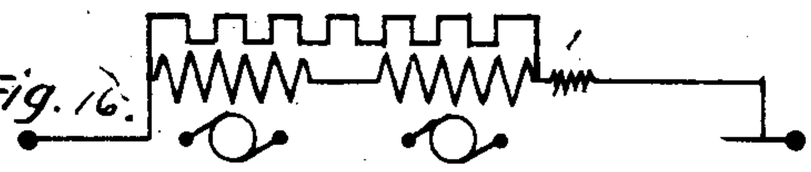


Fig. 17.

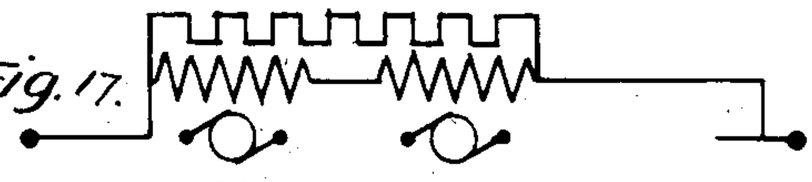


Fig. 18.

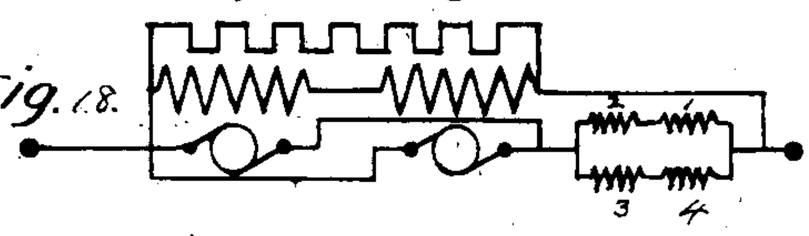


Fig. 19.

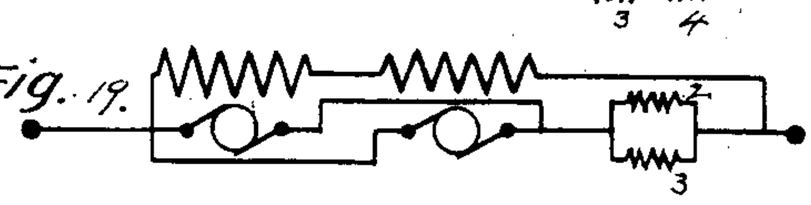


Fig. 20.

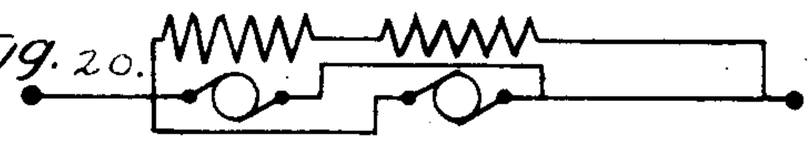


Fig. 21.

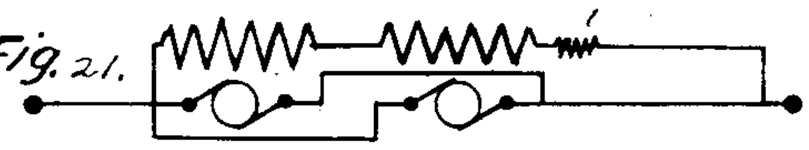


Fig. 22.

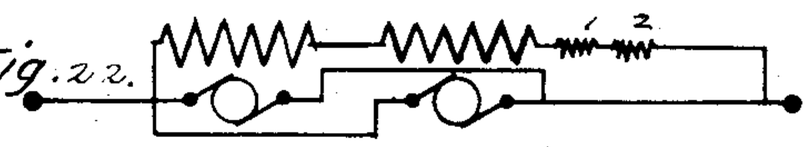


Fig. 23.

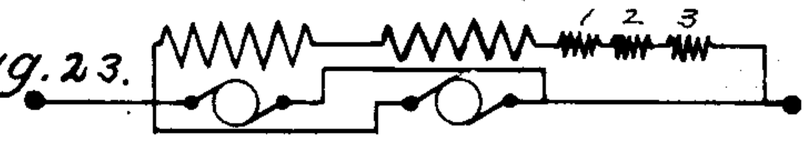


Fig. 24.

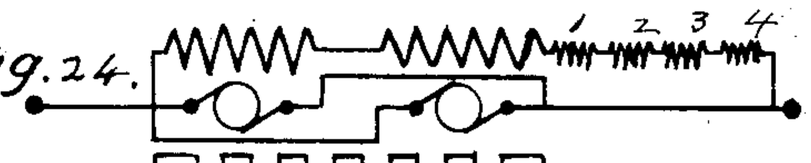


Fig. 1A.

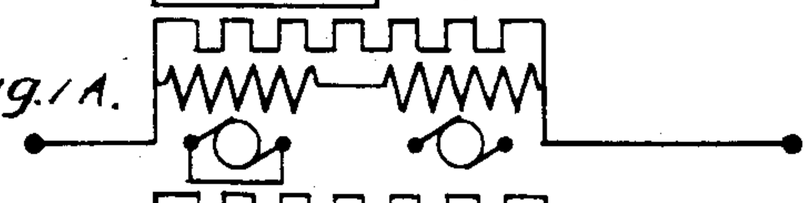
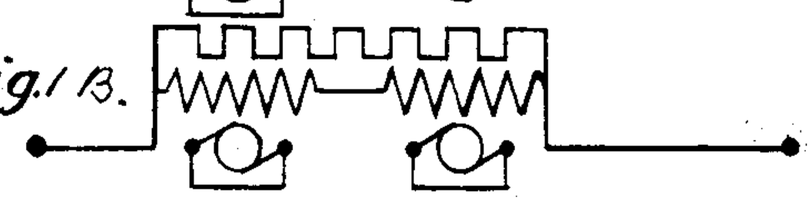


Fig. 1B.



Witnesses
Gerald Alley
Geo. Sandt

Inventor
John C. Henry

No. 610,445. Patented Sept. 6, 1898.

J. C. HENRY.

ELECTRIC RAILROAD.

(Application filed June 30, 1898.)

(No Model.) 3 Sheets—Sheet 2.

Fig. 27.

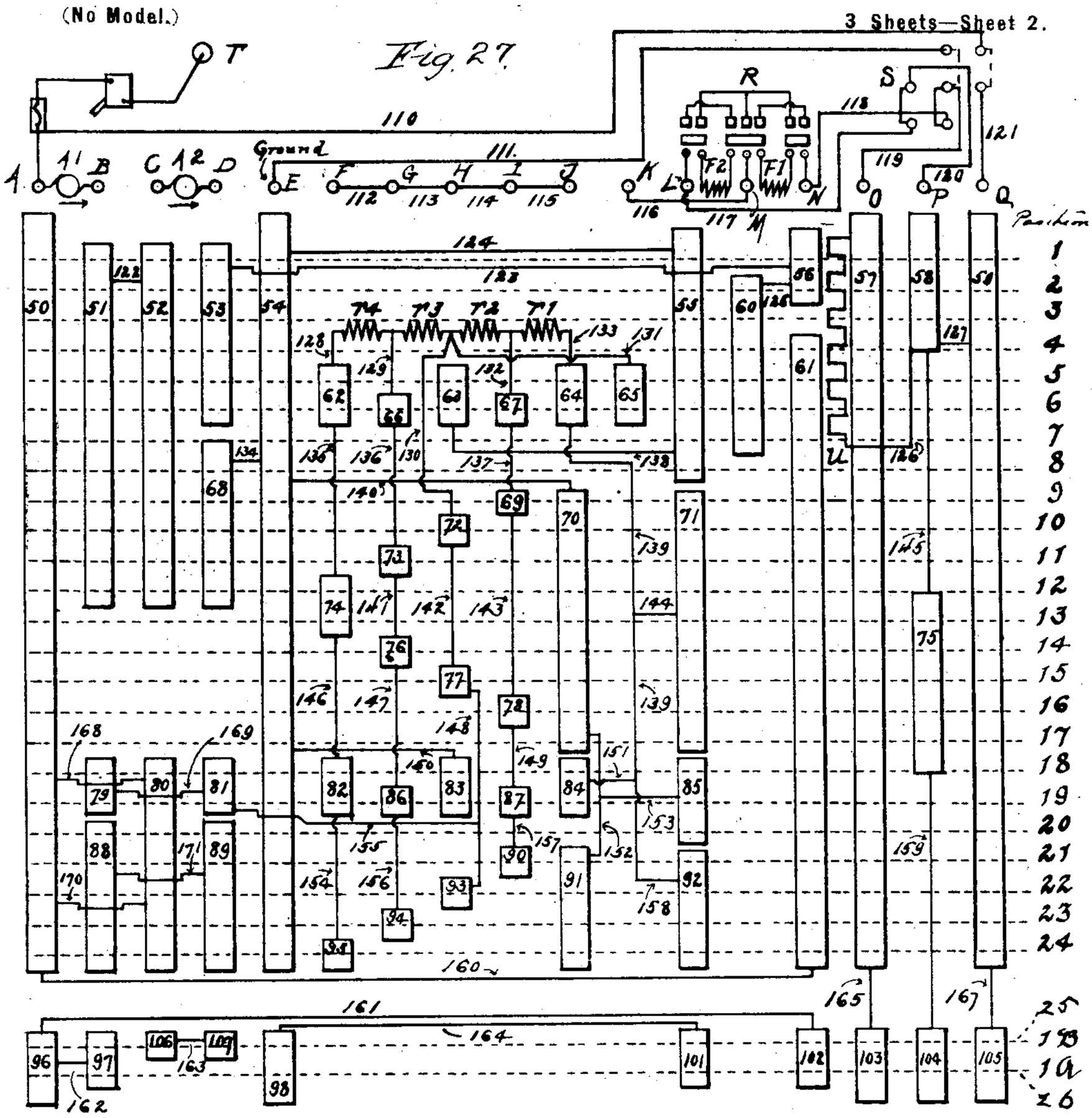
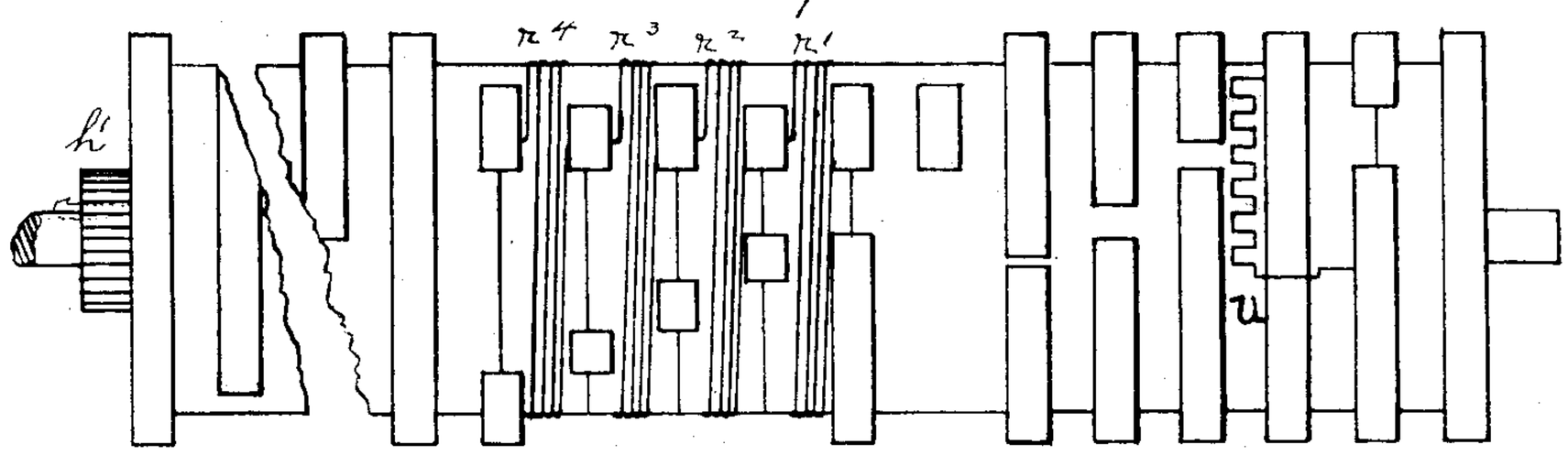


Fig 25



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(No Model.) 3 Sheets—Sheet 3.

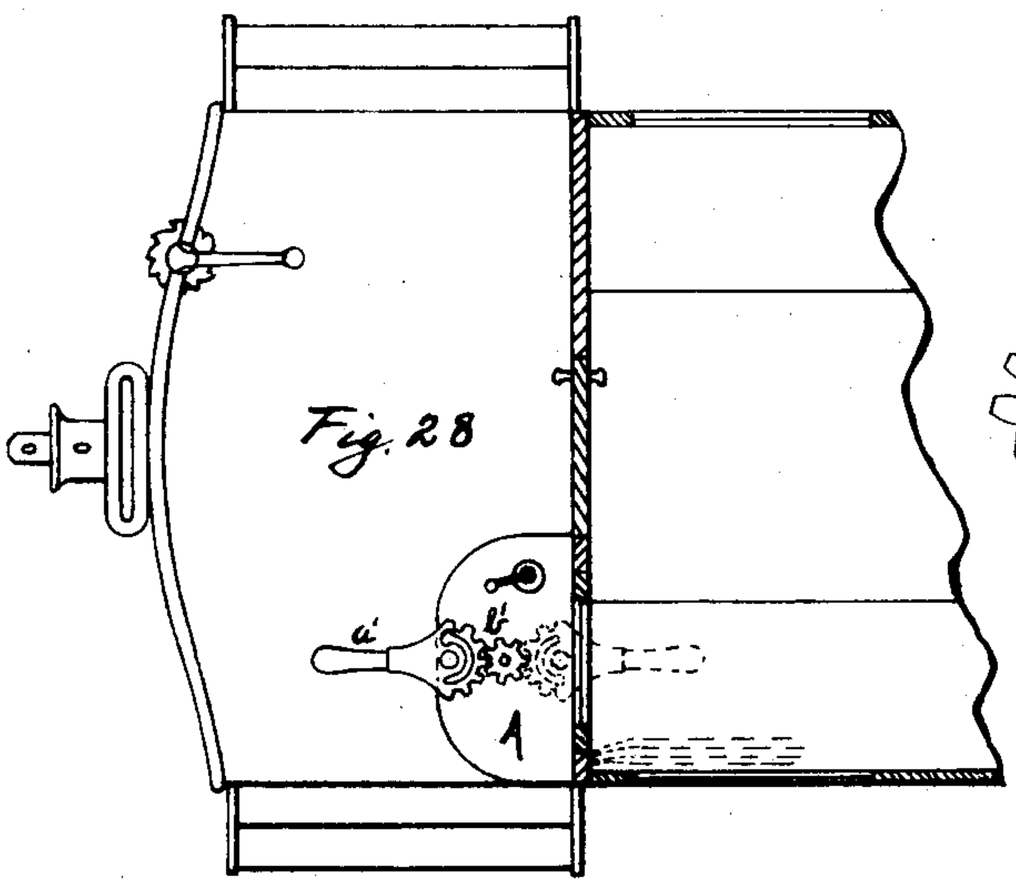


Fig. 28

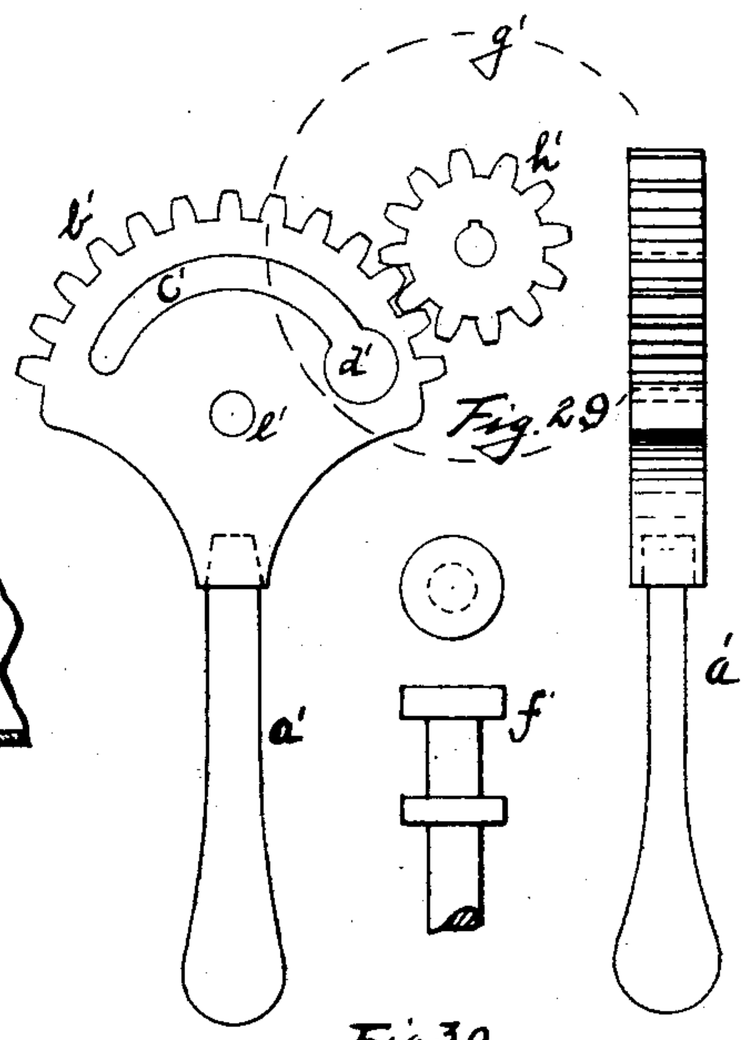


Fig. 29

Fig 30

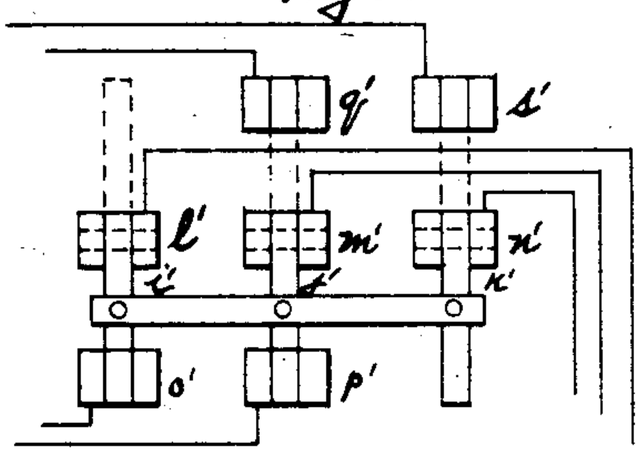
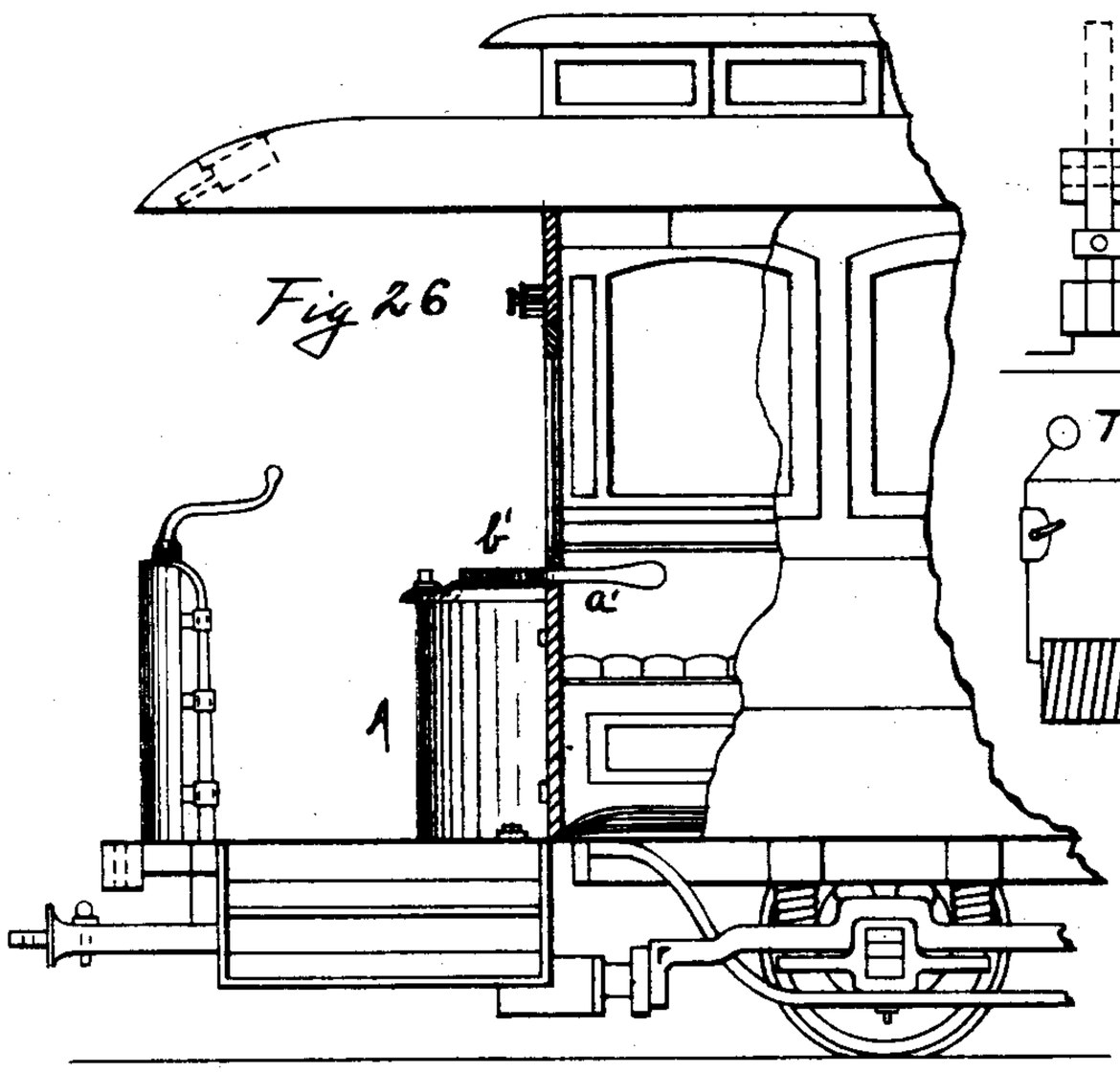


Fig 26



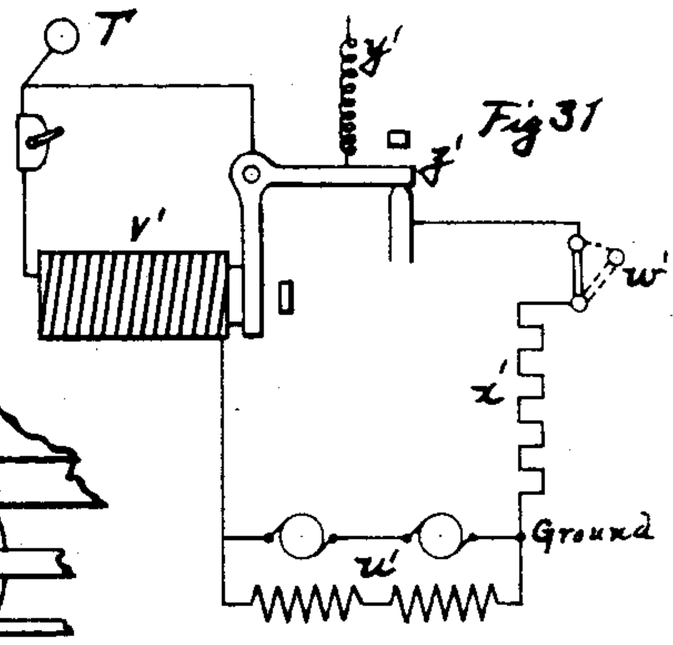


Fig 31

Witnesses
Gerald Alley
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John C. Henry

UNITED STATES PATENT OFFICE.

JOHN C. HENRY, OF DENVER, COLORADO.

ELECTRIC RAILROAD.

SPECIFICATION forming part of Letters Patent No. 610,445, dated September 6, 1898.

Application filed June 30, 1898. Serial No. 684,989. (No model.)

To all whom it may concern:

Be it known that I, JOHN C. HENRY, a citizen of the United States, residing in Denver, county of Arapahoe, and State of Colorado, have invented certain new and useful Improvements in Electric Railroads, of which the following is a specification.

The invention relates to various improvements in electric railways; and it consists principally in novel arrangements and connections for controlling and protecting a pair of motors employed in the operation of an electric car and also in means for operating the controller from different locations on the car. The controller is of the regenerative type—such as is described in my Patent No. 597,374, of January 11, 1898—wherein the energy of momentum or of gravity is recouped and the car braked.

The improvements consist of means for starting the car very slowly and gradually accelerating the same without external or dead resistance, means for absorbing or eliminating the high-tension discharge from the field-magnets when their circuit is broken, means for employing the resistance ordinarily used in series with the fields also in parallel in the armature-circuit, means to protect the motors from lightning, and also means for locating and arranging the controller so that it may be operated from either the front platform or from the inside of the car.

In the drawings, Figure 27 represents a development of the controller. Fig. 25 represents a plan of the same. Figs. 1 to 24 and also 1^A and 1^B represent diagrams of the arrangement of circuits under the different positions of the controller. Fig. 26 represents in side elevation the platform of an electric car, showing the position of the controller and the arrangement of the operating-lever when used on the inside. Fig. 28 shows a plan of the car and the arrangement of the controller-lever when operated from the outside of the car. Fig. 29 shows an enlarged view of the controller-handle and its connection with the controller-cylinder, with detail views. Fig. 30 is the preferred form of switch referred to at S in the development-sheet. Fig. 31 is a modification of the switch which may be applied to any form of electric cars.

In ordinary practice the controller is attached to the dash of the street-car. This gives it an unstable support, exposes it to danger in collisions, permits the rain and snow to fall upon it, and the location usually necessitates cutting through and weakening the end sills to accommodate the passage of the wires from the motor to the controller. Where temporary vestibules are employed, the brake-handle and controller must be moved inward, as car construction will not permit the vestibule to project beyond the dash. In order to protect the motorman from storms, the municipal authorities generally require railway companies to provide their cars with vestibules during the winter months. During said months their use is generally objectionable; but there are times when the motorman suffers without protection. To accommodate this variable condition and to entirely avoid the objectionable vestibule, I arrange my controller so that it may be operated from either outside or within the car. The general plans are shown in Figs. 26 and 28.

In the operation of electric roads one of the most injurious agencies is lightning. The problem of furnishing a path for the lightning to pass through without leaving a carbonized path for the large line-current to follow and enlarge has not yet been completely met. To protect motors during lightning storms, I arrange, through the agency of a supplementary switch, to place a non-inductive resistance in parallel with the motors, its quantity capacity being sufficient for the high-potential lightning discharge, while the armature and field-magnets act as choke-coils, preventing the lightning from passing through them. The supplementary switch is shown in detail in Figs. 30 and 31. It is intended to be connected during storms only and is so connected with the controller that it absorbs current from the line only when the car is running.

In starting the motors or running at slow speed I arrange to decrease the current by passing it through the high-resistance field-magnets, which are placed in series with the armature, thus avoiding the use of dead resistance. To accelerate, I change the field-magnets dissimultaneously from series to shunt, being careful at the same time to avoid breaking the main circuit.

In making the transitory change of the armatures from series to parallel I prefer to provide means for connecting the armatures in

parallel in steps, using the resistance ordinarily employed in regulating the field-magnets for this purpose; but to avoid heating and to afford greater carrying capacity I divide the current through the resistance in parallel.

In the diagrams the armature and field-magnets represented on the left side will be referred to as belonging to motor No. 1, while those on the right side will be referred to as belonging to motor No. 2.

In order to make the controller more compact and to avoid the numerous flexible connections between the resistance and the controlling-cylinder, I prefer to mount the resistance-conductors directly on the cylinder, as shown in Fig. 25.

In order to insure that the circuit is open within the controller when the handle is removed and to insure placing it in connection with the cylinder in its proper relation, I arrange a slot on the circular geared rack, which engages a stud, the former being removable therefrom only at the enlarged opening, which corresponds with the off position on the cylinder.

In the development Fig. 27, the different changes in the controller are completed on the dotted lines which lead to the different position-numbers on the right hand of the sheet, which are numbered consecutively from 1 to 26. The resistances r', r^2, r^3, and r^4 are located within the controller-cylinder, as is also the non-inductive resistance. On the top of the drawings, T represents the trolley, and R the reverse-switch. A′ represents armature No. 1, while A^2 represents armature No. 2. F′ and F^2 represent the corresponding field-magnets. S represents a switch in the non-inductive circuit.

The general scheme is to first start the motors as series machines in series and gradually change them to shunt or independently-excited machines without breaking the armature-circuit. To protect the motors from the injurious high-voltage "back kick," which is liable to occur whenever from any cause the circuit is broken, I in all cases arrange a path to accommodate it, which is of lower resistance than the insulation between the fields and the ground. In ordinary cases this path is through the armature; but where the armature-circuit is to be broken I place resistance in parallel with the field, so that in the event of the line-circuit being broken at that instant the back kick would be discharged through the resistance referred to. For this and the other purposes to be described I prefer to use the same resistance and have it wound non-inducting. Previous to breaking the field-circuit I place the non-inductive resistance in parallel with the field to protect it from the back kick. For use during lightning storms I arrange this same non-inductive resistance in parallel with the motor through the aid of the supplementary switch S.

In position No. 1 the circuit is completed through the motors, as shown in the diagram Fig. 1. The current passes from the trolley T, through armature No. 1, to contact B, thence to cylinder-contact 51, through connection 122 to cylinder-contact 52, thence to contact C, through armature No. 2 to contact D, cylinder-contact 53, through connection 123 to cylinder-contact 56, to contact N, thence through reverse-switch R, through fields 1 and 2 to contact L, thence to cylinder-contact 55, connection 124, cylinder-contact 54, to contact E, to the ground, thus connecting both armatures and field-magnets in series between the trolley and ground. In this position the non-inductive resistance U is connected in parallel with the field-magnets by cylinder-contacts 57 and 58 engaging contacts O and P, thence through switch S to contacts L and N, which (through reverse R) are connected to the field-terminals.

In position No. 2, as shown in diagram No. 2, the only change is in short-circuiting field No. 1. This is accomplished by connecting the terminal of field 1^m to the other terminal of the same field at N through cylinder-contact 60, connection 125, and cylinder-contact 56.

In position No. 3, as shown in diagram 3, field No. 1 is broken by contact N leaving cylinder-contact 56.

In position 4 field No. 1 is connected to the trolley, as shown in Fig. 4, by contact N engaging cylinder-contact 61, thence through connection 160 to cylinder-contact 50, to contact A, to trolley, the non-inductive resistance being dropped from the circuit by contact P leaving cylinder-contact 58.

Position 5 compares with the diagram 5. It is the same as position 4, except an additional circuit of resistance in parallel is connected in parallel with field No. 2. This is accomplished as follows: One terminal of field 2, through contact M, connection 116, contact K, cylinder-contact 65, connection 131, is connected between resistances r^2 and r^3. The circuit here divides, one branch passing through resistances r^2 and r' to connection 133, cylinder-contact 64, contact J, connection 115, contact I, connection 114, contact H, cylinder-contact 63, connection 138, cylinder-contact 55, contact L to the other terminal of field 2. The other branch passes through r^3 r^4, connection 128, cylinder-contact 62, contact F, wire 112, contact G, connection 113, contact H, cylinder-contact 63, connection 138, cylinder-contact 55, contact L to field-terminal.

In position 6 (shown in diagram 6) the condition described in Fig. 5 remains, except that resistances r' and r^4 are short-circuited by contact I engaging cylinder-contact 67, contact J engaging cylinder-contact 64, the contacts I and J being connected by wire 115, contacts F and G, connected by wire 112, engaging cylinder-contacts 62 and 66.

In position 7 (shown in diagram Fig. 7) the same condition referred to in the previous steps remains, except field No. 2 is short-cir-

cuited and the resistance is withdrawn. In this position a short gap will be noticed between cylinder-contact 53 and 68, and it should be understood that the contact D is of sufficient width to bridge over this gap and to connect with both sides. This connection establishes a short circuit around field No. 2 and permits the withdrawal of the resistance. This is accomplished by contact D bridging the gap between cylinder-contacts 53 and 68, thus short-circuiting field 2 by connecting the terminal at M of field 2 to ground by cylinder-contact 60, connection 125, cylinder-contact 56, connection 123, cylinder-contact 53, bridge to cylinder-contact 68, connection 134, cylinder-contact 54, contact E to ground. At the same time the resistance is withdrawn by contacts F, G, H, I, J, and K leaving their corresponding cylinder-contacts 62, 66, 63, 67, 64, and 65. It will be observed in this position armature No. 2 is doing no work, while armature No. 1 is working under a very intense field.

In position 8 (shown in diagram 8) the short circuit is removed from field No. 2. The fields are consequently placed in series and moderately magnetized over their corresponding armatures, which are now working equally in series; but combined they give no greater back electromotive force than the single armature 1 did in the previous position. The field short circuit referred to is removed by contact D ceasing to connect with cylinder-contact 53 and contact M leaving cylinder-contact 60. The same conditions remain in the positions 9, 10, 11, and 12, except that the fields are gradually weakened by connecting them in series by steps with resistances r', r^2, r^3, and r^4. In position 9, r' is inserted between the fields and ground. In position 12 the non-inductive resistance is placed in parallel with the fields, so as to protect them when the armature-circuit is broken. As shown in the following position and diagrams 13, 14, 15, 16, 17, and 18, the means of connection is the same as explained in position No. 1, except that cylinder-contact 75 is substituted for cylinder-contact 58, which contacts are joined by wire 145.

In position 13 the armature-circuits are broken under the weak fields, as shown in diagram 13, in the following manner, contacts B, C, and D leaving their corresponding cylinder-contacts 51, 52, and 68.

In positions 14, 15, 16, and 17 the strength of the field-magnets is gradually increased by short-circuiting the resistances r^4, r^3, r^2, and r'.

In position 18 the armatures are connected to the line in parallel, but in series with resistance, as shown in the diagram 18. In this and in the succeeding position r', r^2, r^3, and r^4 are connected in parallel and form a connecting-link between the armatures and ground. The current passes through armature 1 from the trolley T to contact B, to cylinder-contact 79, through connection 169 to cylinder-contact 81, connection 155, connection 148, cylinder-contact 77, connection 142, cylinder-contact 72, connection 130 to a central point in the resistance, which is between r^2 and r^3. A connection is also established from trolley T through armature No. 2 to the same point on the resistance in the following manner: beginning at contact A, thence to cylinder-contact 50, connection 168, cylinder-contact 80, contact C, through armature-contact D to cylinder-contact 81, through connection 155 to the same central point in the resistance in parallel, which leads to the ground in the following course: r', connection 133, cylinder-contact 64, connection 139, connection 151, cylinder-contact 84, contact J, connection 115, contact I, connection 114, contact H, cylinder-contact 83, connection 150, cylinder-contact 54, contact E to ground. In position 19 the same connections remain, except that the resistances r' and r^4 are short-circuited, as shown in the diagram 19, in the following manner: contact I engaging cylinder-contact 87, thus short-circuiting r', and contact G engaging cylinder-contact 86, short-circuiting r^4. In position 20 the same conditions remain, except that all of the resistance is removed from the armature-circuit. This is accomplished by contacts F, G, H, I, and J leaving their corresponding cylinder-contacts 82, 86, 83, 87, and 84 and by contacts B and D leaving cylinder-contacts 79 and 81, respectively, and engaging with cylinder-contacts 88 and 89.

In the following positions 21, 22, 23, and 24 the fields are gradually weakened by inserting the resistances r', r^2, r^3, and r^4 in series with them, as in positions 9, 10, 11, and 12.

In position 1^A (shown in diagram 1^A) the armature 1 is short-circuited, the fields are connected in series to the line, and the non-inductive resistance is in parallel with the fields. The armature is short-circuited through cylinder-contact 97, connection 162, and cylinder-contact 96. The fields are connected in the line-circuit by contact A, cylinder-contact 96, connection 161, cylinder-contact 102, field-terminal contact N, through fields 1 and 2, field-contact terminal L, cylinder-contact 101, connection 164, cylinder-contact 98, contact E to ground. The non-inductive resistance is connected as follows: One end is connected to cylinder-contact 57 through wire 165, cylinder-contact 103, contact O, through switch S, to field-terminal contact N. The other end is connected to connection 126, cylinder-contact 58, connection 145, cylinder-contact 75, connection 159, cylinder-contact 104, contact P, through switch S, to field-contact terminal L. In position 1^B the same connections are retained. In addition thereto armature 2 is also short-circuited, as shown in diagram 1^B. The connection is made by contacts C and D engaging cylinder-contacts 106 and 107.

In Figs. 28 and 26 the controller is shown at A. The handle a' and the circular geared

rack to which it is attached are removable and adapted to be used in the different positions shown in Fig. 28, a slot being cut in the lower part of the window-sash to accommodate the handle when it is operated from the inside.

In Fig. 29, C′ represents a slot having an enlarged opening at d', which permits the removal of the rack from the stud f'. The rack, being centered on the pin e', cannot be removed until the controller-cylinder g' is in the off position or when the circuits are broken. The pinion h' is connected to the cylinder, as shown in Fig. 25.

Fig. 30 shows, on an enlarged scale, the form of switch shown in the development. The contact-blades l', j', and k' are hinged at and connected to the stationary pieces l', m', and n' and are arranged to connect either with the terminals o' and p' or with the terminals q' and s'.

Fig. 31 shows a modification of the switch suitable for application on any form of electric cars. T represents the trolley; u', the motors; v', a magnet in the main circuit, and w' a supplementary hand-operated switch. The operation is as follows: With the switch w' closed, as shown, a circuit is maintained through the non-inductive resistance x' as long as the current is passing to the motors through the magnet v'. When, however, the main current ceases, the retractile spring y' breaks the local circuit at z'.

In Fig. 25 the field-resistances r', r^2, r^3, and r^4 are shown wound around the contact-cylinder.

The term "independently excited" used in the claims is meant to apply to cases where the current absorbed by the fields is independent of that passing through the armature—that is, being in a circuit of its own—but emanating from the same source as the current which passes through the armature.

I claim—

1. A method of accelerating electric motors which are ordinarily independently excited, which consists of starting with the armature and field-magnets in series and gradually decreasing the motors' resistance by changing them to independently-excited machines.

2. A method of accelerating electric motors which are ordinarily independently excited, which consists of starting with the armature and field-magnets in series and gradually decreasing the motors' resistance by changing them to independently-excited machines without breaking the armature-circuit.

3. A method of controlling motors where the armatures and field-magnets are ordinarily independently excited, which consists of first operating the armatures and field-magnets in series, then changing them dissimultaneously to independently-excited machines.

4. In combination with a pair of motors where the armatures and field-magnets are independently excited and regulated by variable resistance in the field-circuit, means substantially as described for utilizing the field-magnet resistance in parallel in the armature-circuit.

5. In an electric car, a non-inductive resistance arranged to be placed in parallel with the motors by a supplementary switch under the control of the motorman, substantially as and for the purpose set forth.

6. In an electric car in combination with the controller a non-inductive resistance arranged to be placed in parallel with the motors having a supplementary switch to complete its circuit when the motors are connected with the lines.

7. In an electric car, a non-inductive resistance, a supplementary circuit-closing switch, arranged in series with said resistance, a magnet in the motor-circuit arranged to close the resistance-circuit and place it in parallel with the motors while they are in connection with the line.

8. In an electric car having the controllers located on the platform substantially as shown and having removable handles capable of connection with said controllers so that they may be conveniently manipulated from either the inside or outside of the car.

9. In an electric car having the controllers located on the platform substantially as shown and having removable handles capable of connection with said controllers so that they may be conveniently manipulated from either the inside or outside of the car, and having means to prevent the removal of said handle except when the controller-cylinder is in the off position.

10. In a controller, in combination with a non-inductive resistance, means for closing said resistance in parallel with the field-magnet when the circuit through said field is to be broken and breaking said connection after said field-circuit is broken.

11. A method of controlling a pair of motors which are ordinarily independently excited which consists in operating one of them as an independently-excited machine, the other as a series machine and then changing the latter to an independently-excited machine.

12. A method of controlling electric motors which are ordinarily independently excited which consists of independently exciting the fields of one of the motors by placing it in shunt with both armatures, and exciting the fields of the other motor by connecting it in series with both armatures.

JOHN C. HENRY.

Witnesses:
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