No. 793,514. PATENTED JUNE 27, 1905.

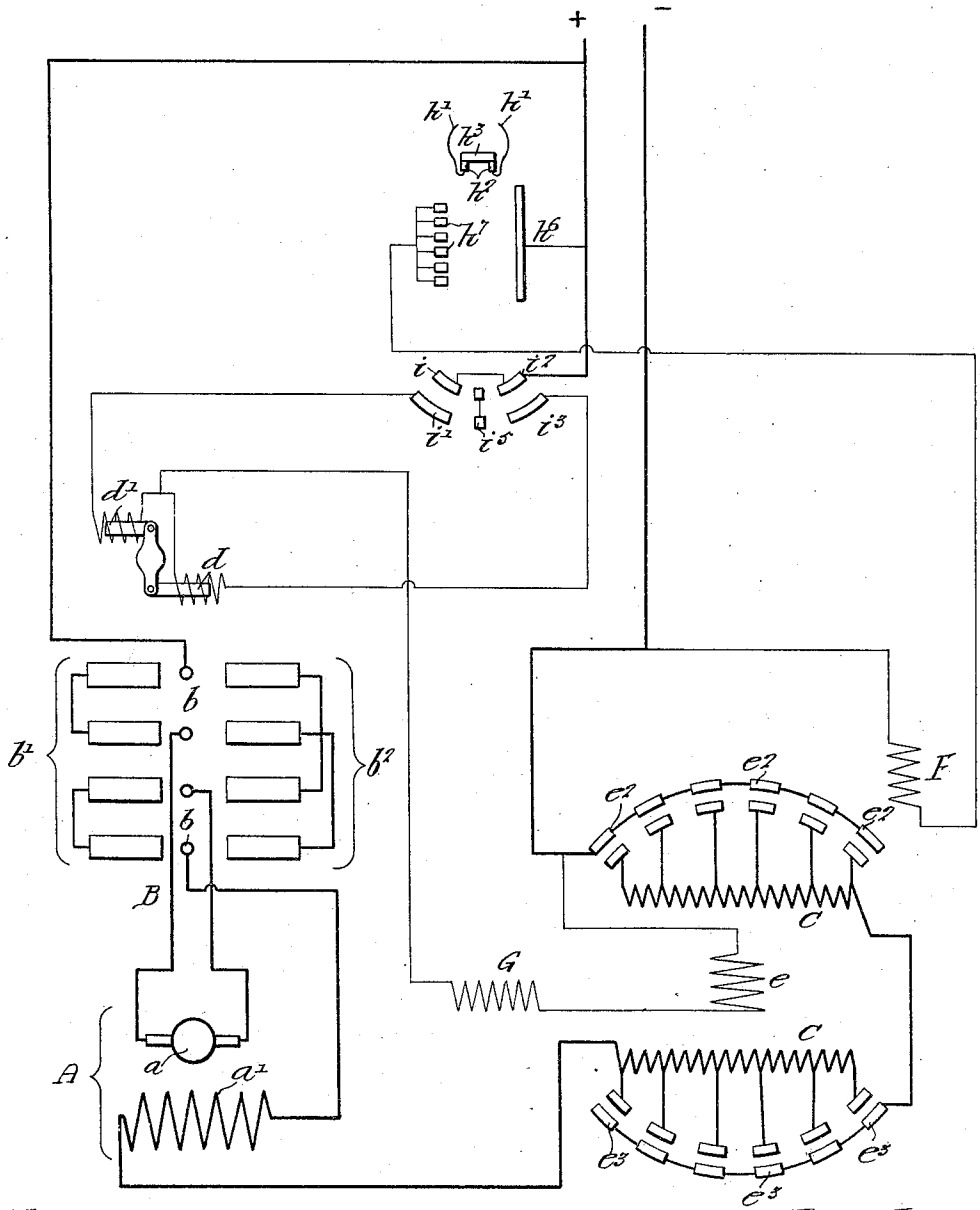
A. C. EASTWOOD.

CIRCUIT CONTROLLING SYSTEM.

APPLICATION FILED APR. 15, 1905.

5 SHEETS—SHEET 1.

Fig. 1.



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5 SHEETS—SHEET 2.

Fig. 5.

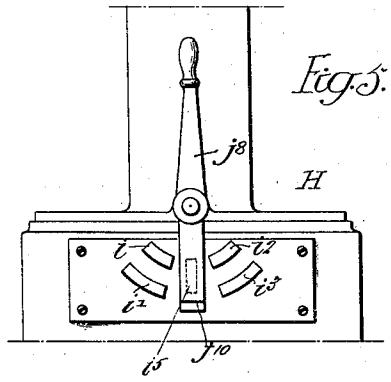


Fig. 4.

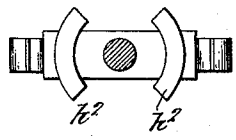


Fig. 3.

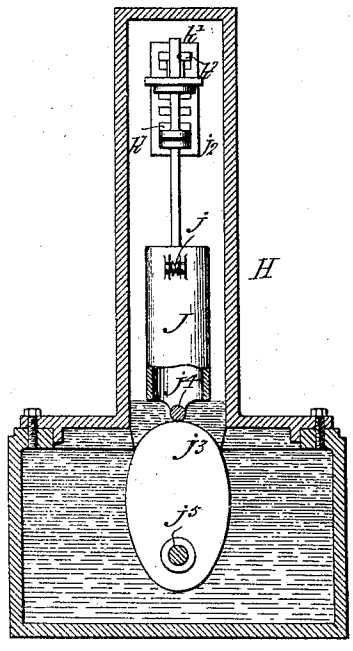
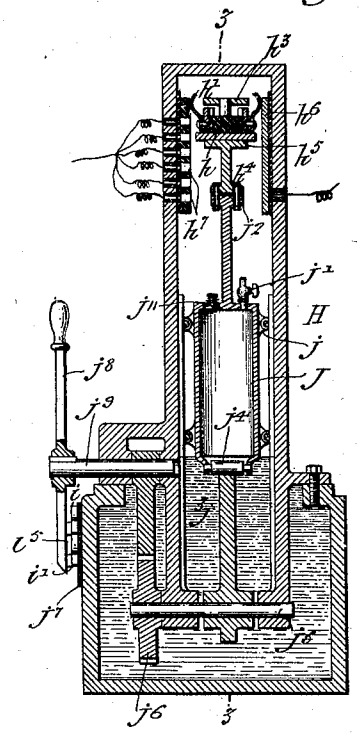


Fig. 2.



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5 SHEETS—SHEET 3.

Fig. 6.

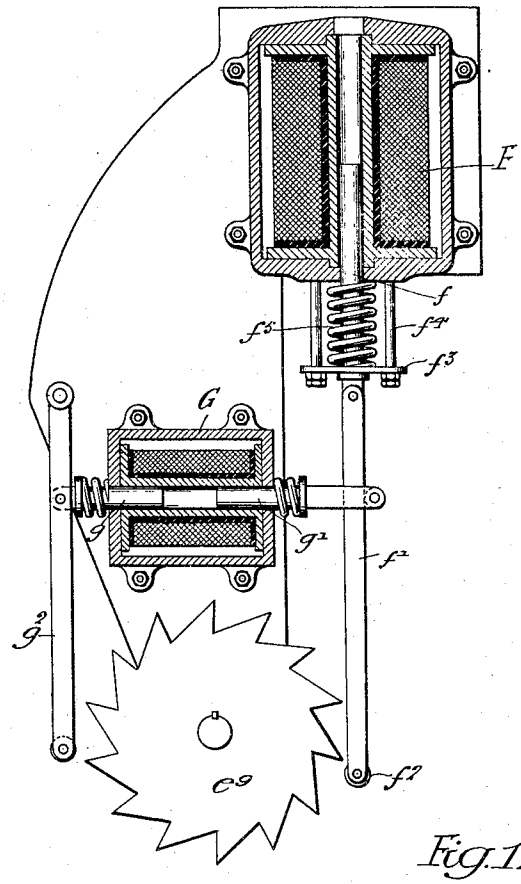


Fig. 7.

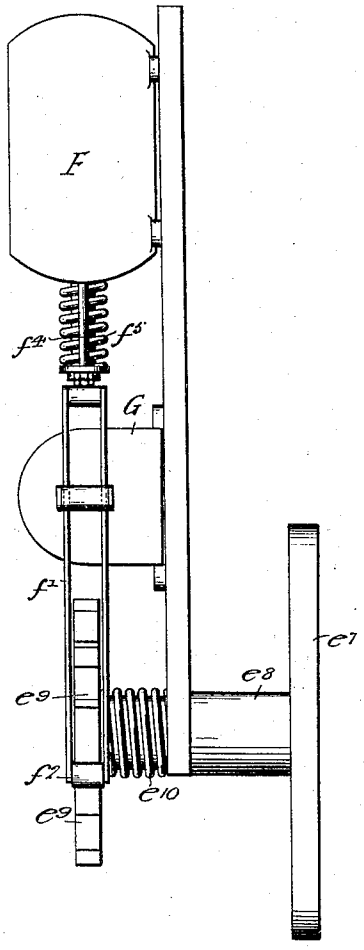
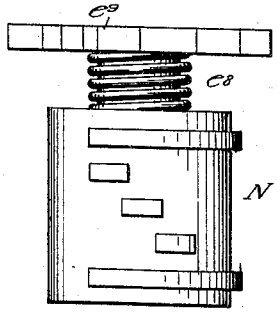


Fig. 11.



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5 SHEETS—SHEET 4.

Fig. 9.

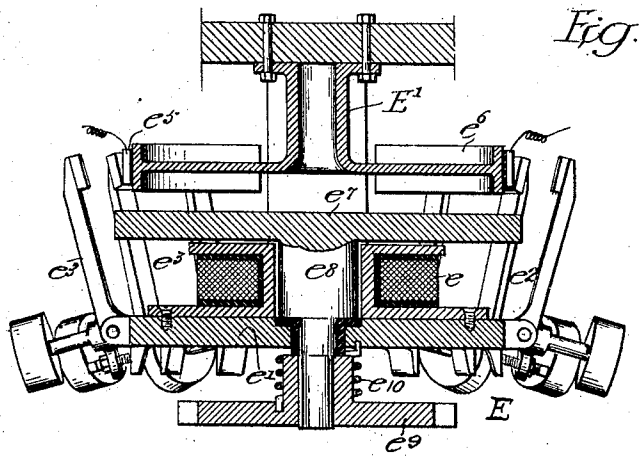
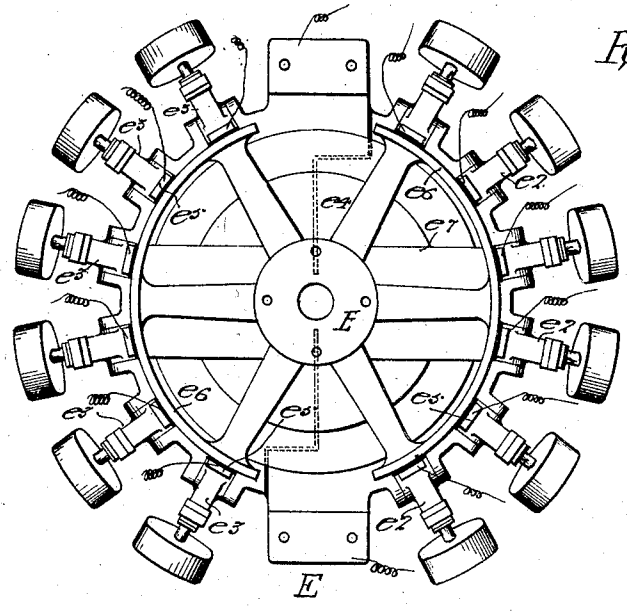


Fig. 8.



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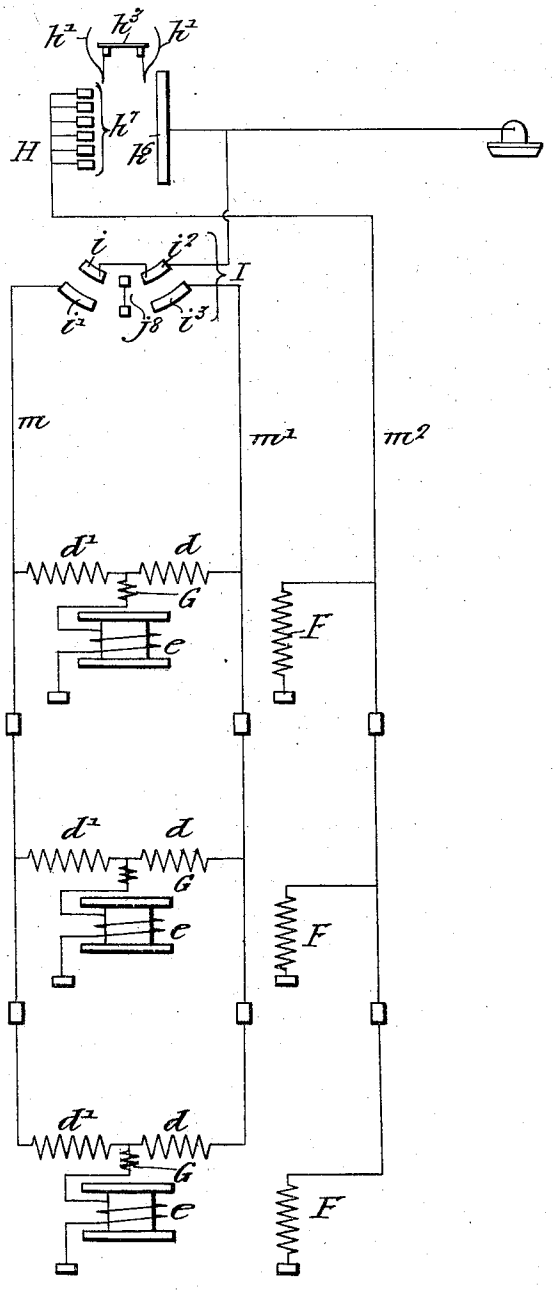
5 SHEETS—SHEET 5.

Fig. 10.



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UNITED STATES PATENT OFFICE.

ARTHUR C. EASTWOOD, OF CLEVELAND, OHIO.

CIRCUIT-CONTROLLING SYSTEM.

SPECIFICATION forming part of Letters Patent No. 793,514, dated June 27, 1905.

Application filed April 15, 1905. Serial No. 255,740.

To all whom it may concern:

Be it known that I, ARTHUR C. EASTWOOD, a citizen of the United States, residing in Cleveland, Ohio, have invented certain Improvements in Circuit-Controlling Systems, of which the following is a specification.

My invention consists of a combination of apparatus particularly designed for the control of electric motors by means of some form of master controlling device at a distance therefrom.

One of the specific applications of my invention is in connection with the multiple-unit system of control, whereby the motors comprising the propelling mechanism for a number of cars on an electrically-propelled train are controlled from a single point. Another application of the system is to the control of the motor or motors for operating a conveying-bridge of the type shown in my United States Patent No. 770,630, dated September 20, 1904.

In both of the above-mentioned cases experience has shown not only the desirability but also the necessity of providing a number of running speeds to meet the requirements of operation and has further demonstrated the fact that a given operative position of the master-controller lever must indicate to the operator a certain definite speed of operation. One of the ways of accomplishing this in the past has been to provide a series of magnetically-operated switches independently connected to the master-controller, in which case there were a number of wires between the controller and the switches equal to the number of said switches plus one. In such a system it is obvious that there is necessarily objectionable complication in the wiring, and this becomes in the case of a multiple-unit train a very serious item where connecting-couplings must be provided between successive cars. In the case of a conveying-bridge the large number of wires hitherto considered necessary is also most objectionable, particularly where the operator, with the master-controller, is in motion relatively to the magnetically-operated switches and the motor. In such a case trolleys and trolley-wires or other forms of sliding contact devices must be introduced between the master-controller and the main or magnetically-operated mechanism. It is obvious that the delays which may be experienced vary substantially as the square of the number of connecting-wires employed, because, first, the danger of open circuits, short circuits, and grounds increases directly as the number of wires employed, and, second, the delay requisite to locate or remedy a defect also increases directly as to the number of wires to be examined.

It is the object, therefore, of my invention to provide a system of control which, while answering all of the requirements of such a system as that above referred to, is of such a nature as to permit of a very material reduction in the number of conducting-wires between the master-controller and the apparatus operated.

A further object of the invention is to simplify the apparatus employed and also to reduce the expense of installing the same.

In connection with my improved system I preferably employ magnetic controlling mechanism for actuating the resistance-controlling switches of the main motor or motors, and this is similar to that shown in United States Patent No. 782,731, issued to me February 14, 1905. With this device only a single magnetizing-coil is required to actuate the controlling-switches, a structure forming a part of the magnetic circuit of said coil being moved to produce successive actuation of the switches. In order to produce a step-by-step motion of this revoluble portion of the magnetic circuit, I provide a solenoid in connection with a suitable ratchet device, controlling said solenoid by a master-controller. Each step or contact-point of this controller excites the winding of the solenoid and causes it to operate its plunger, with the result that the ratchet mechanism advances one tooth and causes closure of one or more of the resistance-controlling switches. To prevent the contact member of the main controller from passing over its successive contact-points so rapidly that the operating-solenoid cannot properly respond to each step or contact, I

provide means whereby even though the lever of the operating-controller be moved as rapidly as desired the contact member of the master-controller always travels over its contacts at a predetermined speed, and consequently remains a sufficient time in engagement with each contact to insure proper action of the ratchet-solenoid. This arrangement has the additional advantage of limiting the speed at which it is possible to cut out or otherwise vary the starting resistance, and consequently insures smooth acceleration of the motor and of its load without excessive current-flow.

The above-noted objects and advantageous method of operation I secure as hereinafter set forth, reference being had to the accompanying drawings, in which—

Figure 1 is a diagrammatic view illustrating the preferred apparatus and connections thereof comprising my invention. Fig. 2 is a sectional elevation illustrating the detail construction of my preferred form of master-controller. Fig. 3 is a sectional elevation taken on the line 3 3, Fig. 2, further illustrating the construction of the master-controller. Fig. 4 is a plan view, partly in section, illustrating the arrangement of contacts in the upper portion of the master-controller. Fig. 5 is a front elevation of the operating-handle and master reversing-switch actuated thereby. Fig. 6 is a sectional elevation of the ratchet locking and actuating solenoids. Fig. 7 is a side elevation of the mechanism shown in Fig. 6. Fig. 8 is a plan view of the magnetic switch-controlling device employed in connection with my system. Fig. 9 is a sectional elevation of the structure shown in Fig. 8. Fig. 10 is a diagrammatic view illustrating the connections of my system when applied to the control of a multiple-unit train, and Fig. 11 is a side elevation of a slightly-modified portion of one feature of my invention.

In Fig. 1 I have shown my system as applied to the control of a single motor A of the series type, its armature being indicated at a and its field-winding at a'. For the purpose of controlling the current-flow through this motor I preferably provide a reversing-switch of the drum type having fixed contacts b and two sets of movable contacts b' and b^2. For the purpose of turning this drum to bring either set of movable contacts into engagement with the fixed contacts I provide two solenoids d and d' in connection with certain mechanism indicated diagrammatically in the figure, but not further explained, inasmuch as it may be of any of the well-known forms known to the art.

For governing the amount of starting or speed-controlling resistance C in circuit with the motor A, I provide a form of magnetic switch-controller E illustrated in detail in Figs. 8 and 9 and including a fixed frame E', carrying a coil e, which is provided with a disk e', so placed as to form part of the magnetic circuit of the coil. To the periphery of this disk are pivoted a number of switch-blades e^2 and e^3, it being noted that the pivotal ends of the switches e^2 are insulated from the similar ends of the switches e^3 in any desired manner—in the presence instance by inserting insulating material between the two halves of the disk e', as indicated at e^4, Fig. 8. There is for each of the switches a contact e^5, and all of these are carried upon a frame e^6 in such manner as to be electrically insulated from one another. The blades of the switches are of magnetic material, and in order to actuate any of them I provide a bar e^7, forming an armature carried upon the core e^8 of the coil e in such manner that when said core is turned said armature is successively brought opposite different pairs of the switches e^2 and e^3. For the purpose of turning this armature and operating the switches I provide an actuating-solenoid and ratchet mechanism, (shown in Figs. 6 and 7,) it being noted that the core e^8 is provided with an extension carried in a suitable bearing on the frame E' and having fixed to it a ratchet-wheel e^9. This wheel, together with the armature e^7 and the core e^8, is normally held in a predetermined position by means of a spring e^{10}, having its ends respectively connected to the fixed disk e' and to said ratchet-wheel.

The actuating-solenoid F is supported in any desired manner and has attached to its core f a bar or bars f', provided with a roller f^2, placed to engage the teeth of the ratchet-wheel. A bar f^3 is fixed to the core, and there are bolts f^4 on the frame of the solenoid, serving as a stop for said bar and core. The bar f' and the roller, together with the core of the solenoid, are normally kept in their lower or outer position by means of a spring f^5, confined between the bar f^3 and the frame of said solenoid, and in order to prevent motion of the ratchet-wheel e^9 under the action of its spring e^{10} I provide a locking-solenoid G, having two cores g' and g, normally kept in their outer positions by suitable springs, as shown. The first of these cores is operative upon the bar f' and is so placed that while permitting longitudinal motion of the bar it swings it on its pivotal connection with the core f in such manner that the roller f^2 may be brought into engagement with the teeth of the ratchet e^9. The core g, on the other hand, operates upon a bar g^2, pivotally supported so that its free end may be moved into engagement with the teeth of the ratchet-wheel e^9 and prevent its revolution under the action of its spring e^{10}, its function being that of a pawl. In order to properly actuate the two solenoids F and G, as well as the coil e of the magnetic controlling mechanism E, I provide a master-controller H, which consists of a frame having within it a body of liquid, and also provide

electrical controlling mechanism in its upper portion, as well as upon its outer face.

It will be understood that in operating the magnetic controller E a series of successive current flows or impulses is necessary, and for this purpose I provide a vertically-movable contact-head consisting of a block h of insulating material, on which are carried two contacts h'. These are electrically connected to two plates h^2, normally insulated from one another, but having a contact h^3 carried upon the vertically-movable rod h^4 in such manner as to be capable of connecting said two plates h^2. It will be seen that the bar h^4, with its contact, is movable relatively to the block h of insulating material and its attached parts, so that if said bar be moved upwardly the contact h^3 first breaks connection between the two contacts h^2, after which a collar h^5 on said bar raises the block h. Placed to be engaged by one of the fingers h' and supported along one side of the casing of the controller is a plate h^6, while on the opposite side are a series of contacts h^7, electrically connected so as to be successively engaged by the second one of the fingers h' when the contact-head is moved up or down. In order to regulate the speed of such movement of the contact-head, I provide a form of dash-pot, including a cylinder J, vertically supported within the controller-casing and having rollers j operative upon suitable guideways. The lower end of this cylinder is open, while the upper end is provided with a valve j', whereby the escape of air from its interior may be regulated, and also with a check-valve j^{11}, constructed to automatically open when said cylinder is moved upwardly. As before noted, the lower portion of the casing is filled with liquid, such as oil, and in order to control the position of the cylinder J, which is connected to the rod h^4 by means of an insulating-coupling j^2, I provide a cam j^3, placed to engage a roller j^4, revolubly carried on the lower end of said cylinder. This cam is fixed to a spindle j^5, which also carries a pinion j^6, meshing with a toothed segment j^7, operated by the controller-handle j^8 through a spindle or shaft j^9. Fixed to the outside of the casing and carried upon a suitable plate of insulating material is a master reversing and controlling switch, including four segmental contacts $i\ i'\ i^2\ i^3$, designed to be electrically connected by a plate i^5, carried upon an extension of the operating-handle j^8, it being noted from Fig. 1 that the two contacts i and i^2 are permanently connected. From this diagram it will be seen that the actuating-solenoid F has one terminal connected to the various contact-plates h^7, while the contact-plate h^6 is connected to one side of the line and the second terminal of said solenoid is connected to the other side of said line. The two contacts i and i^2 are connected to the positive side of the line, while the contact i' is connected to the first solenoid d' of the reversing-switch, and contact i^3 is connected to the second reversing-solenoid d. The second terminals of these two reversing-solenoids are connected to each other and thence to the negative side of the line through the locking-solenoid G and through the winding e of the magnetic controller E. Under operating conditions if the lever j^8 is moved in one direction from its vertical position its plate i^5 will electrically connect one pair of the contacts adjacent thereto—for example, $i\ i'$—with the result that current will flow from the positive supply-main through said contact-plate i^5 to the reversing-solenoid d', locking solenoid G and winding e of the controller E. As a result the drum having the reversing-contacts b' and b^2 will be turned so that contacts b' will be brought into engagement with the fixed contacts b. The energization of solenoid G draws together the two cores g and g', and the solenoid e, while not immediately affecting the operation of the system, sets up a magnetic flux through its movable armature e^7, which is normally in a position at right angles to that shown in Fig. 8, and will not immediately affect the operation of the system. The turning of the lever j^8, in addition to causing the above-noted actions, moves the cam j^3 from under the cylinder J, so that this is free to move downward. As a result the plate h^3, carried by the rod h^4, connects the contacts h^2 of the traveling head, and as soon as one of the fingers h' engages the first of the contacts h^7 there is a current-flow to the actuating-solenoid F, which continues for a predetermined time, depending upon the position of the cam j^3 and the adjustment of the valve j' for permitting the escape of air from the cylinder J. As before noted, the locking-solenoid G was energized with the winding e, so that the drawing together of the two cores g and g' caused the rollers carried by the two bars f' and g^2 to engage with the teeth of the ratchet-wheel e^9. Consequently as soon as the solenoid F is energized the bar f' is drawn upward, and said ratchet, with the attached armature e^7, is turned through a predetermined arc so as to bring said armature in line with the first pair of switches e^2 and e^3. As a consequence said switches are closed and current is free to flow from the positive main through the reversing-switch B, armature a of the motor, back to the reversing-switch, the field a' of the motor, through the two banks of resistance C, and to the negative side of the line, thus starting the motor and permitting it to operate at its first or lowest speed. If the operating-handle j^8 has been turned to its full "on" position, it will be understood that the air-cylinder J and the head actuated thereby will continue to fall at a rate determined by the entrance of the liquid into the cylinder J, as permitted by the escape of air through valve j', so that after the first

current-flow through the actuating-solenoid F the finger h' will move off of the first contact h^7, and thereby cause deënergization of said solenoid. This permits the core f and the bar f' to be moved under the action of spring f^5 into the position in Fig. 6; but it will be noted that the ratchet-wheel e^9 and its bar e^7 are held from turning under the action of the spring e^{10} by the pawl-bar g^2. After a predetermined time, however, the continued downward movement of the contact-head causes the finger h' to strike the second of the contacts h^7, so that the solenoid F is again energized and made to raise its bar f'. This again turns the ratchet-wheel e^9 and the armature e^7 through a certain angle, so that said armature is brought opposite the second pair of switches e^2 e^3. The closure of these switches short-circuits two sections of the motor resistance, with the consequence that said motor speeds up, and it will be seen that the continued fall of the air-cylinder J, with its attached head, thus causes successive energizations of the solenoid F and consequent revolution of the ratchet-wheel and the armature e^7 until finally all of the switches e^2 e^3 have been successively closed and the motor is connected directly across the supply-mains without any of the resistance C in circuit. If the operating-lever j^8 be not turned to its full on position, but to some intermediate point between this and its "off" position, the air-cylinder J will fall until its roller j^4 engages the cam j^3, when further movement of the contact-head will be prevented. It will be noted, however, that after the downward movement of the said cylinder has ceased the portion h of the contact-head will still be free to move downwardly for a distance sufficient to break the connection between the contact-segments h^2 and the plate h^3 at the upper end of the rod h^4. Consequently it will be understood that the main motor will continue to run at a speed depending upon the position last given to the armature e^7, for the reason that said armature is held in this position by means of the locking-solenoid G, while the switches e^2 and e^3 are still held closed, owing to the fact that current still flows through the winding e. Owing, however, to the breakage of the connection between the contacts h^2 and h^3 the actuating-solenoid F is deënergized, so that current is thereby economized. It will be seen that in operating the controller from its full on position or from any of its intermediate positions to its off position the passage of the contact-fingers h' over contacts h^6 and h^7 is accomplished without sending a series of impulses to the actuating-solenoid F, owing to the above-noted open circuit between the contacts h^2 on the contact-head. As soon, however, as the contact-plate i^5 of the lever j^8 passes off of the segments i and i' the locking-solenoid G, as well as the winding e for the switches e^2 and e^3, are deënergized, as is also the reversing-solenoid d'. This permits the reversing-drum, with its contacts b' and b^2, to be automatically moved to the off position by any of the well-known devices used in the art for that purpose, in addition to which the cutting off of current from the coil e permits all of the switches e^2 and e^3 to open. The deënergization of the locking-magnet G releases both of the cores g and g', so that the two bars f' and g^2 are swung on their pivots under the action of their springs and their end portions thereby moved out of engagement with the teeth of the ratchet-wheel e^9, thus permitting this, with its armature e^7, to be turned to the off position under the action of the spring e^{10}. Moving the operating-handle j^8 in the opposite direction from that above described, so that its contact-plate i^5 connects with the segments i^2 and i^3, while causing the same operation of solenoids F and G and winding e, with their attached parts, as that above described, energizes the reversing-solenoid d, so that the contact-segments b^2 are moved into engagement with the fixed fingers b. As before, the cam j^3 permits the contact-head to move so as to successfully engage the contacts h^7 at a predetermined rate, or it may arrest such motion at any desired point, depending upon the position of the operating-handle. Since, however, the connections of the motor-armature have been reversed, it will be understood that said motor is started and accelerated so as to operate in a direction the reverse of that previously noted.

In Fig. 10 I have shown diagrammatically the connections of my system when applied to control the electrical equipment of the cars of a train, there being one or any number of the master-controllers H, including the master reversing-switch I, and connected by means of three train-wires m, m', and m^2 to various sets of controlling-solenoids, each similar to that shown in Fig. 1 and previously described. Each of the actuating-solenoids F is connected between the train-wire m^2 and the ground, while the reversing-solenoids d and d' each have a terminal respectively connected to the train-wires m and m' and their second terminals connected to each other and to one end of the winding e of the switch-controlling device, the second end of said winding being grounded. The locking-solenoids G are in each case connected in series with the switch-controlling winding e.

It will be understood that by adjusting the valve j'' on the cylinder J the rate of movement of the contact-head and the consequent time intervals between the successive actuations of the ratchet-wheel e^9 and the closure of the resistance-controlling switches e^2 and e^3 may be varied to bring the motor A up to full speed as quickly as desired. It will further be noted that by the use of a dash-pot, such as that formed by the cylinder J, the irregularity or uncertainty of operation hith-

erto characteristic of the well-known forms of dash-pots has been obviated.

It will be noted that the number of the main switches operated by movement of the controlling-lever j^8 through a given angle is always the same, so that the operator always knows to what point his motor will be accelerated by moving said handle to any position.

By connecting the windings e G and d or d' in series it is permissible to make them of larger-size wire than could be used if the coils were connected in multiple, the series connection therefore resulting in a less expensive construction, as well as one which is more substantial. In addition there is the advantage that if the winding of one of these coils should open circuit for any cause the circuit of all three would be opened, thereby also automatically opening the main motor-circuit.

It will be noted that my invention involves the valuable feature of protecting the motor from any failure and subsequent restoration of the supply-current, for if said motor were operating at full speed and the current should be cut off all of the solenoids would be de-energized, with the result that the armature e^7 would be automatically returned to its off position, as would also the switches controlled thereby. Even if the master-controller were left in its full on position no damage could result when the current was again restored to the line, since the motor-circuit, as above noted, would be open and the motor could not again be started until the master-controller was thrown to its off position and then operated in the regular manner.

If desired, the ordinary drum-type controller may be substituted for the winding e and its switches e^2 and e^3, in which case the spindle of said drum would merely be a continuation of the spindle or core e^8. Such a combination is shown in Fig. 11, in which N is the barrel of a controller revolved by the spindle e^8. It will of course be understood that it is immaterial whether such a drum-controller is connected directly in the main motor-circuit or is merely a master-controller governing the flow of current to the coils of electromagnetic switches.

I claim as my invention—

1. A circuit-controlling system including a number of electromagnetic switches, a common actuating-coil therefor having a movable member and placed so that the flux set up by it is available to directly cause operation of said switches, means for intermittently moving said member to operate the switches, and a device for controlling said means, substantially as described.

2. A current-controlling system including a number of electromagnetic switches, an electromagnetic device including a movable member so placed that the flux set up by said device is available for directly operating said switches, with means for automatically giving a step-by-step motion to said movable member and thereby causing successive actuation of the switches, substantially as described.

3. A circuit-controlling system including a series of automatic switches having a single actuating-coil provided with a movable pole-piece, electromagnetic mechanism for moving said pole-piece adjacent to successive switches, and means for intermittently energizing said mechanism, substantially as described.

4. A circuit-controlling system including a series of switches having a common actuating-coil, with means for successively actuating said switches, said means including an electromagnetic device and a hand-operated controller for intermittently energizing said device, substantially as described.

5. A circuit-controlling system including a series of independently-movable switches, means for automatically operating said switches, mechanism for actuating said means to cause successive operation of the switches, and a controller for intermittently energizing said mechanism, substantially as described.

6. A circuit-controlling system including a series of switches, a magnet for operating the same provided with a movable element, ratchet mechanism for moving said element, a solenoid for operating said mechanism, and a controller for intermittently energizing said solenoid, substantially as described.

7. A circuit-controlling system including a series of switches, a magnet for operating the same provided with a movable element, ratchet mechanism for moving said element, a solenoid for operating said mechanism, means for opposing operation of the ratchet mechanism, a device for locking the ratchet mechanism in a given position, and a controller for intermittently energizing said operating-solenoid, substantially as described.

8. A circuit-controlling system including a series of switches, a magnet for operating the same provided with a movable element, ratchet mechanism for moving said element, a solenoid for operating said mechanism, means opposing operation of the ratchet mechanism, a second solenoid having means for locking said mechanism in a given position, and a controller for intermittently energizing the switch-operating magnet, substantially as described.

9. A circuit-controlling system including a series of switches, and means for causing successive actuation of said switches, said means including a series of electrically-connected contacts, a contact-head having means for successively engaging said contacts, and means for controlling the position of said contact-head, substantially as described.

10. A circuit-controlling system including a series of switches, and means for causing successive actuation of said switches, said means including a series of contacts, an electromagnetic device connected to be energized from any of said contacts, a contact-head movable

to successively engage said contacts, and a device for controlling the position of said head, substantially as described.

11. A circuit-controlling system including a series of switches having a common electromagnetic actuating device, a member of said device being movable to cause operation of the respective switches, mechanism for moving said member, a solenoid for operating said mechanism, a series of contacts all in circuit with the solenoid, and a contact device for governing the flow of current to said contacts, substantially as described.

12. A circuit-controlling system including a series of switches having a common electromagnetic actuating device, a member of said device being movable to cause operation of the respective switches, mechanism for moving said member, a solenoid for operating said mechanism, a series of contacts in circuit with the solenoid, a movable contact member for supplying current to said contacts, and a hand-operated device for governing the action of said contact member, substantially as described.

13. A circuit-controlling system including a series of switches, mechanism for operating the same having an actuating-solenoid, a series of contacts in circuit with the solenoid, a member for successively connecting the contacts to a source of current, hand-operated mechanism for controlling the movement of said member, with a switch controlled by said mechanism in circuit with the connecting member, substantially as described.

14. A circuit-controlling system including a series of switches, mechanism for operating the same having an actuating-solenoid, a series of contacts in circuit with the solenoid, a member for successively connecting the contacts to a source of current, hand-operated mechanism for controlling the movement of said member, with a switch controlled by said mechanism in circuit with the connecting member, said switch being constructed to be operated when said mechanism is operated in one direction, substantially as described,

15. A circuit-controlling system including a series of switches, mechanism for successively operating the same including a series of contacts, a movable contact for successively connecting the contacts of said series to a source of supply, a switch carried thereby, and mechanism for controlling the movement of said movable contact, said mechanism including a handle operative in either of two directions and constructed to open the switch when operated in one direction, substantially as described.

16. A circuit-controlling system including a series of switches, mechanism including a series of contacts for successively operating the same, a contact member for successively completing the circuit through said contacts, means for causing said member to move at a uniform speed over the contacts, and means for controlling the amount of such movement, substantially as described.

17. A circuit-controlling system including a series of switches, mechanism including a series of contacts for successively operating the same, a contact member for successively completing the circuit through the same, a container having a body of liquid, an air-container attached to the contact member and movable into said liquid, with hand-controlled mechanism for governing the position of said air-container, substantially as described.

18. A circuit-controlling system including a series of switches, mechanism incuding a series of contacts for successively operating said switches, a contact member for successively completing the circuit through the same, a dash-pot having one member connected to said contact member, and a device for controlling the position of the member, substantially as described.

19. A circuit-controlling system including a series of switches, and mechanism for successively operating the same, said mechanism including a series of contacts, a contact member for successively completing the circuit through said contacts, a cam having operating means for controlling the position of said member, and means for causing said member to pass over its contacts at a uniform speed independently of said cam, substantially as described.

20. A circuit-controlling system including a series of switches, and mechanism for successively operating the same, said mechanism including a series of contacts, a contact member for successively completing the circuit through said contacts, a cam having operating means for controlling the position of said member, and a dash-pot for regulating the movement of the contact member independently of the cam, substantially as described.

21. A circuit-controlling system including a series of switches, and mechanism for successively operating the same, said mechanism including a series of contacts, a contact member for successively completing the circuit through said contacts, a cam having operating means for controlling the position of said member, a container having a body of liquid, an air-cylinder connected to the contact member and movable into the liquid, and means for turning the cam to permit movement of said contact member, substantially as described.

22. A circuit-controlling system including a series of switches, and mechanism for successively operating the same, said mechanism including a series of contacts, a contact member for successively completing the circuit through said contacts, a dash-pot having one element connected to the said contact member so as to permit of a limited movement thereof, a switch carried by and in circuit

with the contact member, said switch being operated by motion of the said dash-pot element, with means for controlling the position of the contact member relatively to the series of contacts, substantially as described.

23. A circuit-controlling system including a series of electromagnetic devices having means whereby they may be successively operated, said means including fixed contacts, a movable contact member therefor, a switch in circuit with said contacts, and means for controlling the movement of the contact member, said switch being placed to be opened whenever said controlling means is operated in a predetermined direction, substantially as described.

24. A circuit-controlling system including a series of electromagnetic devices having means whereby they may be successively operated, said means including fixed contacts, a movable contact member therefor, a switch carried by the contact member and in circuit with the same, and means for controlling the position of said contact member, said means having a portion placed to cause opening of the switch whenever operated in a predetermined direction, substantially as described.

25. A circuit-controlling system including a series of electromagnetic devices having means whereby they may be successively operated, said means including fixed contacts, a movable contact-head automatically movable in one direction over said contacts, an operating device for moving said head in the opposite direction, the same including a portion movable relatively to the remainder, with a switch carried by the head and placed to be opened when the said device is moved in a certain direction, substantially as described.

26. A circuit-controlling system including a series of electromagnetic devices having means whereby they may be successively operated, said means including fixed contacts, a movable contact-head automatically movable in one direction over said contacts, a switch carried by the head, a rod having a limited movement relatively to the head and placed to open the switch when moved in one direction, and an operating-handle having a cam operative on said rod for moving said head at will, substantially as described.

27. A circuit-controlling system including a series of electromagnetic devices having means whereby they may be successively operated, said means including fixed contacts, a movable contact-head automatically movable in one direction over said contacts, a switch carried by the head, a rod having a limited movement relatively to the head and placed to open the switch when moved in one direction, an operating-handle having a cam operative on said rod for moving said head at will, a solenoid also in circuit with the contacts and switch-operating mechanism actuated thereby, substantially as described.

28. A circuit-governing system including a controller having a rotatable element, and mechanism for operating said element including a solenoid for positively turning the same, means acting in opposition to said solenoid, a second solenoid for locking said element in a given position, and means including a hand-governed, gravity-actuated switch for governing the action of said solenoids, substantially as described.

29. A circuit-governing system including a controller having a rotatable element, and mechanism for operating said element including a ratchet-wheel, a solenoid for positively turning said wheel, a spring acting in opposition to the solenoid, a locking-pawl for the ratchet, a second solenoid for actuating said pawl, and a master-controller including a gravity-actuated make-and-break switch for governing the action of said solenoids, substantially as described.

30. A circuit-governing system including a series of controllers each having a rotatable element, and sets of mechanism for operating said elements, each set including a solenoid for positively turning an element, means acting in opposition to said solenoid, a second solenoid for locking said element in a given position, and a master-controller having a single device for intermittently supplying current to all of said first solenoids, substantially as described.

31. A circuit-governing system including a controller having a rotatable element, and mechanism for operating said element including a solenoid for positively turning the same, means acting in opposition to said solenoid, a second solenoid for locking said element in a given position, and means for governing the action of said solenoids, the solenoids being in different circuits, and the first having a mechanically-governed controlling device whereby it is intermittently energized, substantially as described.

32. A circuit-governing system including a controller having a movable element, mechanism for operating said element, including a solenoid, means tending to move the element in opposition to said solenoid, a second solenoid having one core for locking said movable element in position and a second core operatively connected to the core of the first solenoid, with means for controlling the current-flow to said solenoids, substantially as described.

33. A circuit-controlling system including a series of electromagnetic switches having a common actuating-winding whose magnetic circuit includes a movable member, pawl-and-ratchet mechanism for turning said member, and a master-controller for governing the operation of said mechanism, substantially as described.

34. A circuit-controlling system including a series of switches having a common actuating-winding whose magnetic circuit includes a movable member, pawl-and-ratchet mechan-

ism including a solenoid for moving said member, and a master-controller having means for intermittently energizing said solenoid, said switch-actuating winding and the solenoid being in different branch circuits, substantially as described.

35. A circuit-controlling system including a controller, a reversing-switch having operating means including a solenoid, mechanism including a second solenoid for operating one element of said controller, a master-controller, and two conducting-lines from said master-controller respectively in circuit with the said solenoids, substantially as described.

36. A circuit-controlling system including a controller, a reversing-switch having two operating-solenoids, mechanism including a third solenoid for operating the movable element of the controller, a master-controller, and three conducting-lines from said master-controller respectively in circuit with said solenoids, substantially as described.

37. A circuit-controlling system including a magnetic controller provided with a series of switches actuated from a single winding, a relatively movable member forming part of the magnetic circuit of said winding, a reversing-switch having two operating-solenoids, mechanism including a third solenoid for operating said movable member, a master-controller and three conducting-lines therefrom respectively connected to said three solenoids, the said controller-winding being in circuit with said reversing-switch solenoids, substantially as described.

38. A circuit-controlling system including a controller, a reversing-switch having two operating-solenoids, mechanism including a third solenoid for operating the movable element of said controller, a master-controller, and independent conducting-lines therefrom to the solenoids, said master-controller including means for intermittently energizing said third solenoid, substantially as described.

39. A circuit-controlling system including a controller, a reversing-switch having two operating-solenoids, mechanism including a third solenoid for operating the movable element of said controller, a master-controller and independent conducting-lines therefrom to the solenoids, said master-controller including means for intermittently energizing said third solenoid, and a switch for energizing at will either of the reversing-switch solenoids, substantially as described.

40. A circuit-controlling system including a magnetic controller provided with a series of switches actuated from a single winding, a relatively movable member forming part of the magnetic circuit of said winding, a reversing-switch having two operating-solenoids, mechanism including an actuating and a locking solenoid for operating said movable member, a master-controller, three conducting-lines therefrom to the solenoids, one of said lines being connected to the actuating-solenoid and the other two lines being respectively connected to the reversing-switch solenoids, with a connection common to said reversing-switch solenoids and including the controller-winding and the locking-solenoid, substantially as described.

41. A circuit-controlling system including a main controller constructed to be actuated by successive current-flows, a master controlling device including an operating-handle movable in either direction from its off position to cause intermittent current-flow to the main controller, reversing mechanism, and a switch for said mechanism placed to be operated when said handle is moved in either direction from its off position, substantially as described.

42. A circuit-controlling system including a main controller constructed to be actuated by successive current-flows, a master controlling device including an operating-handle movable in either direction from its off position to cause intermittent flow to the main controller, reversing mechanism including two solenoids, and a switch actuated by said operating-handle having contacts connected respectively to said solenoids, one contact being placed to be energized when the handle is moved in one direction and the other being placed to be energized when said handle is moved in the opposite direction, substantially as described.

43. A circuit-controlling system including a main controller constructed to be actuated by successive flows of current, a master controlling device including a dash-pot, means controlled by the dash-pot for causing intermittent current-flow to said main controller, and an operating-handle movable in either direction from its off position for governing the action of said dash-pot, substantially as described.

44. A circuit-controlling system including a main controller constructed to be actuated by successive flows of current, a master controlling device including a dash-pot, means controlled by the dash-pot for causing intermittent current-flow to said main controller, and an operating-handle movable in either direction from its off position for governing the action of said dash-pot, with reversing mechanism, and a switch therefor having one member connected to said operating-handle, substantially as described.

45. A circuit-controlling system including a main controlling apparatus and a master controlling device therefor, the same having an operating-handle, a cam connected thereto, a liquid-container, an air-cylinder vertically movable into the container and controlled by said cam, guiding means for said cylinder and a contact member connected to the cylinder for governing the current-flow to the main controlling apparatus, substantially as described.

46. A circuit-controlling system including a master-controller and a main controller governed thereby, with electromagnetic mechanism for operating said main controller, the same including a ratchet-wheel, an actuating-solenoid having an arm connected to its movable member, a locking-solenoid having two cores, and a pawl connected to one core, the second core being connected to the arm of the first solenoid, substantially as described.

47. Controlling apparatus for a multiple unit system including a master controlling device, a number of motor-controlling equipments, and three conductors extending from the master controlling device to the several equipments, each of said equipments including a series of switches, an actuating-solenoid for causing operation of said switches, and a reversing-switch having two operating-solenoids, the actuating and the reversing solenoids being respectively connected to the three conductors, substantially as described.

48. Controlling apparatus for a multiple unit system including a master controlling device, a number of motor-controlling equipments, and conductors extending from the master controlling device to the several equipments, said master controlling device having means for causing intermittent flows of current on one of the conductors, and each equipment having a series of switches, with an actuating-solenoid for causing operation of said switches, said solenoids all being connected to said conductor, substantially as described.

49. Controlling apparatus for a multiple unit system including a master controlling device, a number of motor-controlling equipments, and conductors extending from the master controlling device to the several equipments, said master controlling device having means for causing intermittent flows of current on one of the conductors, and each equipment having a series of switches, with an actuating-solenoid for causing operation thereof, said solenoids all being connected to said conductor, with reversing mechanism for each equipment including solenoids connected to others of said conductors, substantially as described.

50. Controlling apparatus for a multiple unit system including a master controlling device, a number of motor-controlling equipments, and three conductors extending from the master controlling device to the several equipments, each of said equipments including a series of switches, a single winding for operating the same, an actuating-solenoid for causing said switches to be operated successively, and reversing mechanism having two solenoids, all of the actuating-solenoids being connected to one of said conductors and each of the other conductors being connected to one reversing-solenoid of each equipment, the switch-operating winding of each equipment being connected in a line common to the reversing-solenoids thereof, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR C. EASTWOOD.

Witnesses:
NATHAN L. MILLER,
HENRY A. SHARPE.