(No Model.) 4 Sheets—Sheet 1.

F. H. FOSTER.

MECHANISM FOR STARTING, STOPPING, AND CONTROLLING SPEED OF MOTORS OF ELECTRIC CARS.

No. 598,199. Patented Feb. 1, 1898.

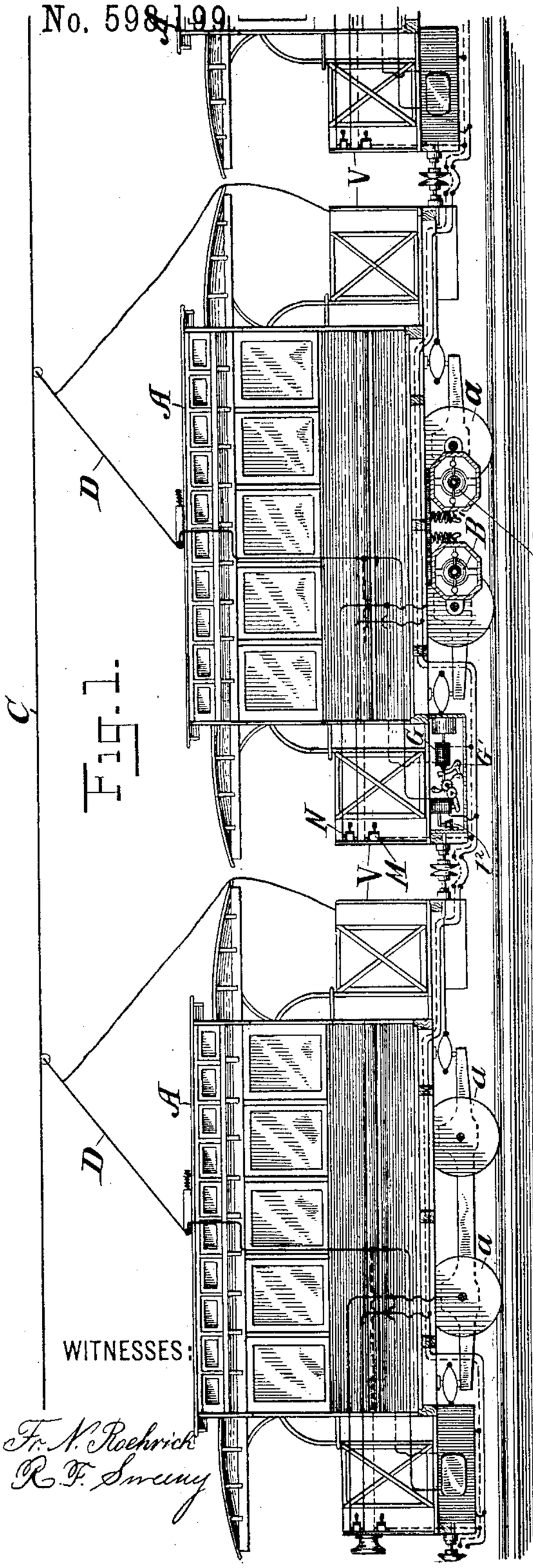


Fig. 1.

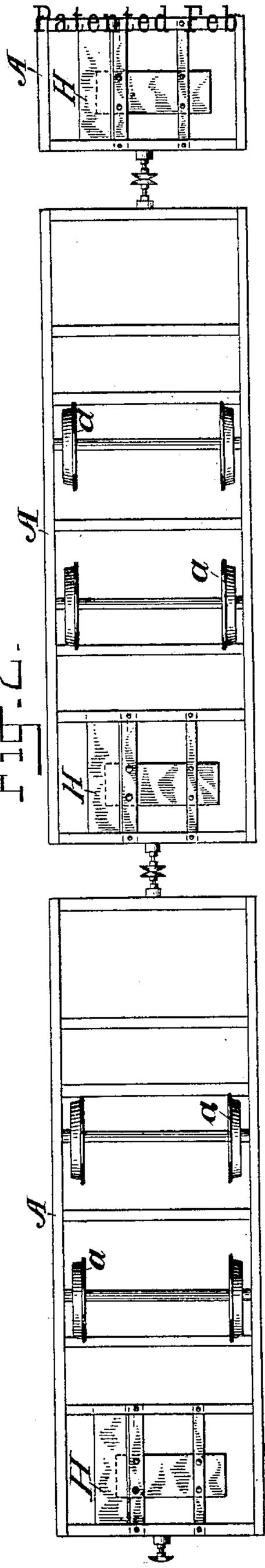


Fig. 2.

WITNESSES:

F. N. Roehrick

R. F. Sweeny

INVENTOR

Frank H. Foster.

By Wm. H. Appleton

ATTORNEY

(No Model.)

4 Sheets—Sheet 2.

F. H. FOSTER.

MECHANISM FOR STARTING, STOPPING, AND CONTROLLING SPEED OF MOTORS OF ELECTRIC CARS.

No. 598,199. Patented Feb. 1, 1898.

Fig. 3.

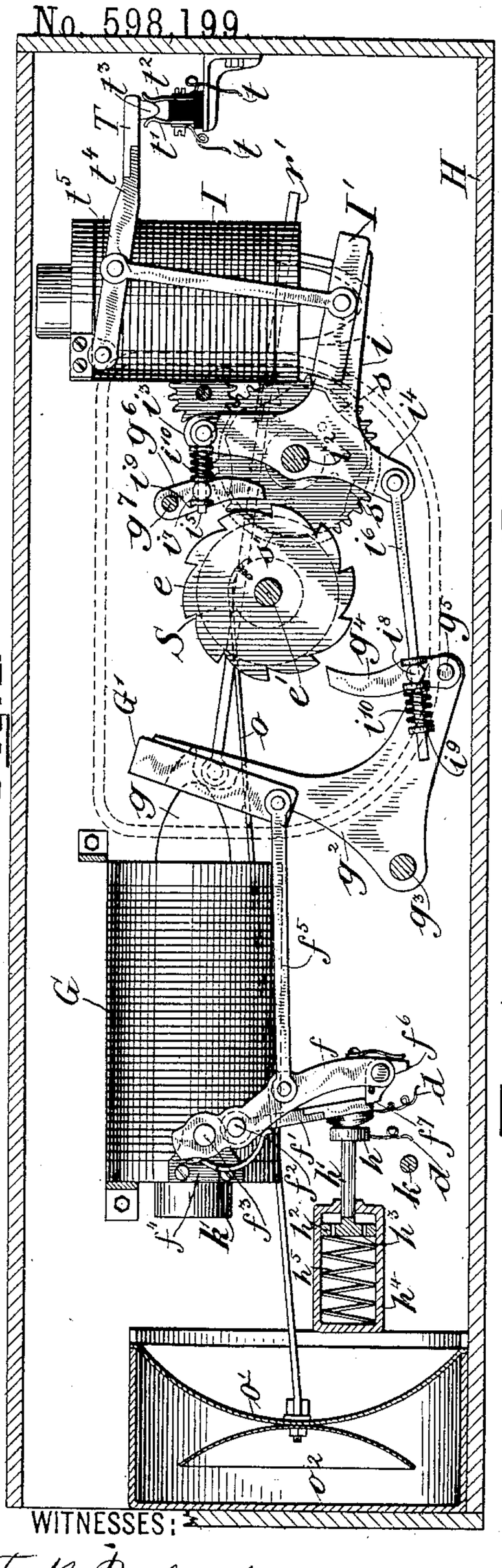
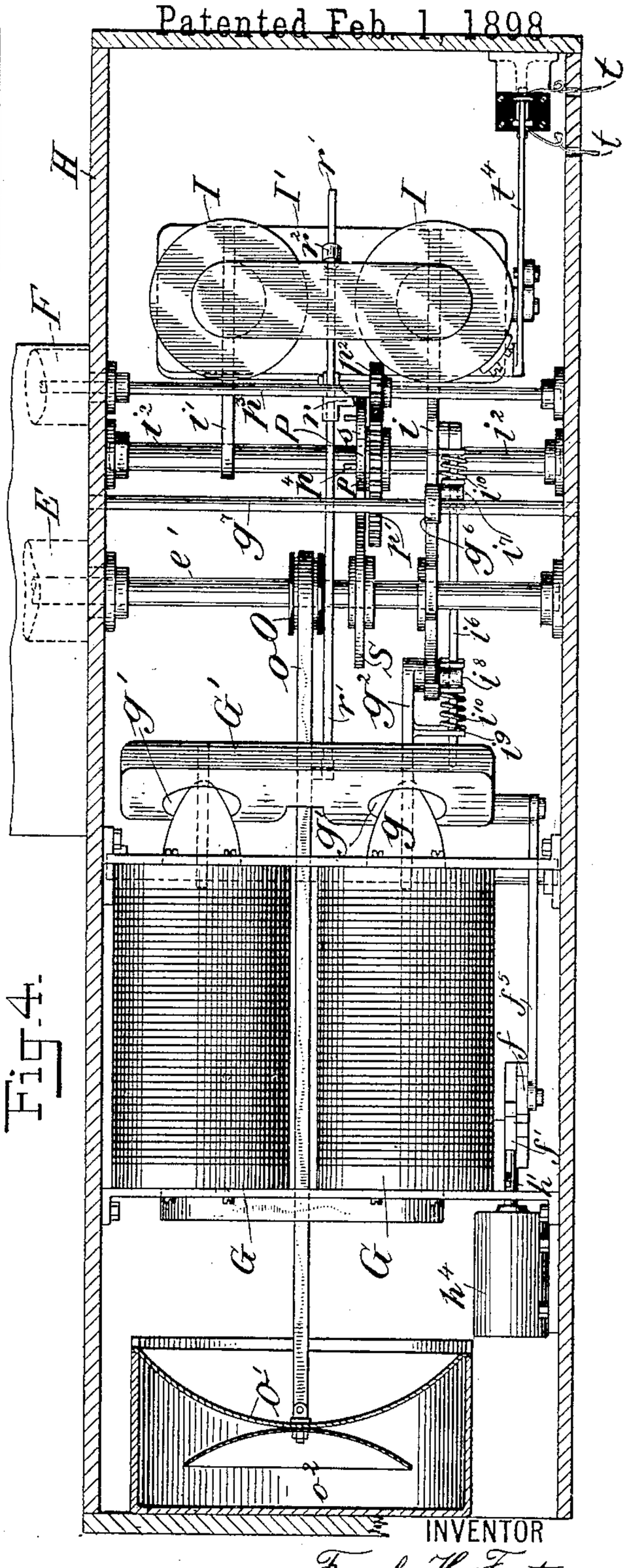


Fig. 4.



WITNESSES:

F. N. Roehrich

R. F. Sweeny.

INVENTOR

Frank H. Foster

BY Wm. F. Appleton.

ATTORNEY

(No Model.) 4 Sheets—Sheet 3.

F. H. FOSTER.

MECHANISM FOR STARTING, STOPPING, AND CONTROLLING SPEED OF MOTORS OF ELECTRIC CARS.

No. 598,199. Patented Feb. 1, 1898.

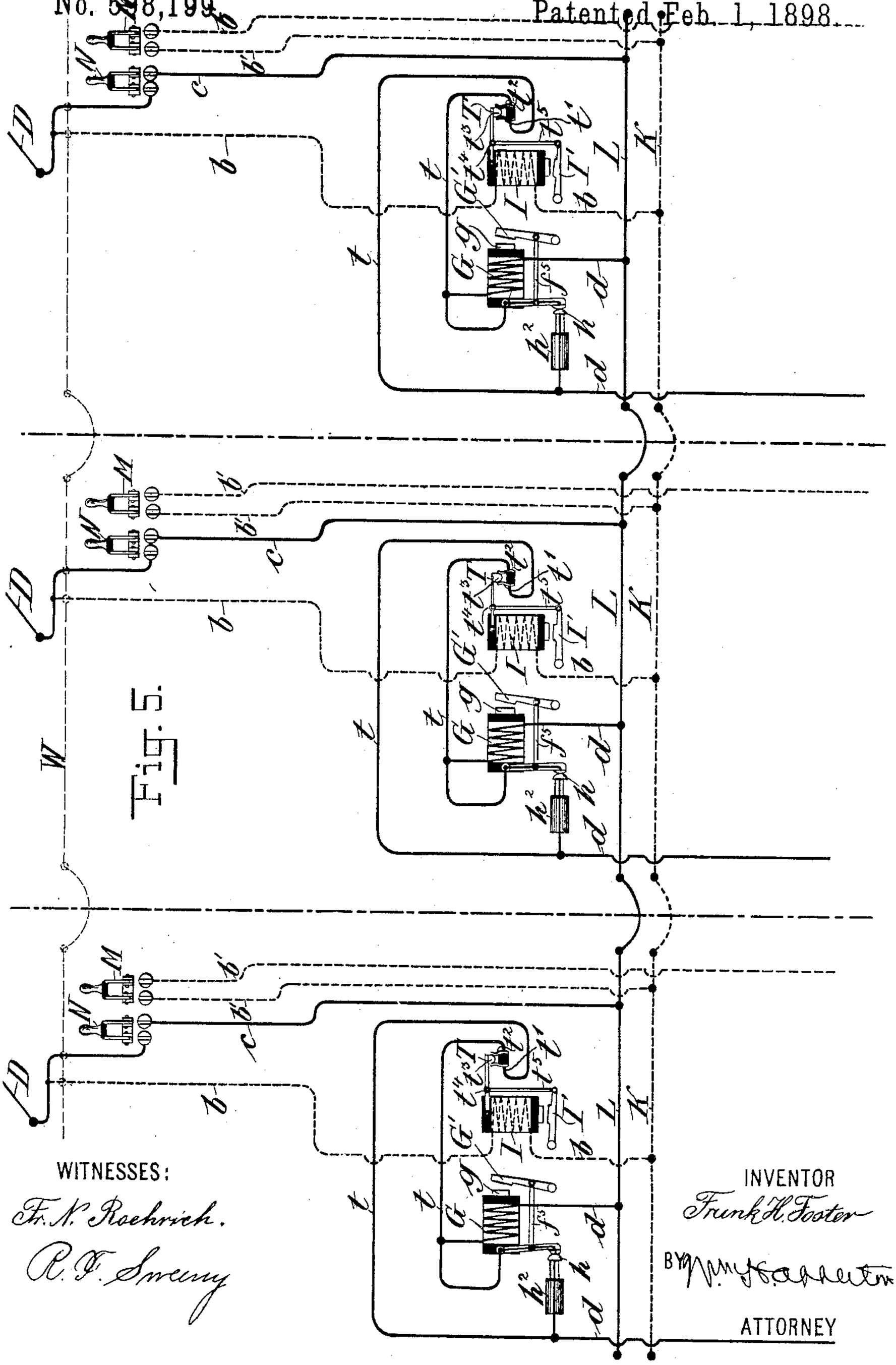


Fig. 5.

WITNESSES:

Fr. N. Roehrich.

R. F. Sweeny

INVENTOR

Frank H. Foster

BY Munn & Co.

ATTORNEY

(No Model.) 4 Sheets—Sheet 4.

F. H. FOSTER.

MECHANISM FOR STARTING, STOPPING, AND CONTROLLING SPEED OF MOTORS OF ELECTRIC CARS.

No. 598,199. Patented Feb. 1, 1898.

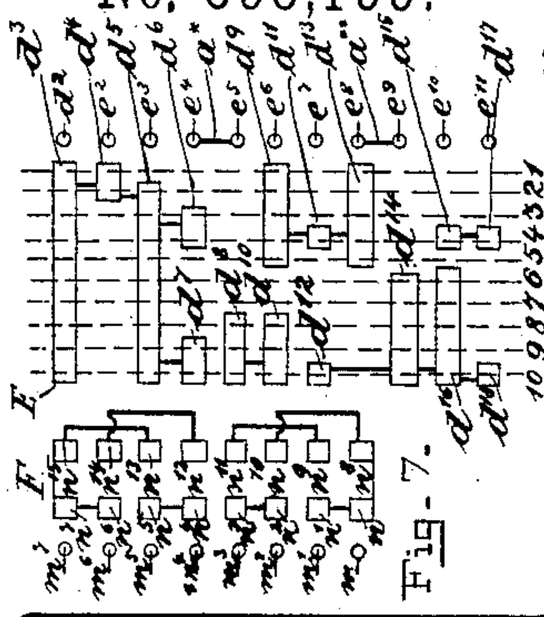


Fig. 7.

Fig. 6.

INVENTOR
Frank H. Foster.

BY
Wm. F. Appleton

ATTORNEY.

WITNESSES:
F. N. Roehrick
R. F. Sweeny.

UNITED STATES PATENT OFFICE.

FRANK H. FOSTER, OF BROOKLYN, NEW YORK.

MECHANISM FOR STARTING, STOPPING, AND CONTROLLING SPEED OF MOTORS OF ELECTRIC CARS.

SPECIFICATION forming part of Letters Patent No. 598,199, dated February 1, 1898.

Application filed August 12, 1897. Serial No. 647,964. (No model.)

To all whom it may concern:

Be it known that I, FRANK H. FOSTER, a citizen of the United States, and a resident of Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Mechanism for Starting, Stopping, and Reversing the Direction of Motion of Electric Cars and Controlling the Speed of Their Motors, of which the following is a specification.

My invention is designed as an improvement upon that class of mechanism which is made use of for starting, stopping, and reversing the direction of motion of electric cars, and has for its object to provide a mechanism of this class in which the starting, stopping, and reversing of the direction of motion of a series or train of electric cars and the control of the speed of their several propelling-motors may be effected in synchronism from any one of the car-platforms desired through the controlling devices usually carried by the several cars.

To this end the invention consists in various constructions and combinations with the motors and controllers of appropriate magnets and electric and other connections whereby the several results specified are accomplished, all as will hereinafter more fully appear.

Referring to the accompanying drawings, which form a part of this specification, Figure 1 is a side elevation of a number or train of cars with my invention applied in connection therewith, the propelling-motors being omitted from all but the middle car; Fig. 2, a reverse plan view of such cars with the propelling-motors and various of the parts omitted; Fig. 3, a side elevation of the mechanism through which the controller and current-reversing switch of each of the cars are operated, the containing-case, the vacuum-chamber, and various of the other parts being shown in vertical longitudinal section; Fig. 4, a plan view thereof, the containing-case, vacuum-chamber, diaphragm, and stop being illustrated in horizontal longitudinal section; Fig. 5, a diagram showing the magnets for each of the several cars and the electric circuits in which they are respectively located with the switches through which the several electric circuits are opened and closed. Fig. 6 is a diagrammatic plan view of the controller, reverse-switch, and electrical connections intermediate such parts and the motors with my invention applied in connection therewith, the motors and parts of a car being shown in dotted lines; and Fig. 7, a further diagrammatic view of the controller and reverse-switch with the several contacts with which they respectively coöperate.

In all the figures like letters of reference are employed to designate corresponding parts.

A indicates a series of cars, *a* the wheels upon which they are supported and propelled, B and B′ the motors through which such propulsion is effected, C the overhead or other main conductor, D the trolley arms or poles for conducting the electric current from the overhead or other conductor to the motors, E the current-controllers, and F the reverse switches through which the reversal of the motion of the cars is effected, all of which are or may be of any ordinary or preferred construction and require no further description herein.

Located upon each of the cars A is an electromagnet G, by means of which and its cooperating armature G′ the controller and reverse switch of such car may be operated. This electromagnet, with its armature, may be constructed in various forms. I prefer, however, to construct the first of these in the form of a double electromagnet with conically-shaped pole-pieces *g* projecting outward from its operating end, and to construct the other with correspondingly-shaped recesses *g′* for reception of the said pole-pieces when the armature is moved toward the magnet under the influence of the latter or otherwise. As thus constructed the required rotation of the controller E and the reverse switch F may be imparted therefrom through various means. In my preferred form of construction, however, I find it convenient to mount the armature G′ upon the upwardly-extending arms of the bell-crank levers g^2, which are pivoted within the casing or housing H on the pivot g^3, and to communicate the required rotation to the controller through the intervention of a pawl g^4 and a ratchet *e*, the former being pivoted to the horizontally-extending arm of the bell-crank lever g^2 on a pivot g^5 and the latter being fixedly secured

to the shaft e' of the controller E, which in the embodiment of the invention shown in the drawings is, with the reversing-switch F, arranged in a horizontal position. The several parts being thus arranged, when the pawl g^4 is brought into engagement with the ratchet e the rotation of the controller E by a step-by-step progressive movement will be effected by simply moving the armature G′ back and forth toward and away from the magnet G, and its rotation in the opposite direction will be prevented by the pawl or detent g^6, which, pivoted within the casing or housing H upon the pivot g^7, engages with the ratchet e, as shown.

To provide for bringing the pawls g^4 and g^6 into engagement with the ratchet e when the step-by-step rotation of the controller in one direction is required and for carrying them out of engagement therewith when the rotation in the opposite direction is desired, the electromagnet I and coöperating armature I′ are employed. This magnet, like the magnet G, may be constructed in various forms. As here shown, however, it is, like that magnet, constructed in the form of a double electromagnet, and the armature is secured to the ends of two levers i and i', which are pivoted upon a rod i^2, that is secured within the casing or housing H, with the lever i, provided with an upwardly-extending arm i^3 and a downwardly-extending arm i^4, to the extremities of which, by connecting-rods i^5 and i^6, the pawls g^6 and g^4 are respectively connected. As thus arranged the engagement of the said pawls with the ratchet e and their disengagement therefrom are effected by simply moving the armature I′ back and forth toward and away from the magnet I, and in order to permit of these pawls moving back over the teeth of the ratchet when in engagement therewith the connecting-rods i^5 and i^6, instead of being positively jointed to their respective pawls, are arranged loosely in orifices formed in studs i^7 and i^8 on the latter and are each provided with a collar i^9, between which and the outer side of its respective pawl is arranged a coiled spring i^{10}.

To provide for the energization of the magnets I and G, whereby to impart to the armatures I′ and G′ the required movements to effect the engagement of the pawls g^4 and g^6 with the ratchet e and the appropriate movements of the controller E and reverse-switch F, I make use of the conductors K and L. These conductors extend throughout the length of the car and are provided at their ends with suitable coupling devices whereby the corresponding conductors of the several cars may be united and the magnets of the several cars thereby rendered active in synchronism.

The conductor K is connected through a magnet I on each of the cars with the trolley by a conductor b, and the circuit in which these several elements are combined is rendered complete by a conductor b', leading from the conductor K to the ground or to one of the car-wheels a, a suitable switch M being located within the circuit, and preferably in the conductor b', whereby the said circuit may be opened and closed when desired. A magnet I, a trolley D, conductors b and b', and a switch M being thus arranged in connection with each of the cars, and the conductor K being common to them all, the magnets I of all the cars of the series may be rendered active or inactive and all the pawls g^4 and g^6 thereby carried into and out of engagement with the teeth of their respective ratchets in unison by operating the switch M on any one of the platforms of the series of cars in the required direction. The conductor L is likewise connected to the trolley D on each of the cars by a conductor c, in which is preferably located a switch N, whereby the current passing therethrough may be interrupted or allowed to flow, and the circuit in each of the cars in which these several elements are included is rendered complete by the employment of a conductor d, leading from the conductor L, through the magnet G, to the ground or to one of the car-wheels, as desired. A trolley D, a magnet G, conductors c and d, and a switch N being thus employed in connection with each of the cars in the series, and the conductor L being common to them all, the magnets G of the several cars composing the train may be similarly rendered active or inactive in unison and the several pawls g^4 thereby operated to rotate their respective controllers E in synchronism, as is the case with the parts operated from the magnets I, by simply opening or closing the switch N on any one of the platforms of the cars making up the train. The operation of the controller E of each car, when brought into action, being thus effected by the back-and-forth movement of its respective armature G′ through its particular pawl g^4 and ratchet e, and the necessities of its operation requiring that its forward rotation be accomplished by a step-by-step progressive movement, it is necessary to the imparting of the required movement to such armature that the circuit in which its respective magnet G is brought by the closing of the switch N be broken and made a number of times in succession, whereby to render said magnet in like succession inactive and active.

For breaking and making the circuit in which each of the magnets G is arranged I make use of a circuit-breaker. This circuit-breaker may be constructed in various forms. I prefer, however, to construct it in the form of two levers f and f', which are pivoted together by a pivot f^2, and the former fulcrumed upon a pivot f^3 in a stand f^4, secured to the support of the magnet G or to the housing H, as desired. The lever f is connected with the armature G′ by a suitable connecting-rod f^5, whereby to be caused to move back and forth therewith, and is provided at its free end with the spring-actuated bell-crank-shaped trigger f^6, which normally engages

with a notch f^7, formed in the free end of the lever f', that constitutes one terminal of the conductor d in circuit with magnet G. At all points, except where the trigger engages with the notch f^7, the lever f' is insulated from the lever f and in its movements it cooperates with the terminal h of the conductor d, that is also in circuit with the magnet G. This terminal h is preferably carried upon the free end of a rod h' of a piston h^2, which, provided with air-passages h^3, formed therethrough, is fitted to move back and forth in the cylinders or dash-pot h^4, secured to the housing H or other convenient part of the car. As thus arranged, with the trigger f^6 engaged with the notch f^7, whenever the armature G' is moved toward the magnet G, either through the attraction of the latter or otherwise, the levers f and f', with the two terminals and the rod and piston of the dash-pot, will be moved in a similar direction therewith in unison or in a direction toward the left in Figs. 3 and 4 of the drawings without any break between the two contacting terminals taking place. In order, therefore, to provide for breaking the circuit in which the magnet G is located when this movement of the parts is taking place, I provide a pin or an abutment k, which is arranged in the line of travel of the outer end of the trigger f^6 and employed in connection with the levers f and f' and with the piston h^2 of the dash-pot appropriately-formed springs k' and h^5, respectively. By this arrangement whenever the circuit in which the magnet G on any one of the cars is located is closed by the proper movement of its appropriate switch N, such magnet will be immediately magnetized and its armature thereby attracted and caused to swing toward it on its pivot g^3. As a result of this movement of the armature the pawl g^4 thereon will be caused to rotate the controller E through the distance of one tooth of the ratchet e, and the parts composing the circuit-breaker will be carried in the direction in which the armature was attracted. In moving with the armature G' the outer end of the trigger f^6 in passing the pin or abutment k will engage therewith and be thereby disengaged from the notch f^7 in the outer end of the lever f', which will then be forced back away from the terminal h of the conductor d by the spring k', and the circuit in which the magnet G is located thereby broken. This breaking of the circuit will cause the immediate demagnetization of the magnet G, when the armature G' will fall back away from the same, the pawl g^4 thereby drawn back over the ratchet e for engagement with another tooth thereof, and the levers f and f' of the circuit-breaker drawn back away from the terminal h. As these levers f and f' are thus carried in a direction away from the terminal h this terminal will follow thereafter under the influence of the spring h^5; but in consequence of the resistance offered to the piston h^2 by the air in the cylinder or dash-pot h^4 the movement of the terminal h will be retarded. It will, however, be forced back in contact with the lever f', forming the terminal of the conductor c, when the current will be again restored, the magnet G again magnetized, the armature G' again attracted, the controller E rotated through the space of one tooth, and the levers f and f' moved for a second break of the circuit, and so on, the breaking and making of the circuit and the operation of the various parts being thus continued until the switch N is opened or the rotation of the controller E is restrained by a suitable stop, with which it may in practice be provided. While thus the breaking and making of the circuit in which the magnet G is included on each of the cars is automatically effected, when the operation of the controller is required the breaking and making of the corresponding circuits on all the cars of the train when the several controllers are to be operated is similarly effected automatically in unison in consequence of all of such circuits, including as one of their elements the common conductor L, which extends throughout the series of cars composing the train.

With the parts above described for carrying the pawls g^4 and g^6 into and out of engagement with their respective ratchets e and operating the several controllers E of the train in unison from any one of the platforms of the cars of the train I make use of devices whereby, after the several controllers have been rotated to start and control their respective cars, these several controllers are all returned to their initial positions in unison, when their respective pawls g^4 and g^6 are removed from their actuating-ratchets ready for the next forward movement. The mechanism through which this return of the controllers to their initial positions is effected may be modified in various ways. In the form, however, selected by me for the illustration of my invention it consists of a drum O, which is fixedly secured to the shaft e' of the controller E of each of the cars and has secured thereto one end of a band o, the other end of which is secured to appropriate retracting means—as, for instance, a diaphragm o' of a vacuum-chamber o^2, that is or may be secured to the casing or housing H or other convenient part of the car. By these means when the controllers of the several cars are rotated forward under the action of their respective pawls g^4 and ratchets e the several bands coöperating with them will all be wound upon their respective drums O, and the diaphragms o', to which they are respectively secured, thereby distorted. The several diaphragms having been thus distorted as their respective controllers have been rotated under the action of their coöperating pawls and ratchets will when such pawls are removed from engagement with their respective ratchets, as when the current in which the magnets I are located is broken by the switch M

to stop the train, resume their normal form and thereby, through the bands *o* and drums O, automatically return their respective controllers to their original positions ready for a further forward rotation when the current is again restored, as is the case when the train is to be again started.

In order to provide for rotating the reverse-switch of each of the cars, whereby to reverse the direction of the current passing from the controllers E to the propelling-motors B and B′ when it is desired to reverse the direction of the car and cause it to run in an opposite direction, I make use of a disk P on each of the cars, which is loosely mounted on a shaft i^2, that is supported in suitable bearings secured to the casing or housing H. This disk is provided on one of its sides with a spur-gear p', which meshes with and communicates a rotary motion to a pinion p^2, that is fixedly secured to the shaft p^3 of the reverse-switch F, while projecting from its other side is a circular row of pins p^4, that are disposed thereon at approximately equal distances from the axis of the disk and coöperate with a hook *r*, secured to or formed as a part of a rod *r′*, which is jointed at one of its ends to the armature G′. The other end of this rod passes loosely through an orifice in a lug r^2, which extends upwardly from the armature I′ a sufficient distance therefrom as to bring the hook *r* on such rod into engagement with the pins p^4 on the disk P when such armature is not attracted by the magnet I and is at its farthest distance therefrom, but carry said hook above and out of engagement therewith when attracted by and in contact with said magnet. With the parts constructed and arranged as thus described and with the magnet I inactive and its armature I′ removed from it to the limit of its backward movement the rotation of the reverse-switch may be effected by simply moving the armature G′ toward its magnet G, which in practice is done by energizing such magnet through the means by which it is ordinarily energized to rotate the controllers. When the armature G′ is thus moved toward its magnet G, the hook *r* on the rod *r′* will engage with one of the pins p^4 and rotate the disk P through approximately the same distance as the armature is moved. The rotation thus imparted to the disk will then be communicated to the reverse-switch through the gears p' and p^2, and in order to insure the proper movement of the switch to reverse the current the gears p' and p^2 are so proportioned that for every movement of the disk P by the armature G the switch will be rotated the required distance. In the construction shown in the drawings the distance through which the switch is moved is a semirotation, or one hundred and eighty degrees; but this distance may be more or less, as the exigencies of the particular form of switch employed may require.

With a view to locking each of the reverse-switches in the position to which it may be moved during the time that its respective controller E is being progressively rotated by the movements of its appropriate armature G, while yet permitting of its being rotated when the controller is occupying its extreme backward position and the current for operating the propelling-motors B is interrupted, I provide the periphery of the disk P with a series of curved recesses *s*, which are arranged in proper relations with respect to the pins p^4, and employ in connection therewith a disk S, which is fixedly secured to the shaft *e′* of the controller E and is in turn provided with a similar curved recess *s′* in its periphery. The radii of the disks P and S are approximately the same as that of the curves of their respective coöperating recesses *s* and *s′*, and the recesses *s* are successively engaged by the disk S as the disk P is intermittingly rotated to effect the successive movements of the switch F, the recesses *s* being thus successively engaged by the disk S. The disk P, and with it the switch F, is locked thereby and prevented from turning in either direction, except when the recess *s′* in the disk S is brought opposite to the disk P, which is done when the controller E is occupying its extreme backward position and the current for operating the propelling-motors is interrupted. When the controller occupies this position, the movement of the reverse-switch may be readily effected without obstruction; but the moment that the controller is moved forward either under the influence of the armature G′ or otherwise the disk S engages with the particular recess that may be opposite to it and locks the disk P and the switch F against further movement until the controller is again returned to its original or initial position.

As the movement of each of the disks P is in practice effected from its respective magnet G through the armature G′, hook *r*, and rod *r′* and as one movement of the armature toward the magnet is sufficient to rotate that disk the proper distance to cause the reverse-switch F to reverse the direction of the current passing therethrough, it is necessary that provisions be made to prevent the current passing through such magnet from being interrupted and allowed to flow a number of times and the magnet thereby rendered inactive and active a corresponding number of times, as would be the case if such current was allowed to pass from the magnet to the ground through the terminals *f′* and *h* of the circuit-breaker. To this end I make use of the conductor *t*, which extends from each of the magnets G to the conductor *d*, and provide it intermediate of its length with a switch T, which is or may be opened and closed by the armature I′. In the construction of this switch various forms may be adopted. As here shown, however, it consists of the two contacts t' and t^2, to which the respective portions of the conductor are connected, and of

a blade t^3. This blade is preferably connected with the free end of a lever t^4, which is fulcrumed at its other end to a cap on the magnet I or other convenient part, and is connected with the armature I′ by a connecting-rod t^5 in such a manner that when the magnet I is inactive and the armature I′ is in its retracted position the blade t^3 will be carried between the contacts t' and t^2 and the switch thereby closed, and when, on the other hand, the magnet is rendered active and the armature attracted thereby it will be carried from between such contacts and the switch thereby opened. With the parts as thus arranged when the switch T is closed the current admitted to the magnet G by closing the switch N will pass therefrom to the ground through the conductor d by way of the conductor t and switch T instead of by way of the terminals f' and h of the circuit-breaker. As a consequence of this a circuit will be established through the magnet G, which will remain unbroken so long as the two switches N and T remain closed, and only such movement be given thereby to the reverse-switch F as is necessary to effect the required reversal of the direction of the current passing therethrough.

In practice I find it desirable to arrange the controller and reverse-switch of each car, with their respective operating devices, in a suitable casing or housing H, which may be secured to any convenient part of the car—as, for instance, under either of the platforms thereof—and to support the various parts therein in any approved way, using non-magnetic and insulating materials in connection therewith wherever required. The switches M and N may in like manner be supported from any convenient part of the car. I prefer, however, to support them from the dashboard V, and, although shown in the drawings as supported from only one of the dashboards of each car, in practice they will be preferably supported from both dashboards thereof and connected with their respective magnets by appropriate conductors. So, too, with the propelling-motors B and B′. These motors instead of being applied in connection with but one of the cars of the series will in practice be preferably applied in connection with each one of the series. Similarly with respect to the trolleys D. While I have shown them in side elevation in Fig. 1 of the drawings and in full lines in Fig. 5 as applied to each of the cars of the series, and in some cases may elect so to apply them, I prefer in practice to omit them from some or all of the cars but one and communicate the current therefrom to such cars through suitable conductors carried by them, as shown by dotted lines at W in Fig. 5.

With the several cars of the series or train individually provided with a current-controller and a reverse-switch and with the mechanism above explained for actuating them, the starting, stopping, and reversal of the direction of the motion of the several cars and the control of their speed from any one of their platforms are thus effected. Starting with the cars at a standstill and with the parts in the position shown in the drawings, the switch M on any one of the platforms of the train will first be closed and the circuit in which each of the magnets I is located thereby established. As a result of this the armature I′ coöperating with each of these magnets will be thereby attracted and the pawls g^4 and g^6 operated therefrom brought into engagement with their respective ratchet e. The switch N on any one of the platforms of the train will then be closed, thereby closing the circuit in which each one of the magnets G is arranged, and through it and the circuit-breaker coöperating therewith such magnets will be rendered active and inactive a number of times in quick succession and its respective current-controller E thereby progressively rotated by a step movement through the armature G, pawl g^4, and ratchet e. The rotation thus given to the controller will successively start its respective car and increase its speed of movement until the required speed is attained, when the switch N will be opened, the magnet G rendered inactive, and the controller left in the position to which it was adjusted. In this position the controller will be left until it is required to either increase the speed of the car or to arrest its movement, when in the former case the switch N will be again closed and a repetition of the former movement of the controller effected, and in the latter case the switch will be opened and in that condition left with the switch M until the car is again started. The stopping of the car having been effected by the opening of the switch M, and this operation of the latter serving to render the magnet I of each car inactive, the respective pawls g^4 and g^6 operated thereby will be disengaged from their respective ratchets e and the respective controller E returned to its initial position through the action of the diaphragm O and band o. To again start the series or train of cars, the switches M and N will be again closed in succession, when the same movement of each of the controllers, with its operating parts, will be repeated, and so on. The series or train of cars having arrived at the end of its route, or otherwise, and it be the desire to reverse the direction of movement of the train, the switches M and N will be both opened, and the latter then closed, while the former remains open, when the rotation of each of the reverse-switches F from their respective magnets G will be effected through the coöperating armatures G′, hook r, rod r', disk P, and gears p' p^2, the direction of the current passing therethrough will be reversed, and the several cars, when again started, moved in an opposite direction.

With a view to a clearer understanding of my invention I have in Figs. 6 and 7 shown a current-controller and a reverse-switch of

well-known form, with the electrical connections whereby the starting, stopping, and reversal of motion of the motors and the control of their speed from the mechanism above described are respectively effected.

The controller E thus selected by me for the purpose of illustration consists of a suitable cylindrical body E′, which is provided along its periphery with a series of contacts d^3 to d^{18}, inclusive, and is supported upon the shaft e' in such relationship to the contacts d^2 and e^2 to e^{11}, inclusive, as to bring the contacts thereon into and out of engagement with these latter contacts in the required order as the body is progressively rotated. The contact d^3 on this controller-body E′ extends around the upper end of the same, with a short break therein that is located opposite the contact d^2 when the controller is in its original or normal position. As thus disposed this contact d^3 is electrically connected to the contacts d^4, d^5, d^6, and d^7 by suitable conductors, (shown by heavy lines in Fig. 7,) and the same is true respecting the contacts d^8 and d^{10}, the contacts d^9, d^{11}, and d^{13}, the contacts d^{12}, d^{14}, d^{16}, and d^{18}, and the contacts d^{15} and d^{17}. The reverse-switch F in like manner also consists of a cylindrical body F′, that is provided with two longitudinal rows of contacts n to n^7, inclusive, and n^8 to n^{15}, inclusive, and is supported upon the shaft p^3 in such a position with respect to the contacts m to m^7, inclusive, as to bring first one and then the other of the rows of contacts n to n^7 and n^8 to n^{15} thereon into engagement therewith as the body F′ is rotated. The contacts being thus arranged upon the body F′ the contacts n and n', n^2 and n^3, n^4 and n^5, and n^6 and n^7 of the row n to n^7 and the contacts n^8 and n^{10}, n^9 and n^{11}, n^{12} and n^{14}, and n^{13} and n^{15} of the row n^8 to n^{15} are respectively connected in pairs by suitable conductors, as shown by heavy lines in Fig. 7. As thus connected the current, passing from the controller E therethrough to the motors B and B′, may be caused to flow in one or the other direction to the latter, as their rotation in one or the other direction may be required, by bringing one or the other of the rows of contacts n to n^7 or n^8 to n^{15} into engagement with the contacts m to m^7. When the row of contacts n to n^7 is in engagement therewith, the flow of the current from the controller to the motors will be in one direction and the motor rotated in a direction appropriate thereto. When, on the other hand, the row of contacts n^8 to n^{15} is brought into engagement with these contacts m to m^7, which may be accomplished by rotating the body F′ through a semirotation, then the current will be conducted to the motors in an opposite direction and the latter rotated in a reverse direction, and thus by simply rotating the body F′ first one and then the other of the rows of contacts n to n^7 and n^8 to n^{15} will be brought into engagement with the contacts m to m^7 and the direction of the flow of the current from the controller to the motors and the direction of the rotation of the latter reversed, as may be required.

With the controller and reverse-switch constructed as above explained the current supplied through the trolley-arm D or other appropriate device is conveyed to the controller E by a conductor d', which in practice preferably extends to one or the other end of the car, where it is provided with a suitable switch D′, thence to the opposite end thereof, where it is supplied with a second switch D^2, thence to and through a lightning-arrester D^3, and thence to a contact d^2, which is arranged to be brought into electrical connection with the contact d^3, secured to the upper end of the controller-cylinder, when such cylinder is rotated. The contact d^2 of the controller, being thus in electrical connection with the trolley-arm D or other appropriate current-supplying device, is energized at all times when current is present therein and the switches D′ and D^2 are closed, and the current passing thereto is conveyed to the motors, when the step-by-step rotation of the controller is effected and the contacts n to n^7 on the reverse-switch F are in engagement with the contacts m to m^7, as follows: Upon the first forward movement of the controller E to the distance of one step in the direction of the arrow in Fig. 7 the contacts d^3, d^4, d^9, and d^{13} carried by it are brought into electrical connection with their respective coöperating contacts d^2, e^2, e^6, and e^8 along the line 1 of that figure, and the current supplied to the contact d^2 will, through the connected contacts d^3 and d^4, be conducted to the contact e^2, thence along the conductor a' to the terminal a^2, thence through the resistance R to the terminal a^3, thence along the conductor a^4 to and through the contact e^4 to the contact e^5, thence along the conductor a^5 to and through the contact m to the contact n of the reverse-switch F, thence to and through the contact n' thereon to the contact m', thence along the conductor a^6 to and through the armature b^2 of the motor B, thence along the conductor a^7 to and through the contact m^2, thence to and through the contacts n^2 and n^3 on the reverse-switch to the contact m^3, thence along the conductor a^8 to and through the field b^3 of the motor B, thence along the conductor a^9 to the contact e^8, thence to and through the contacts d^{13}, d^{11}, and d^9 on the controller to the contact e^6, thence along the conductor a^{10} to the contact m^4, thence to and through the contacts n^4 and n^5 of the reverse-switch F, thence to the contact m^5, thence along the conductor a^{11} to and through the armature b^4 of the motor B′, thence along the conductor a^{12} to the contact m^6, thence to and through the contacts n^6 and n^7 of the reverse-switch, thence to the contact m^7, thence along the conductor a^{13} to the field b^5 of the motor B′, thence along the conductor a^{14} to the conductor b', and thence to the ground at the point a^{15}, thereby allowing of the flow of the current

from the controller to and through the resistance and to and through the armatures and fields, respectively, of the two motors in series. The next step-by-step forward movement of the controller E brings the contact d^5 against the contact e^3 and, with the contacts d^3, d^4, d^9, and d^{13} and their coöperating contacts d^2, e^2, e^6, and e^8, form electrical connections along the line 2 of Fig. 7. In this position, with contact d^5 electrically connected with the contact d^3 by a suitable conductor, as shown, the current supplied to the latter contact will flow to and through the contact d^5 to the contact e^3, thence along the conductor b^6 to the terminal b^7, thence through a portion of the resistance R to the terminal a^3, and thence to and through the armature and fields of the respective motors B and B′ along the same conductors and through the same contacts on the controller and reverse-switch as above explained in connection with the preceding movement of the controller. The next step forward of the controller in its operation brings the contact d^6 thereon against the contact e^4 and, with the contacts d^3, d^5, d^9, and d^{13} and their respective coöperating contacts d^2, e^3, e^6, and e^8, forms an electrical connection along the line 3, while carrying the contact d^4 away from the contact e^2 and thereby breaking connection therewith. The contact d^6 being thus brought into operative connection with the contact e^4 and being connected with the contact d^3 through the contacts d^4 and d^5 by suitable conductors, as shown by heavy lines in Fig. 7, the current delivered to the conductor d^3 will flow thereto, thence to the contact e^4, whence, instead of flowing therefrom to and through the resistance R, it cuts out such resistance and passes directly to the contact e^5, through the short conductor $a^\times$, thence to the conductor a^5, and thence along the same conductors and through the same contacts on the controller and reverse-switch to and through the armature and field of each of the motors B and B′ in series as were referred to above in describing the course of the current from this point forward when the controller is in the position it occupies after having been moved forward to the distance of its first step. The next or fourth step forward of the controller brings the contacts d^{11}, d^{15}, and d^{17} thereon against their respective coöperating contacts e^7, e^{10}, and e^{11} and, with the contacts d^3, d^5, d^6, d^9, and d^{13} and their coöperating contacts d^2, e^3, e^4, e^6, and e^8, establish electrical connections at different points along the line 4 of Fig. 7. As a result of this, with the contact d^{11} on the controller electrically connected with the contacts d^9 and d^{13} thereon and with the contacts d^{15} and d^{17} also thereon similarly connected, as is shown by the full lines extending between them, the current delivered to the contact d^3 by the contact d^2 passes to the contact d^6, thence to and through the contact e^4, thence through the short conductor $a^\times$ to the contact e^5, thence along the conductor a^5 to the contact m, thence to and through the contacts n and n' on the reverse-switch F to the contact m', thence along the conductor a^6 to and through the armature b^2 of the motor B, thence along the conductor a^7 to the contact m^2, thence to and through the contacts n^2 and n^3 on the reverse-switch to the contact m^3, thence along the conductor a^8 to the point c', where the current divides and one portion continues along the conductor a^8 and passes to and through the field b^3 of the motor B, thence along the conductor a^9 to and through the contact e^8 to the contact d^{13} on the controller, and thence to the contact d^{11} thereon, while the other portion of the current divided off at the point c' passes along the shunt-conductor c^2, thence through the resistance R′, thence along the conductor c^3 to the contact e^7, thence to the contact d^{11}, where it unites with the portion divided off at the point c' and with it passes to and through the contact d^9 on the controller to the contact e^6, thence along the conductor a^{10} to the contact m^4, thence to and through the contacts n^4 and n^5 on the reverse-switch to the contact m^5, thence along the conductor a^{11} to and through the armature b^4 of the motor B′, thence along the conductor a^{12} to the contact m^6, thence to and through the contacts n^6 and n^7 on the reverse-switch, thence to the contact m^7, thence along the conductor a^{13} to the point c^4, where the current is again divided and one portion passes to and through the field b^5 of the motor B′, thence along the conductor a^{14} to the conductor b', and thence to the ground at the point a^{15}, while the other portion divided off at the point c^4 passes along the shunt-conductor c^5 to and through the resistance R^2, thence along the conductor c^6 to the contact e^{11}, thence to and through the contacts d^{17} and d^{15} on the controller, thence to and through the contact e^{10}, thence along the conductor c^7 to the ground at the point a^{15}, the current being thus passed as a whole through the armature of the motor B, then divided and a portion passed through the field of that motor, then the two portions of the current united and passed through the armature of the motor B′, then divided and a portion passed through the field of this latter motor, and thence to the ground. The next forward step of the controller carries the contacts d^6, d^{11}, d^{15}, and d^{17} away from their respective coöperating contacts e^4, e^7, e^{10}, and e^{11}, thereby breaking electrical connection with them and leaving only the contacts d^3, d^5, d^9, and d^{13} in contact with their coöperating contacts d^2, e^3, e^6, and e^8, along the line 5 of Fig. 7. In this position the current supplied will be passed through a portion of the resistance R, thence through the armature and field of the motor B, and thence through the armature and field of the motor B′ in series along the same conductors and through the same contacts as is the case when the controller E is moved to its second forward step position. The sixth forward movement of the

controller carries the contacts d^9 and d^{13} away from their coöperating contacts e^6 and e^8 and brings contacts d^{14} and d^{16} on the controller against their coöperating contacts e^9 and e^{10}, thereby breaking connections between the former and making connections between the latter. The connections thus made between these contacts d^{14}, d^{16}, e^9, and e^{10} with those existing between the contacts d^3, d^5, d^2, and e^3 will be formed along the line 6 of Fig. 7, and the current supplied to the contact d^3 through the contact d^2 will be passed to the contact d^5, thence to and through the contact e^3 to the conductor b^6, thence along this conductor to the terminal b^7, thence through a portion of the resistance R to the terminal a^3, thence along the conductor a^4 to and through the contact e^4 to the contact e^5, thence along the conductor a^5 to and through the contact m to and through the contacts n and n' on the reverse-switch, thence to and through the contact m', thence along the conductor a^6 to and through the armature b^2 of the motor B, thence along the conductor a^7 to and through the contact m^2, thence to and through the contacts n^2 and n^3 on the reverse-switch to the contact m^3, thence along the conductor a^8 to and through the field b^3 of the motor B, thence along the conductor a^9 to the contact e^8, thence through the short conductor $a^{\times\times}$ to and through the contact e^9, thence to the contact d^{14} on the controller, thence to the contact d^{16} thereon, thence to and through the contact e^{10}, and thence along the conductor c^7 to the ground at a^{15}, thereby cutting out of the circuit the armature and field of the motor B′. The next or seventh forward movement of the controller maintains the same connections as the last preceding movement thereof, but upon line 7 of Fig. 7, and the current delivered to the contact d^3 passes through the armature and field of the motor B along the same conductors and through the same contacts as in that movement. The next forward movement of the controller continues the same electrical connections between the contacts d^3, d^5, d^{14}, and d^{16} thereon and their respective coöperating contacts d^2, e^3, e^9, and e^{10} as in the last, but upon the line 8 of Fig. 7, and in addition thereto brings the contacts d^8 and d^{10}, which are connected as shown, into electrical connections with their respective coöperating contacts e^5 and e^6. As thus related the current is confined wholly to the motor B′, cutting out entirely the motor B, and passes to the contact d^3 from the contact d^2 and is conducted to and through the contact e^3, thence along the conductor b^6 to the terminal b^7, thence through a portion of the resistance R to the terminal a^3, thence along the conductor a^4 to and through the contact e^4 to the contact e^5, thence to and through the contact d^8 to and through the contact d^{10}, thence to and through the contact e^6, thence along the conductor a^{10} to and through the contact m^4, thence to and through the contacts n^4 and n^5 on the reverse-switch F, thence to the contact m^5, thence along the conductor a^{11} to and through the armature b^4 of the motor B′, thence along the conductor a^{12} to and through the contact m^6, thence to and through the contacts n^6 and n^7 on the reverse-switch F, thence to and through the contact m^7, thence along the conductor a^{13} to the point c^4, thence to and through the field b^5 of the motor B, thence along the conductors a^{14} and b' to the ground at a^{15}, the conductor c^5, that passes through the resistance R^2, being dead-ended at the contact e^{11}. The next step forward of the controller continues the same electrical connections between the contacts d^3, d^5, d^8, d^{10}, d^{14}, and d^{16}, with which such controller is provided, and their respective coöperating contacts d^2, e^3, e^5, e^6, e^9, and e^{10}, as that just described in connection with the last preceding movement, but upon the line 9 of Fig. 7, and also brings the contact d^7, which is likewise carried by the controller and connected with the contact d^5, into electrical connection with the contact e^4 along the same line. As a result of this the motor B and the several resistances are cut out and the current confined wholly to the motor B′, passing thereto from the contact d^2 to and through the contacts d^3, d^4, d^5, and d^7 on the controller to the contact e^4, thence to and through the contact e^5 to the contact e^8, thence to and through the contact d^{10} to the contact e^6, and thence successively to and through the armature and field of the motor B′ along the same conductors and to and through the several contacts as it does from this point forward when the controller is in the position it occupied at the end of its last preceding movement. The next and last step forward of the controller maintains the same electrical connections between the several contacts d^3, d^5, d^7, d^8, d^{10}, d^{14}, and d^{16} thereon and their several coöperating contacts d^2, e^3, e^4, e^5, e^6, e^9, and e^{10} as it did at the end of its last preceding movement, but upon the line 10 in Fig. 7, and in addition thereto brings the contacts d^{12} and d^{18}, which are upon the former and connected with the contacts d^{14} and d^{16} thereon, into electrical connections with their respective coöperating contacts e^7 and e^{11}. With the several contacts thus mentioned electrically connected as described the current supplied to the contact d^3 by the contact d^2 will, through the contacts d^4 and d^5 and their connections, be concluded to and through the contact d^7 to the contact e^4, thence through the conductor $a^{\times}$ to the contact e^5, where it will be divided and one portion passed along the conductor a^5 to and through the contact m, thence to and through the contacts n and n' on the reverse-switch F to the contact m', thence along the conductor a^6 to and through the armature b^2 of the motor B, thence along the conductor a^7 to and through the contact m^2, thence to and through the contacts n^2 and n^3 on the reverse-switch to the contact m^3, thence along the conductor a^8 to the point c', where this portion of the current is itself divided and one portion con-

ducted along the conductor a^8 to and through the field b^3 of the motor B, thence along the conductor a^9 to and through the contact e^8, thence along the conductor a^{XX} to and through the contact e^9 to the contact d^{14}, while the other portion of this current divided at the point c' is conducted along the conductor c^2 to and through the resistance R', thence along the conductor c^3 to and through the contact e^7, thence to and through the contact d^{12} to the contact d^{14}, where it forms a junction with the portion divided off at c', and with it is conducted to and through the contact e^{10} to the conductor c^7, and thence along the same to the ground, having in its travel, after dividing off at the contact e^5, passed as a whole through the armature of the motor B, then divided and a portion thereof passed through the field of this motor, then united with the portion from which it was separated after passing the armature and passed to the ground. The other portion of the current divided off at the contact e^5 during this time will be passed from this contact to and through the contacts d^8 and d^{10} on the controller E, thence to and through the contact e^6, thence along the conductor a^{10} to and through the contact m^4, thence to and through the contacts n^4 and n^5 on the reverse-switch F to the contact m^5, thence along the conductor a^{11} to and through the armature b^4 of the motor B', thence along the conductor a^{12} to and through the contact m^6, thence to and through the contacts n^6 and n^7 on the reverse-switch F to the contact m^7, thence along the conductor a^{13} to the point c^4, where this portion of the current is also divided and one part thereof carried to and through the field b^5 of the motor B', thence along the conductor a^{14} to the conductor b', and thence to the ground at a^{15}, while the other part of this current divided off at c^4 is carried along the conductor c^5 to and through the resistance R^2, thence along the conductor c^6 to and through the contact e^{11}, thence to and through the contacts d^{18} and d^{16} on the controller to the contact e^{10}, and thence along the conductor b' to the ground at a^{15}, the portion of the current divided off at the contact e^5 thus passing as a whole through the armature of the motor B', thence divided and one part thereof passed through the field of such motor, and thence with the other part conveyed to the ground at the point a^{15} in the same way as the other portion was passed through the armature and field of the motor B to the same destination. The controller E, having been thus rotated to the limit of its forward movement or other required distance, is returned to its original position when desired by simply rotating it in a backward direction to the proper distance, when the contacts thereon will be carried away from their coöperating contacts and the current thereby cut off from it and from the motors ready for the next forward movement of the former to start and control the movements of the latter, and so on.

The directions in which the current from the controller E passes to and through the motors B and B', above explained, are those in which it travels when the contacts n to n^7 on the reverse-switch F are in electrical connection with the contacts m to m^7. When, on the other hand, the contacts n^8 to n^{15} thereon are in engagement with these contacts m to m^7, then the directions in which it passes from the reverse-switch to and through the motors are reversed, and while conducted through the same resistances and through the same armatures and fields of the motors as it does when the other sets of contacts are in engagement and the controller is in its different positions, respectively, it is conducted therethrough in an opposite direction, as is common to this peculiar arrangement of mechanism and as shown in the drawings, wherein the connection of the contacts on the reverse-switch and the disposition of these contacts with respect to the parts with which they coöperate are illustrated.

From the foregoing it will be seen that I produce a simple and efficient mechanism whereby a series or train of electrically-propelled cars may be not only started, stopped, and their motion reversed, when desired, from any one of the platforms thereof, but the speed thereof when in motion likewise controlled therefrom.

Although in the above I have described the best means contemplated by me for carrying my invention into practice, I wish it distinctly understood that I do not limit myself thereto, as it is obvious that I may modify the same in various ways without departing from the spirit thereof.

Having thus described my invention and specified certain of the ways in which it is or may be carried into effect, I claim and desire to secure by Letters Patent of the United States—

1. The combination, with an electric motor, a current-controller therefor, and means through which an electric current may be passed to them, of an electromagnet, a conductor for leading an electric current thereto, a switch through which the flow of this current may be permitted and interrupted as required, and mechanism intermediate the electromagnet and the controller, whereby the said controller may be automatically operated from the electromagnet to start and control the speed of the motor, when the switch is operated in the required direction, substantially as described.

2. The combination, with an electric motor, a current-controller therefor, a reverse-switch for the current, and means through which an electric current may be passed to them, of an electromagnet, a conductor for leading an electric current thereto, a switch through which the flow of this current may be per-

mitted and interrupted as required, and mechanism intermediate the electromagnet and the controller and reverse-switch, whereby the said controller and reverse-switch may be automatically operated from the electromagnet to start and control the speed of the motor and to reverse the direction of the flow of the current thereto, when the switch in the conductor leading to the electromagnet is operated in the required direction, substantially as described.

3. The combination, with an electric motor, a current-controller therefor, a reverse-switch for the current, and means through which an electric current may be passed to them, of an electromagnet, a conductor for leading an electric current thereto, a switch through which the flow of this current may be permitted and interrupted, a second electromagnet, a conductor for leading an electric current thereto, and a switch through which the flow of the current along this latter conductor may also be permitted and interrupted, whereby the first-mentioned electromagnet may be engaged with, and disengaged from, the controller and reverse-switch, and the two latter automatically operated from the former to start and control the speed of the motor, reverse the direction of the flow of the current thereto, and permit of the return of the controller to its original or normal position when required by simply operating the switches in the conductors leading to the two electromagnets in the required order, substantially as described.

4. The combination, with a plurality of electric cars, each of which is provided with an electric motor, a current-controller, and means through which an electric current may be conducted to these devices, of an electromagnet arranged upon each of such cars, conductors for conducting an electric current to each of these electromagnets, a switch located on each of the cars for coöperating with these conductors, and mechanism intermediate each of these electromagnets and its respective current-controller, whereby the controllers on all of the cars may be automatically operated from their respective electromagnets to start and control the speed of all the motors, by operating the switch on any one of the cars in the required direction, substantially as described.

5. The combination, with a plurality of electric cars, each of which is provided with an electric motor, a current-controller therefor, a reverse-switch, and electrical connections through which an electric current may be supplied to these parts, of an electromagnet arranged upon each of such cars, conductors for conducting an electric current to each of these electromagnets, a switch located on each of the cars for coöperating with these conductors, and mechanism intermediate each of these electromagnets and its respective current-controller and reverse-switch, whereby the controllers and reverse-switches on all of the cars may be automatically operated from their respective electromagnets to start and control the speed of their appropriate motors, and to reverse the direction of the flow of the current thereto when required, by operating the switch in the conductors leading to the electromagnets on any one of the cars in the required direction, substantially as described.

6. The combination, with a series of controllers, a series of electromagnets, and a trolley or other source of electric supply, of a circuit in which each of the electromagnets is arranged, an automatic circuit-breaker also located in each of said circuits, an electric conductor between each of said circuits and the trolley or other source of electric supply, a switch located in said conductor, and devices intermediate each of the electromagnets and its respective controller, whereby the several controllers may be operated in synchronism from their respective magnets by simply closing the said switch, substantially as described.

7. The combination, with a current-controller, an electromagnet, and a trolley or other source of electric supply, of a circuit in which the electromagnet is arranged, devices through which this circuit may be made and broken a number of times in succession, a switch located in said circuit, mechanism through which the electromagnet may be engaged with, and disengaged from, the current-controller and the latter automatically operated therefrom, and retracting devices, whereby the said controller may be automatically operated from the electromagnet when engaged therewith, by simply closing the switch, and returned to its original position when disengaged therefrom, substantially as described.

8. The combination, with an electric controller, an electromagnet and armature, a source of electric supply, a circuit in which said magnet is arranged, and an automatic circuit-breaker and a switch also located in said circuit, of a ratchet secured to the controller, a pawl carried by said armature for engaging with said ratchet, and devices through which the said pawl may be thrown into and out of engagement with such ratchet, whereby the controller may be operated from the electromagnet by closing said switch and the pawl thrown into and out of engagement with said ratchet when desired, substantially as described.

9. The combination, with an electric controller provided with an operating-ratchet, an electromagnet and armature, a pawl carried by said armature for engagement with said ratchet for rotating the same, and a second pawl or detent for preventing the backward rotation of the ratchet, of a second electromagnet and armature connected with said pawls, an electric circuit for each of said magnets, a switch arranged in each of the circuits, and an automatic circuit-breaker arranged

in the circuit of the first-mentioned magnet, whereby the pawls may be thrown into and out of engagement with the ratchet, and the rotation of the controller effected or arrested as may be desired by opening and closing the said switches, substantially as described.

10. The combination, with an electric controller provided with an actuating-ratchet, and pawls for engaging with said ratchets for respectively rotating it and preventing it from turning backward, of an electromagnet, an armature therefor with which the said pawls are connected, an electric circuit in which said magnet is arranged, a switch located in said circuit, and means for returning the controller to its initial position after having been rotated, substantially as described.

11. The combination, with a plurality of electric cars, an electric controller arranged upon each, and mechanism through which the several controllers are rotated in unison to start and control the speed of the several cars, of an electromagnet, arranged in connection with each of the controllers, an electric circuit in which the several electromagnets are arranged, a switch also located in such circuit, devices through which the mechanism for rotating the several controllers are thrown into and out of engagement with their respective controllers in unison, and means through which the several controllers may be returned to their initial positions when released from their rotating devices, substantially as described.

12. The combination, with an electric controller, of a vacuum-chamber, a diaphragm, a drum mounted on the shaft of the controller, and a band leading from the diaphragm to the drum, substantially as described.

13. The combination, with a reverse-switch, and an electromagnet and armature, of an electric circuit in which such magnet is carried, a switch located in said circuit, a disk connected with said reverse-switch, means whereby the rotation of the said disk from the armature of the electromagnet is effected, a conductor leading from the magnet to the ground, a switch located in said conductor, and means whereby this switch may be opened and closed, whereby when this last-mentioned switch is closed the rotation of the reverse-switch may be effected and the direction of the current passing therethrough reversed by closing the first-mentioned switch, substantially as described.

14. The combination, with an electromagnet, and an armature therefor, of a circuit in which such magnet is arranged, a circuit-breaker also located in such circuit and operated to break said circuit at every movement of the armature toward the magnet, a current-controller, and devices through which the armature may be engaged with, and disengaged from, the current-controller, substantially as described.

15. The combination, with an electromagnet, an armature therefor, and a circuit in which the electromagnet is arranged, of the circuit-breaker located in said circuit and consisting of the levers f and f', the trigger f^6, the spring k', the abutment k, the terminal h, the piston-rod h', the piston h^2, the dash-pot h^4, and the spring h^5, substantially as described.

16. The combination, with the electromagnet G, armature G', and reverse-switch F, of the disk P connected with such switch and provided with pins projecting from its side, the hook r, the rod r', a circuit in which the magnet is arranged, and a switch located in said circuit, whereby the rotation of the reverse-switch may be effected by simply closing the switch, substantially as described.

In testimony whereof I have hereunto set my hand this 10th day of August, 1897.

FRANK H. FOSTER.

Witnesses:
WM. H. APPLETON,
R. F. SWEENY.