No. 684,609. Patented Oct. 15, 1901.

E. R. HILL.

CONTROLLING SYSTEM FOR RAILWAY VEHICLES.

(Application filed Sept. 20, 1900.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1.

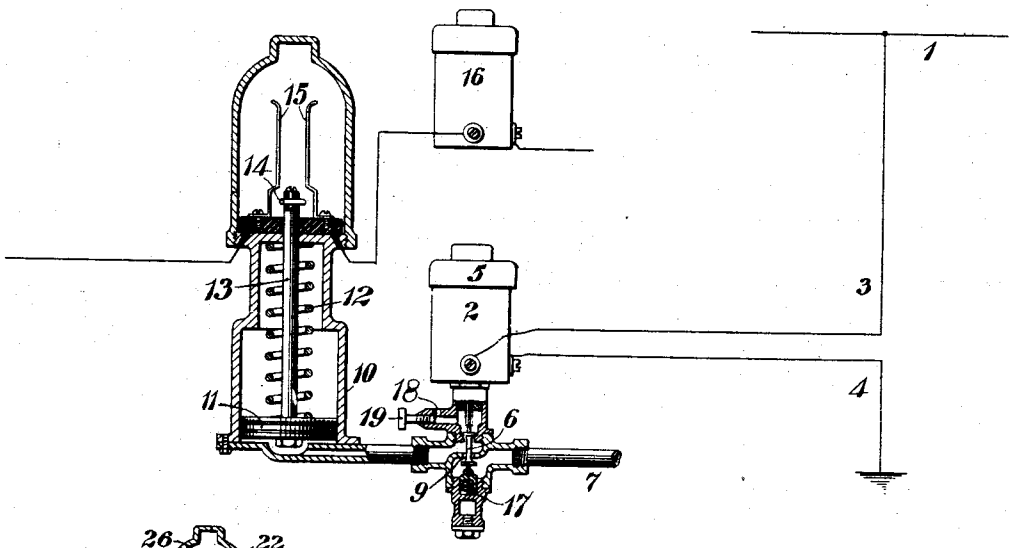
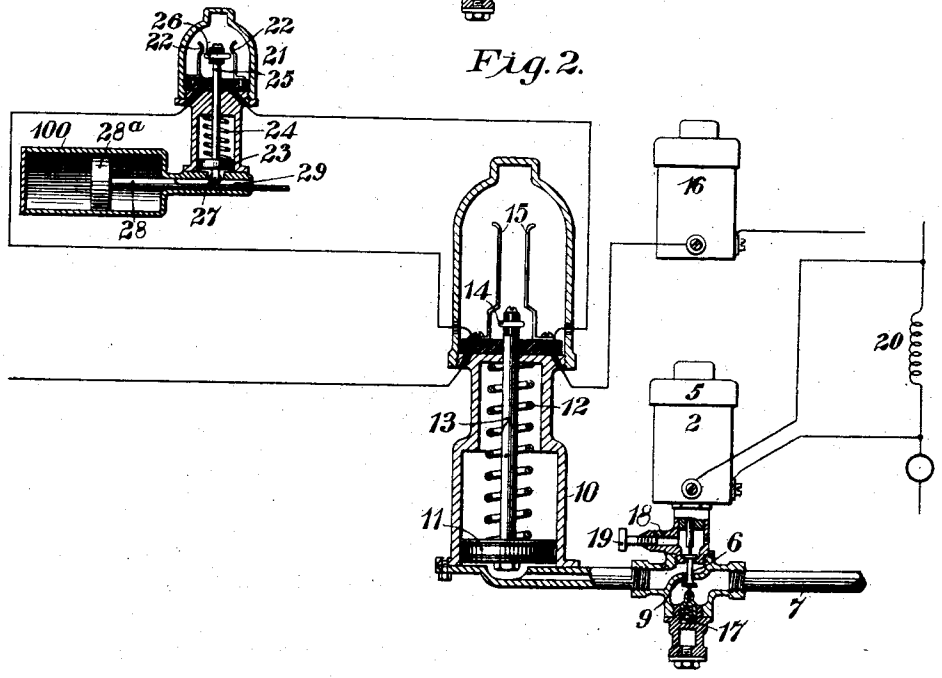


Fig. 2.



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Fig. 3.

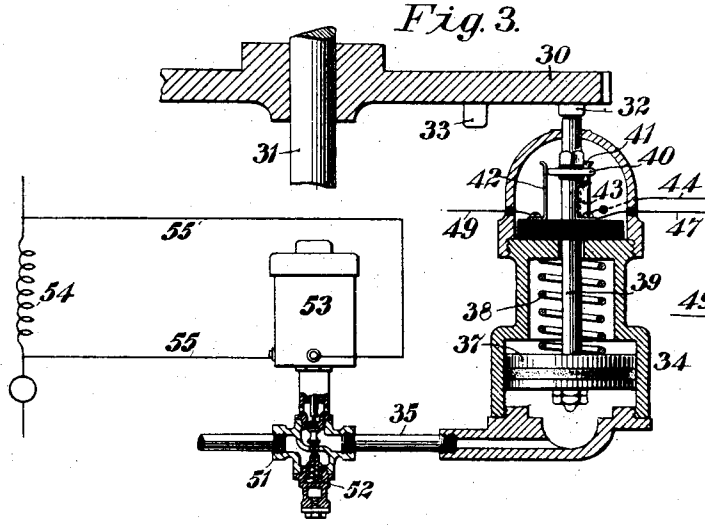


Fig. 4.

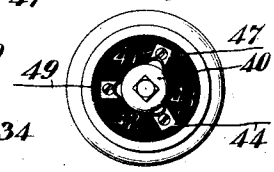
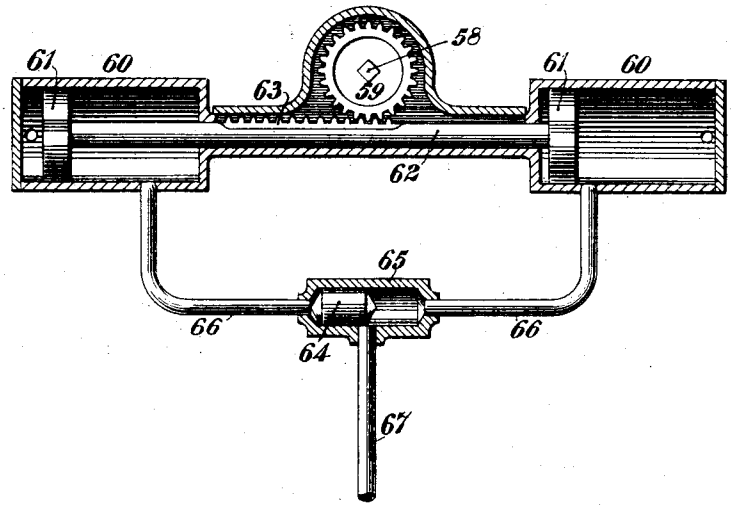


Fig. 5.



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Fig. 6.

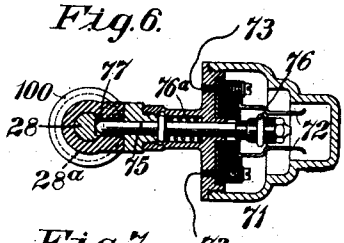


Fig. 7.

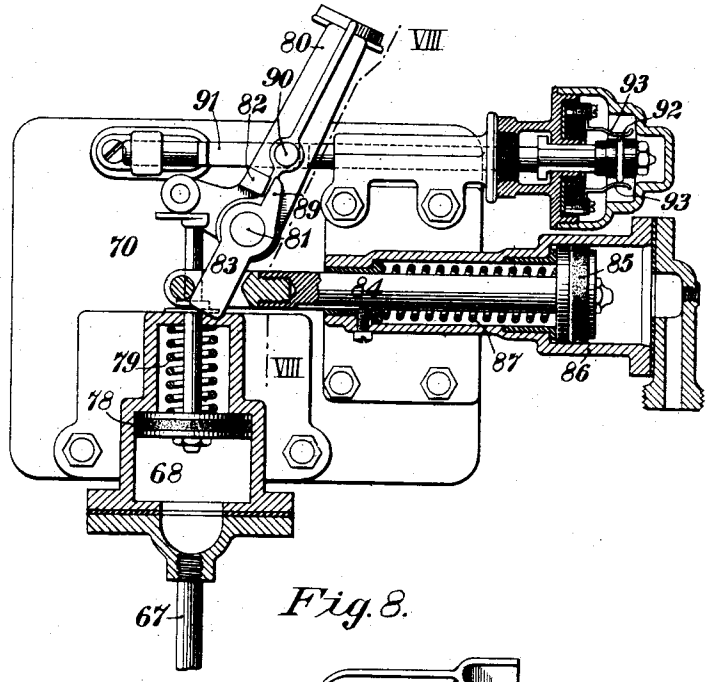
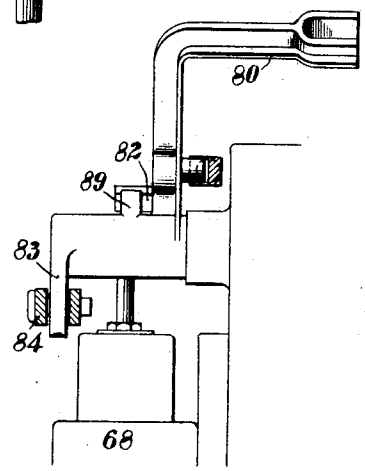


Fig. 8.



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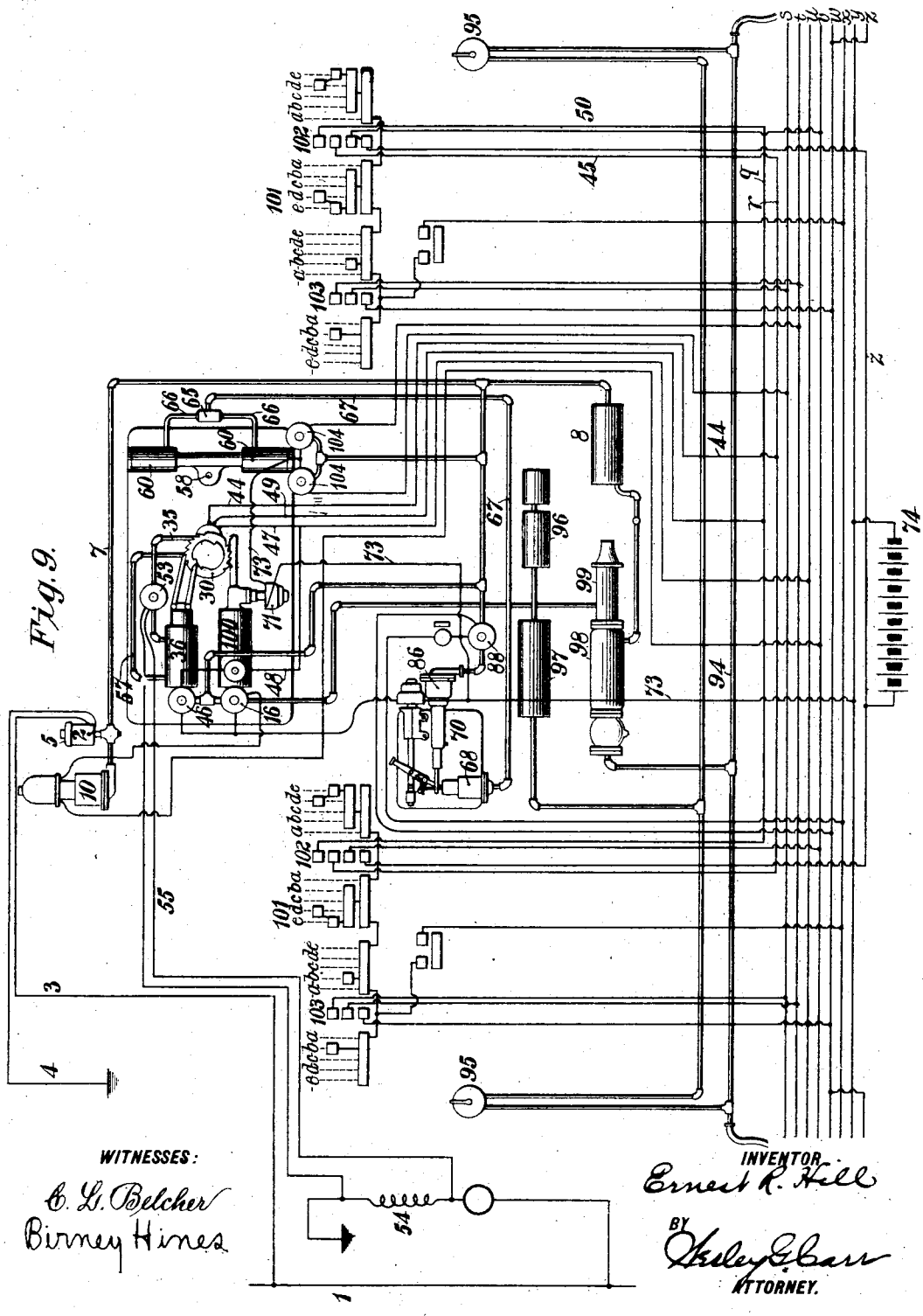
E. R. HILL.

CONTROLLING SYSTEM FOR RAILWAY VEHICLES.

(Application filed Sept. 20, 1900.)

(No Model.) 4 Sheets—Sheet 4.

Fig. 9.



THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

ERNEST R. HILL, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR TO GEORGE WESTINGHOUSE, OF PITTSBURG, PENNSYLVANIA.

CONTROLLING SYSTEM FOR RAILWAY-VEHICLES.

SPECIFICATION forming part of Letters Patent No. 684,609, dated October 15, 1901.

Application filed September 20, 1900. Serial No. 30,635. (No model.)

To all whom it may concern:

Be it known that I, ERNEST R. HILL, a citizen of the United States, residing at Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented new and useful Improvements in Controlling Systems for Railway-Vehicles, of which the following is a specification.

My invention relates to controlling systems for electrically-propelled vehicles; and it has special reference to such systems as embody means located at any selected point on a train of cars whereby a plurality of controllers on one car or on a plurality of cars may be operated in synchronism to start, stop, and vary the speed of the propelling-motors.

Specifically my invention relates to the electropneumatic controlling system covered by Patent No. 624,277, granted to George Westinghouse May 2, 1899; and it has for its objects, first, to provide a means whereby the failure of power for a sufficient length of time to appreciably reduce the speed of the train will effect the opening of the motor-circuit; second, to provide means for automatically stopping the operation of each controller of the system when it reaches full series position and also when it reaches full multiple position; third, to provide means for preventing the closing of the circuit-breaker until the reversing-switch has been thrown to one of its operative positions; fourth, to provide means for preventing the closing of the circuit-breaker except when the controller is in its off position, and, fifth, to provide means for preventing the operation of the controller when the circuit-breaker is open or for returning the controller to its off position when the circuit-breaker automatically opens, or for performing both of these functions.

With these ends in view I have devised the apparatus shown in the accompanying drawings, in which—

Figure 1 is a view, partially in section, partially in side elevation, and partially diagrammatic, of an electropneumatic means for opening the motor-circuit when the power fails for a predetermined length of time. Fig. 2 is a view similar to Fig. 1 of a modified means for effecting the same result. Fig. 3 is a view, partially in side elevation and partially in section, of a means for insuring definite stops for the controller at full series and full multiple positions. Fig. 4 is a detail plan view of the three-point switch shown in Fig. 3. Fig. 5 is a sectional view of a portion of the reversing-switch mechanism and the interlocking valve connection between the same and the circuit-breaker. Fig. 6 is a sectional view of a switch for effecting an interlocking connection between the circuit-breaker and the controller. Fig. 7 is a view, partially in elevation and partially in section, of the circuit-breaker and its attachments. Fig. 8 is a sectional view taken on line VIII VIII of Fig. 7. Fig. 9 is a diagrammatic view of the controlling apparatus for either a single car or a train of cars employing a series multiple controller and two hand-operated control-switches.

In another application filed by me January 13, 1900, Serial No. 1,374, I have illustrated, described, and claimed certain improvements upon the system set forth in the Westinghouse patent hereinbefore referred to, by virtue of which the operation of the system is rendered to a greater extent automatic and whereby certain safety features are incorporated therein. In the present application I have shown some of the devices which are illustrated and described in the Westinghouse patent and also in my earlier application; but in view of the illustration and description of such devices in the prior patent and application referred to an outline illustration in the drawings and an incidental reference in the description of the present application only will be given.

In the Westinghouse patent and in my prior application referred to the hand-operated control-switch was provided with an indicating device so operated by pneumatic pressure as to indicate to the motorman the several positions of the series multiple controller or controllers in service as soon as such positions were reached. Several of the features of my present invention, either as illustrated or when slightly modified, may be employed in connection with a manually-operated switch having an indicator. I have, however, omitted an indicator from the system as illustrated and have provided a means, to be hereinafter described, whereby a movement of the

control-switch handle to a given point will cause the series multiple controller or controllers of the system to be automatically actuated step by step from the off to the full series position and to be stopped and held at that position until the handle of the control-switch is moved to the position corresponding to multiple connection of the motors or backwardly to the off position. The means provided also insures an automatic movement of the controller or controllers from the full series position to the full multiple position and the stopping and holding of said controller or controllers in that position by moving the handle of the control-switch to its full on position.

Referring now particularly to Figs. 1 and 9 of the drawings and assuming that the power-circuit 1 has a ground-return, as indicated, I provide an electromagnet 2, properly wound for the voltage of the power-circuit, and connect the same across the power-circuit by means of the conductors 3 and 4, as indicated. The armature 5 of this magnet is connected to a valve 6, located in a pipe 7, leading from the supplemental reservoir 8 or other source of compressed air, so that when the magnet is energized by the power-current the valve-port 9 will be opened, so as to admit air to a cylinder 10 beneath its piston 11, and thus serve to actuate the piston in opposition to the coiled spring 12, which surrounds its stem 13. The stem 13 is provided at its upper end with a circuit-closing piece 14, which when the piston is raised by the air-pressure beneath it bridges the space between two contact-terminals 15, and thus closes the circuit of the controller-releasing magnet 16. With this arrangement it will be seen that if the power falls off materially or fails entirely the valve 6, actuated by a spring 17, will cut off the air-supply to the cylinder 10 and will open an exhaust-passage from the cylinder to the atmosphere through a restricted opening 18. The effective size of this opening 18 may be varied to suit any conditions by means of a set-screw 19. The opening 18 is made small in order that the motor-circuit will not be interrupted when the failure of power is only momentary. If, however, it lasts for sufficient length of time to materially reduce the speed of the train, the air will leak out to such an extent as to permit the spring 17 to open the switch 14 15.

In Fig. 2 the construction of the apparatus shown and its operation are the same as in Fig. 1, except that the magnet 2 is connected across the field-magnet winding 20 of one of the motors, and it may therefore be wound for low voltage and be consequently like or similar to the other magnets employed in connection with the controlling system. In this case, however, an additional device is provided, whereby the switch 14 15 is cut out or short-circuited when the controller is released. This device may take any one of a variety of forms. The one shown comprises a switch 21, the stationary contact-terminals 22 of which are connected, respectively, to the stationary contact-terminals 15 of the switch 14 15. The piston 23, which is actuated in one direction by a coiled spring 24, is provided with a stem 25, having a bridging contact-piece 26 for engagement with the stationary contact-terminals 22. The stem 25 projects below the piston and is here shown as having a small roller 27 journaled therein, which engages with one side of the stem 28 of the controller-releasing piston 28^a, the stem being cut away or milled out for a portion of its length at 29, so that when the air is exhausted from the controller-releasing cylinder and the piston is accordingly retracted the switch 21 will be opened; but when the piston is moved to its forward position, so as to return the controller to the off position, the roller 27 will ride out of the milled portion of the stem, and thus effect the raising of the piston 23, so as to close the switch 21 and short-circuit the switch 14 15. The length of the milled-out portion of the stem is preferably such that the switch 21 is kept closed until the controller has passed beyond the first point in the series connection of the motors. As soon as this point is passed the roller will drop into the milled-out portion or groove, and thus open the switch 21.

Referring now to Fig. 3 in connection with Fig. 9 of the drawings, the larger ratchet-wheel 30, mounted upon the controller-drum shaft 31, is provided on its under side with a projection 32, corresponding to that position of the controller-drum which provides a full series connection of the motors, and with a longer projection 33, corresponding to the full multiple position of the drum, these two projections being located in the arc of a circumference concentric with the drum-shaft. Located beneath the ratchet-wheel is a cylinder 34, connected at its bottom by means of a pipe 35 with the front end of the controller-operating cylinder 36 and provided with a piston 37, which is acted upon by a coiled spring 38 and having a stem 39, the upper end of which is located the same distance from the controller-drum shaft as the projections 32 and 33, so as to be projected into engagement with the one or the other of such projections when the controller is in the full series or the full multiple position. The stem 39 is also provided with a bridging contact-piece 40, that makes engagement with spring-contact terminals 41, 42, and 43 when the piston 37 is in proper position therefor. The contact-terminal 43 is shorter than the contact-terminals 41 and 42 and is electrically connected to the finger of the control-switch that provides multiple connection of the motors by means of conductors 44^r and 45. The contact-terminal 41 is connected to one terminal of the magnet 46 of the operating-cylinder by conductors 47 and 48, and the contact-terminal 42 is connected to the finger of the control-switch that insures series con-

nection of the motors by conductors 49[a] and 50. The pipe 35, leading from the front end of the operating-cylinder 36, is provided with a valve 51, which is normally in position to permit the passage of air through the pipe, but which is controlled by a spring 52 and an electromagnet 53, the latter being connected across the field-magnet winding 54 of one of the motors by conductors 55, so that if the current to the motors exceeds a predetermined maximum the magnet will shut off communication between the operating-cylinder 36 and the cylinder 34 and exhaust the latter to the atmosphere. So long as the piston-stem 39 is not beneath either the series projection 32 or the multiple projection 33 on the ratchet-wheel 30 it will be moved upward a sufficient distance to open the switch each time that the controller-operating piston moves forward and uncovers the port opening into the pipe 35. As soon as this switch is opened it obviously deënergizes the operating-cylinder magnet 46, and thus permits the operating-cylinder to exhaust, and the operating-piston is then retracted by its spring, when the circuit will be again closed through the action of the spring 38 on the piston of the automatic switch, and the action just stated will be repeated until either the projection 32 or the projection 33 on the ratchet-wheel comes into position to prevent the opening of the automatic switch. The stops on the ratchet-wheel for limiting its movement steps to the length desired are utilized in substantially the same way as in the Westinghouse patent hereinbefore referred to, the air being transmitted from the rear end of the operating-cylinder 36 through the pipe 57 for this purpose, as in the Westinghouse patent.

Referring now to Fig. 5 in connection with Fig. 9, the reversing-switch shaft 58, its pinion 59, the cylinders 60, pistons 61, and connecting-stem 62, provided with rack-teeth 63 to engage the pinion 59, are substantially the same as in the Westinghouse patent; but in order to prevent the closing of the circuit-breaker pneumatically prior to the complete throw of the reversing-switch in the one direction or the other I provide a check-valve 64, so located in a cylinder 65, connecting the adjacent ends of two pipes 66, leading, respectively, from the reversing-switch cylinders 60, near the inner ends thereof, that air admitted in front of either piston 61 can pass by pipe 67 to the cylinder 68, in which is located the closing-piston of the circuit-breaker 70, only after the reversing-switch piston has substantially completed its stroke. The air then passes into the check-valve cylinder 65 and forces the valve 64 over, so as to permit the air to pass to the circuit-breaker cylinder 68 from the reversing-switch cylinder to which the air was admitted to throw the switch and shut off communication between the other reversing-switch cylinder and the circuit-breaker cylinder.

Referring now to Fig. 6 in connection with Fig. 9, the interlocking switch 71 to prevent the circuit-breaker from being closed except when the controller is in the off position is of substantially the same construction as the switch illustrated in Fig. 2. In this case the stationary contact-terminals 72 are connected in the return-circuit 73 from the reversing-switch-cylinder magnets to the battery 74. The stem 75, having the circuit-closing piece 76, is normally held in such position that the circuit is open by means of a coiled spring 76[a], the inner end of the stem being at that time in engagement with a cut-away or milled portion 77 of the stem 28 of the controller-releasing piston 28[a]. Since this switch 71 is connected in the return-circuit from the reversing-switch magnets of the controller and these magnets also control the valve 64, supplying air to the circuit-breaker from the reversing-switch cylinders, it is impossible to close the circuit-breaker when this circuit is interrupted. When the controller is at the off position, the stem 75 will be in engagement with the unmilled portion of the releasing-piston stem 28 and the switch will be closed; but whenever the controller is in one of its on positions the stem 75 will be in engagement with the milled-out portion 77 of the releasing-piston stem, and the circuit will therefore be open. The same result could obviously be accomplished by means of an air-valve located in the pipe 67, leading to the circuit-breaker-closing cylinder and actuated to shut off the air when the controller is in any of its operative positions and to permit it to pass when the controller is released.

Referring now to Figs. 7 and 8 in connection with Fig. 9, the circuit-breaker-closing cylinder 68 is provided with a piston 78, that is actuated in one direction by a spring 79 and in the other direction by air, as is usual in apparatus of this character, the connection between this cylinder and the reversing-switch cylinders being by means of the pipes 67 and 66, as already indicated. The handle 80 for manually closing the circuit-breaker is mounted upon a shaft 81 and is provided on one side with a lug 82. Mounted loosely upon the shaft 81 is an arm 83, with which engages the stem 84 of a piston 85, located in a cylinder 86 and acted upon to move it outwardly by a coiled spring 87. The air-pressure which serves to force the piston inwardly is controlled by means of a valve and magnet 88. (Shown in outline in Fig. 9.) The arm 83 is provided at one side of the shaft with a projection 89 in position to engage the lug 82 on the handle and open the circuit-breaker whenever the air is exhausted from the cylinder 86. The circuit-breaker handle 80 is also provided with a pin 90, which engages with a stem 91, having at its outer end a contact-piece 92, that makes and breaks connection between two spring-contact terminals 93, that are in the circuit between the operating-magnet for the controller-drum and one of the

battery-terminals. This switch has the same construction as that shown in Fig. 6, except that it is not spring-actuated in either direction. When the circuit-breaker is open, the controller cannot be further advanced by means of the operating-piston, for the reason that this switch will be open. This switch may also be connected in circuit with the magnet 16, which controls the releasing-piston of the controller, as indicated, so that when the circuit-breaker is open the air-pressure at once stops the action of the controller-operating piston and also returns the controller to the off position. It follows, therefore, that the controller cannot be operated until the circuit-breaker is closed, since the closing of the circuit-breaker is necessary in order to complete the circuit of the controller-operating-cylinder magnet by means of the switch 92 93. The train-pipe 94, engineer's valves 95, pumps 96, main reservoirs 97, auxiliary reservoirs 98, brake-cylinders 99, supplemental reservoirs 8, and the piping between such apparatus, the operating-cylinders 36, releasing-cylinders 100, and the other coöperating parts, so far as have not been specifically illustrated and described, are or may be substantially the same in construction and arrangement as the corresponding parts in the Westinghouse patent above referred to. The hand-operated control-switches 101 are shown in Fig. 9 diagrammatically, the drums being developed to show the relative positions of the contact-pieces on the rotating members and the two sets of fingers 102 and 103 pertaining to each switch being shown in the position which they occupy when the circuits are all open. If the movable member of either switch be moved one step, so as to bring the contact-fingers, respectively, into either position *a* or position $-a$, the battery-current will flow through the magnet 88, and thus open the corresponding valve and admit air to the cylinder 86, thus setting the arm 83 of the circuit-breaker in a position to permit the closing of the breaker. A further movement to either position *b* or position $-b$ will close the battery-circuit through one or the other of the reversing-switch magnets 104, depending upon which direction the switch is moved, thus admitting air to the corresponding cylinder 60 to throw the reversing-switch and then admitting air to the cylinder 68 of the circuit-breaker, which closes the latter, provided it is not already closed. This closing of the circuit-breaker obviously closes the switch 92 93, thus placing the circuits in position for operating the controller. In position *c* or position $-c$ of the switch the battery-circuit is completed through the switch 14 15 and releasing-cylinder magnet 16, whereby the air is exhausted from the releasing-cylinder. When this position is reached, the apparatus is all in position for the beginning of the forward movement of the controller provided for in position *d* or position $-d$, in which the operating-cylinder magnet 46 is included in the battery-circuit.

It will be observed that the releasing-cylinder-magnet circuit established at position *c* or position $-c$ is maintained throughout the further forward movement of the switch and that if it is desired to run the car or train at a less speed than that provided by the full series position of the controller the switch may be turned back from position *d* or position $-d$ to position *c* or position $-c$ whenever the desired speed is attained, thereby cutting out the magnet 46 and preventing further movement of the controller so long as the control-switch remains stationary. If the control-switch is allowed to rest in position *d* or position $-d$ until the full series position of the controller is reached, there will be an automatic stop of the controller by means of the construction shown in Fig. 3, which has already been described. If it is desired to operate the controller further to connect the motors in multiple, the switch is moved to bring the fingers into position *e* or position $-e$, when the automatic acceleration of the controller will be resumed and continued until the full multiple position is reached, and then the controller will be stopped by means of the apparatus shown in Fig. 3. It will be understood, however, that a running speed between that corresponding to full series position and that corresponding to full multiple position may be secured by turning the switch back to position *c* or position $-c$ when the desired running speed is reached. The operation of the various interlocking and safety devices has already been described in connection with the description of construction of said apparatus, and further description here is therefore unnecessary.

The apparatus illustrated and described has been designed for practical service and has been found satisfactory and efficient; but it is not intended to limit the invention to any specific structural details, since these may be variously modified to effect the same results either in connection with the specific controller-operating devices shown or with others which may be known in the art or devised to take the place of those already known, and hence I do not desire to limit my invention except in so far as limitations may be imposed by the state of the art.

I claim as my invention—

1. In a controlling system for railway-vehicles, the combination with a controller, of a control-switch, electropneumatic means controlled by the switch for automatically imparting a step-by-step motion to the controller and means independent of the switch for stopping the controller at full series position.

2. In a controlling system for railway-vehicles, the combination with a controller, of a hand-operated control-switch, electropneumatic means controlled by the switch for automatically imparting a step-by-step motion

to the controller and means independent of the switch for stopping the controller at full multiple position.

3. In a controlling system for railway-vehicles, the combination with a controller, of a hand-operated control-switch, electropneumatic means controlled by a switch for automatically imparting a step-by-step motion to the controller and means independent of the switch for stopping the controller at full series position and at full multiple position.

4. In a controlling system for railway-vehicles, the combination with a controller, of a hand-operated control-switch and a three-point automatic make-and-break switch for [redacted] control-circuit whereby the controller is given a step-by-step movement when the control-switch is moved to a given on position.

5. In a controlling system for railway-vehicles, the combination with a controller and a pneumatically-actuated ratchet-and-pawl mechanism for operating the same, of electromagnetic means for directing and applying the pneumatic pressure, a manually-operated control-switch and an automatic switch pneumatically actuated to regulate the movement of the controller, and means carried by the controller for coöperating with the movable member of the automatic switch to effect positive stops of the controller at full series position and at full multiple position.

6. In a controlling system for railway-vehicles, the combination with a controller and a hand-operated control-switch therefor, of means for opening the motor-circuit a predetermined length of time after the energy from the power-circuit falls off or ceases.

7. In a controlling system for railway-vehicles, the combination with a controller and a hand-operated control-switch therefor, of a magnet connected to the power or motor circuit and means operated by said magnet to maintain the circuit of the control-switch closed under normal conditions, but serving to open said circuit when the said magnet is deënergized.

8. In a controlling system for railway-vehicles, the combination with a controller and pneumatically-actuated means for operating the same, of electromagnetic means for directing and applying pneumatic pressure, a hand-operated control-switch, an electromagnet connected to the power or motor circuit and means controlled by said magnet for opening and closing the control-switch circuit in accordance with the conditions of the power-circuit.

9. In a controlling system for railway-vehicles, the combination with a controller provided with a reversing-switch, of a circuit-breaker and means depending upon the throw of the reversing-switch for closing the circuit-breaker, said means being capable of operating only after said switch is thrown.

10. In a controlling system for railway-vehicles, the combination with a controller provided with a reversing-switch and with pneumatically-actuated means for operating the controller and the reversing-switch, of a circuit-breaker for the motor-circuit, means for applying the pneumatic pressure to close the same and pipe connections between the reversing-switch and circuit-breaker cylinders and a check-valve for preventing the transmission of pneumatic pressure to the circuit-breaker cylinder until the reversing-switch is thrown.

11. In a controlling system for railway-vehicles, the combination with a controller and pneumatically-actuated means for operating the same, of electromagnetic means for directing and applying the pneumatic pressure, a circuit-breaker for the motor-circuit and means for preventing the circuit-breaker from being closed except when the controller is in the off position.

12. In a controlling system for railway-vehicles, the combination with a controller and a reversing-switch, of a circuit-breaker for the motor-circuit, pneumatically-actuated means for operating the controller, reversing-switch and circuit-breaker, electromagnets for directing and applying the pneumatic pressure, electric circuits for said magnets and interlocking means connected to the controller-operating mechanism for preventing the closing of the circuit-breaker by pneumatic pressure except when the controller is in the off position.

13. In a controlling system for railway-vehicles, the combination with a controller and a circuit-breaker for the motor-circuit, of means actuated by pneumatic pressure for operating the controller in both directions and for closing the circuit-breaker, electromagnets and electric circuits for directing and applying the pneumatic pressure and means actuated by the circuit-breaker mechanism for opening the circuit of at least one of the controller-operating magnets when the circuit-breaker is opened whereby the operation of the controller is prevented when the circuit-breaker is open.

14. In a controlling system for railway-vehicles, the combination with a controller and a circuit-breaker for the motor-circuit, of pneumatically-actuated means for operating the controller in both directions and for closing the circuit-breaker, electromagnets and electric circuits for directing and applying the pneumatic pressure, a circuit making and breaking switch operated by the circuit-breaker mechanism to open the circuit of at least one of the controller-operating magnets when the circuit-breaker is opened whereby the operation of the controller is dependent upon closing the circuit-breaker.

In testimony whereof I have hereunto subscribed my name this 13th day of September, 1900.

ERNEST R. HILL.

Witnesses:
WESLEY G. CARR,
BIRNEY HINES.