B. McINNERNEY.

REGULATING STEP SWITCH.

APPLICATION FILED JUNE 28, 1907.

925,495.

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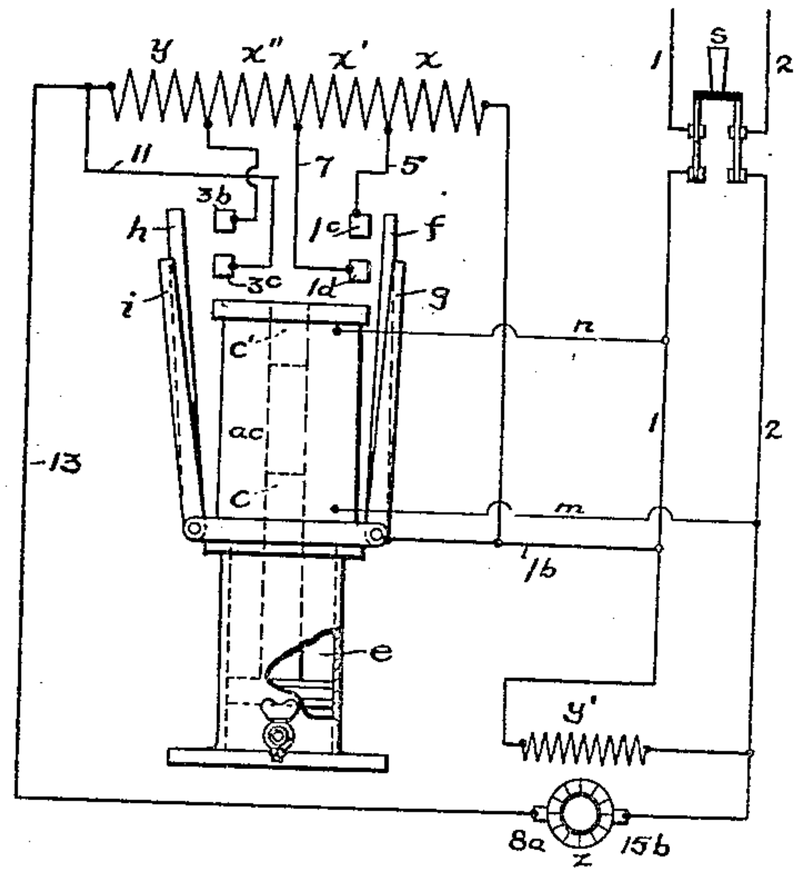
Fig. 1.



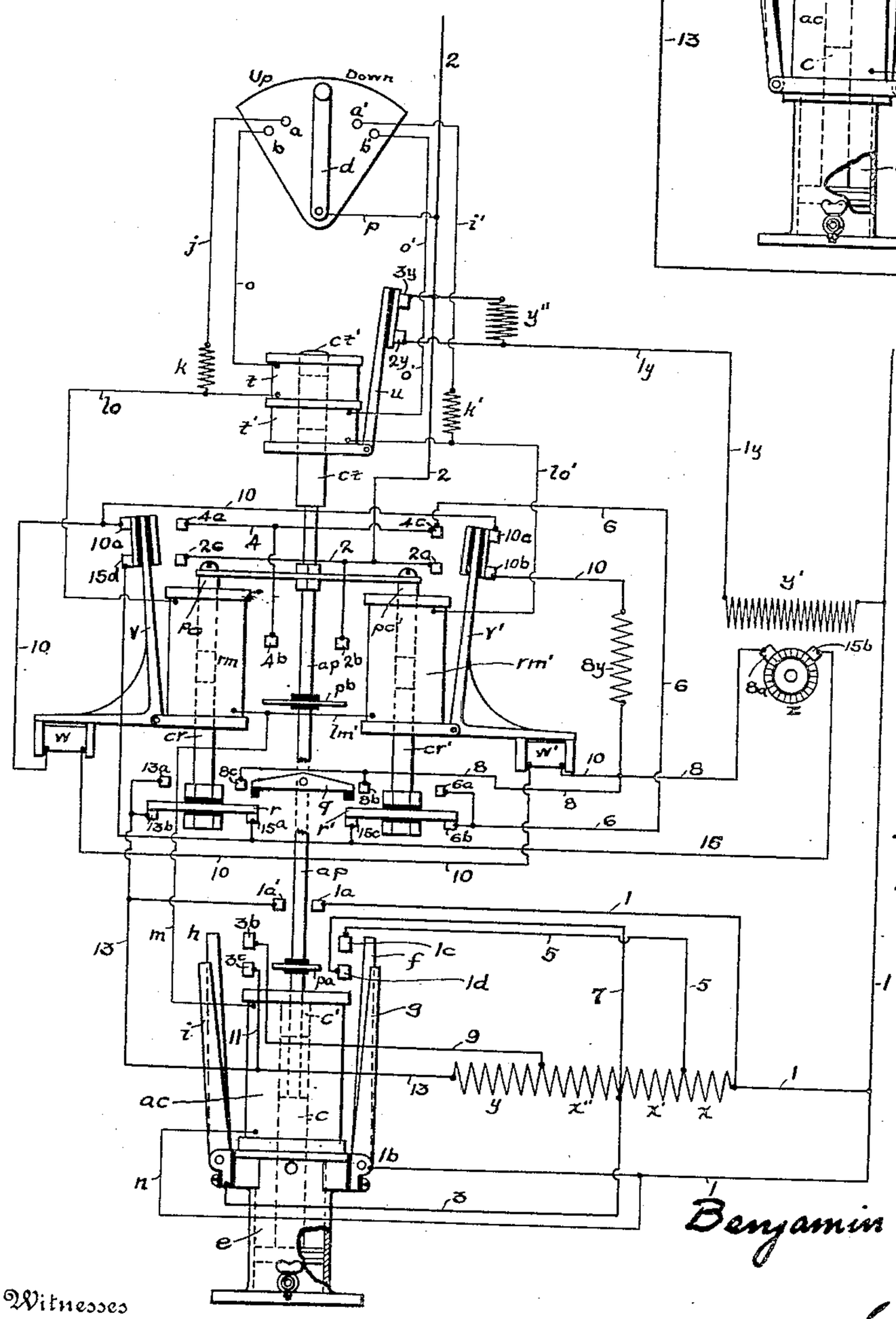


Fig. 2.

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REGULATING STEP-SWITCH.

No. 925,495. Specification of Letters Patent. Patented June 22, 1909.

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To all whom it may concern:

Be it known that I, BENJAMIN McINNERNEY, a citizen of the United States, residing at Council Bluffs, in the county of Pottawattamie and State of Iowa, have invented a new and useful Regulating Step-Switch, of which the following is a specification.

My invention relates to improvements in regulating switches in which a succession of magnetically actuated switches are stepped into action at intervals in the course of the movement of an actuated body or machinery and the objects of my said improvement are; first, to provide such step switch that the series of switches may be thrown in at intervals in the order desired; second, to provide such step-switch capable of regularly and definitely operating a succession of said switches by a single manipulation of the operating switch; third, to provide a means for automatically and regularly throwing in a succession of switches without the intervention of a motor for the purpose of supplying successive circuits, or throwing in or out successive resistances in circuits or in a single circuit; fourth, to provide such step-switch without mechanical means for actuating successively the steps of the said switch or mechanically controlling the same and having a minimum number of contacts and parts for adjustment; fifth, to provide such a step-switch in connection with means for reversing the current successively changed by said step-switch and means in connection therewith for changing power and intensity in circuits established and for locking said reversing switches against interference; sixth, to provide means in connection with the use of said step-switch to prevent operation of line switch except when reversing switch is properly disposed; seventh, to provide means to prevent the operation of both line and reversing switches in case step-switch is improperly disposed for initial operation; eighth, to provide means for preventing operation of field speeding switch until the step-switch has completed its functions; ninth, to accomplish these results and objects without the necessity of opening contacts and inserting extraneous resistances.

Other and further objects of my invention will appear in the description thereof.

I attain these objects by the mechanism and devices illustrated in the accompanying drawing, in which—

Figure 1 is a diagram of the step-switch connected in the circuit of an electric motor, and in which Fig. 2 is a diagram of such step-switch in connection with reversing switches, a motor circuit and an operating switch.

Similar letters and figures refer to similar parts throughout the several diagrams and views.

In many classes of electrical machinery it is desirable to produce by single manipulation of a switch, regular and successive changes in current or to throw in successive circuits or combination of circuits and in electrically operated machinery to thus automatically step in or out successive resistances or circuits. It is also highly desirable to provide means to prevent and to safe guard the operation of other switches to improperly operate the circuits and it is especially advantageous to accomplish these results without the opening of circuits and inserting extraneous resistances as it has been done heretofore.

While the device is here illustrated in connection with the use of a motor and especially a motor for use in the operation of an elevator or car, it may as well be adapted to other purposes as the throwing in or out of circuits for lighting purposes as sign circuits. In Fig. 1 the device is illustrated by the connection in the circuit of a motor without reference to its use or direction of motion. 1 and 2 are the respective lines furnishing current to the machinery, in which is interposed the switch *s*. In this circuit is placed the armature of the motor *z* with the brushes 8^a and 15^b. The line 2 is connected through the line *m* to the solenoid *ac* of the step-switch and the said solenoid *ac* is connected to the line 1 through the line *n*. *c* is a magnetic core arranged to move within the solenoid *c* and having any convenient means for retardation as the dash-pot *e*. A stationary core *c'* is also arranged to be magnetized by the solenoid *ac*. A series of switch levers or arms *f*, *g*, *h* and *i* which may be in any desired number are arranged to move from unequal distances by the magnetic attraction of the core *c'* when energized and respectively connect the line 1^b from the line 1 to the contacts 1^c, 1^d, 3^b and 3^c respectively. The said contacts 1^c, 1^d, 3^b and 3^c respectively connect the successive circuits, which may be used and varied in different systems to which the invention is applied. In the case for illustration the line 1 is con-

nected through the successive armature resistances x, x', x'' and y, or the resistance y may be a series field resistance. The usual shunt field is shown at y'. The contact piece 1^c is connected through the line 5 to the resistance x and x'. The contact piece 1^d is connected through the line 7 through the resistances x' and x''. The contact piece 3^b is connected to the resistances x'' and y. The contact piece 3^c is connected through the line 11 to the line 13 and line 13 connects to the brush of the armature 8^a.

When the step-switch having the solenoid ac is used in connection with a motor and means for reversing the same as in use for elevator or hoisting purposes it may be connected up as illustrated by the diagram in Fig. 2, in which a current in an operating circuit is employed with a motor or power circuit, but the former of which may be taken from the current of the latter. The switch bar d is supplied with current from line 2 through the line p and is arranged to make contact with the contact pieces a—b and a' b'. For the purposes of illustration the contact points a' and b' will be used to represent the contacts for a downward direction marked "Down" upon the diagram and the contact points a and b for an upward direction marked "Up" on the diagram. The contact a is connected through the lines j, 1^o and m to the step-switch of solenoid ac. And the step-switch solenoid ac is connected to the line 1 by the line n. The contact piece a' is connected through the lines i', $1^{o'}$, $1^{m'}$ and m to the solenoid ac. The line 1^o is joined to the line 1^m through the solenoid rm of a suitable reversing switch. And the line $1^{o'}$ is connected to the line $1^{m'}$ through the solenoid rm' of said reversing switch. The line 1 is connected to the levers f, g, h, i at 1^b and through the line 3 (Fig. 2). The switch levers f, g, h and i make contact respectively with the contact pieces 1^c, 1^d, 3^b and 3^c as heretofore described.

When reversing switches are used a suitable connection ap may be passed through the core c', operated by the core c. And upon the connection ap may be placed the movable cores pc and pc' of the reversing switches having the solenoid rm and rm' respectively. The cores cr and cr' are operated by energizing the solenoids rm and rm' respectively and a mechanical means of non-interference as by the lever q may be arranged to prevent both of said cores cr and cr' from holding up the switch plates or blades r, r' at the same time. Line 13 is connected to the contact pieces 13^a, 13^b and $1^{a'}$ and the contact piece 1^a is connected to the line 1. The contact pieces 8^c and 8^b are connected through the line 8 to the brush of the armature 8^a. The contact pieces 15^a and 15^c are connected through the line 15 to the brush of the armature 15^b. The line 2 may connect with the contact pieces 2^a and 2^c. And the contact piece 2^a may be connected by the lever v' to the contact piece 4^c and the contact piece 2^c connected by the switch lever v to the contact piece 4^a. And the contacts 4^a and 4^c are connected through the lines 4 and 6 to the contact pieces 6^a and 6^b, which are arranged to make contact with the plate r' of the reversing switch having the solenoid rm'. The contact piece 2^b is connected to the line 2 and the contact piece 4^b to the line 4. And the switch plate or blade pb is arranged to connect the contact pieces 4^b and 2^b. The contact pieces $1^{a'}$ and 1^a may be connected by the plate or switch bar pa upon the rod or connection ap. The line 15 may be also connected to the contact piece 15^d which by the switch v connects the contact piece 15^d to the contact piece 10^a. And the contact pieces 10^a and 10^c and 10^b are connected by the line 10 and the contact pieces 10^c and 10^b are connected by the switch v'. In the line 10 are the magnet coils w' and w arranged to act respectively upon the switches v' and v. And in the same line 10 may also be placed suitable dynamic brake resistance 8^y. The magnet coil w' when energized is arranged to hold the switch v', connecting the contacts 10^b and 10^c and breaking the connection between contacts 4^c and 2^a. The magnet coil w is arranged to hold the switch v connecting the contacts 10^a and 15^b and breaking the connection between contacts 4^a and 2^c. Upon the switch d may also be placed the contacts b and b'. The contact b is connected by the line o to the solenoid t. And the solenoid t is connected to the line 1^o. The contact piece b' is connected by the line o' to the solenoid t' and the solenoid t' is connected with the line $1^{o'}$. The core ct upon the connection ap is arranged to be energized by the solenoids t and t' and which said core ct is movable with relation to said solenoids t and t'. The core ct' is also energized by the solenoids t and t' and the switch u is actuated by the magnetic energy of the solenoids t and t' respectively. In the line between 1 and 1^y the usual shunt field y' may be placed and the line 1^y connected to the contact piece 2^y and the speeding resistance y'', which speeding resistance is also connected with the contact piece 3^y. The contacts 3^y and 2^y are closed by the switch u. The resistance k in the line j and k' in the line i' may be supplied for equalizing the current in the operating circuit.

In my invention the commencement of action of the switch levers f, g, h, i, v, v' and u is dependent upon their adjusted distance from the cores of the solenoids attracting them and the reluctance of the magnetic circuit. The switch levers f, g, h and i upon the step-switch having the solenoid ac are constructed to occupy such relative positions

to the core c' of the said step-switch having the solenoid ac as may be desired for the purposes for which the switch is used and in the present illustration at regular proportionate distances. As the core c by the action of a current in the solenoid ac is gradually raised against any suitable retardation as the dash-pot e, the core c of the cores is reduced and the magnetic field increased as the core c approaches the core c'. Likewise in the reversing switches having the solenoids rm and rm' respectively, the movement of the cores r and r' toward the respective cores pc and pc' increases the magnetic field of said cores and at the proper position of said cores operate the respective switches v and v'. Likewise the core ct approaching the core ct' changes the magnetic field of said cores to actuate the switch u at the desired period. In this manner it is unnecessary to have any mechanical means to operate or control the respective levers f, g, h and i of the step-switch or to vary or change their distance from or to the energizing cores. By supporting the cores pc and pc' of the reversing switches r and r' upon the connection ap and moving them thereby the reluctance of the magnetic circuits is sufficient to prevent the operation of both of said switches r and r' and they will remain closed upon the respective contacts 13^b and 15^a, and 15^c and 6^b when the core c of the step-switch having the solenoid ac is at or near the extremity of its upward movement, and the operation of the switches v and v' is prevented from closing upon the respective contacts 4^a and 2^c or 4^c and 2^a.

The operation of my invention is illustrated as follows:—The switch d is moved upon the contact a, and a current through the line j and 1^o energizes the solenoid rm and through the line lm and m energizes the solenoid ac, the current passing through the line n out through the line 1. When the core c of the step-switch is in position for initial operation the switch r opens on the contacts 13^b and 15^a and closes on the contacts 13^a and 8^c; the core cr being in close proximity to the core pc, the magnetic field is strong and operates the switch v opening it upon the contacts 10^a and 15^b and closing it upon the contacts 4^a and 2^c. The circuit is therefore established through the line 2 the switch v, the line 4, the line 6, the switch r' through the line 15 to the armature brush 15^b, the motor z, the brush 8^a, the line 8 through the switch r, the line 13, through the resistances y, x'', x' and x out to the line 1. The current through the connections just described tends to start the motor at a slow speed. The operating current through the solenoid ac gradually raises the core c against its retarding effect as the dash-pot e, and as it rises the magnetic reluctance decreases and the strength of the magnetic field of the solenoid ac is increased as the core c approaches the core c'. The switch f is first operated by reason of being first in order of position of the switches f, g, h and i. Upon the operation of the switch f, the current through the line 13, resistances y, x'' and x' passes through the line 5 and the switch f to the line 1, cutting out the armature resistance x. Upon further movement of the core c the lever g is in the same manner operated and the current through 13, resistances y and x'' passes through the line 7 and the switch g to the line 1. In the same manner the switch h is operated upon the contact 3^b and the current through 13 and the resistance y passes through the line 9, the switch 8 and the line 3, the line 7, the switch g to the line 1 as heretofore described. Likewise the lever i is operated to close upon the contact 3^c, sending the current from 13 through the line 11, the switch i as heretofore described to the line 1, short circuiting all of the resistances x, x', x'' and y. The switch plate or bar pa upon the connection ap may then be arranged to close upon the contacts la and $1^{a'}$ short circuiting the step-switch having the solenoid ac. The switch pb upon the connection ap may in a like manner be arranged to close upon the contacts 4^b and 2^b short circuiting the switch v or the switch v' if the latter be closed upon the contacts 2^a and 4^c. During this operation the current from 2, passes through the contacts 3^y and 2^y and the switch u, the line 1^y and the shunt field y' to the line 1.

Having changed the speed of the motor after the operation herein described, additional points upon the switch d may be provided as b, which will in addition to energizing the solenoids rm and ac energize the solenoid t and when the core ct has reached the core ct' and the field of the solenoid t becomes strong enough, it will operate the switch u and increase the shunt field resistance y' by addition of the resistance y''. It is obvious that in the same manner other speeding resistances might be stepped in as the armature resistances are stepped out.

When the switch d is thrown off from the contacts b and a by the operator the solenoids t, rm and ac are not further energized and the switches f, g, h, i open and the connection ap opens the switch pa on the contacts $1^{a'}$ and 1^a and the motor circuit is broken. The switch v likewise opens upon the contacts 4^a and 2^c and closes the contacts 10^a and 15^d and the circuit of the motor through the lines 15, 10, the dynamic brake resistance 8^y and the line 8 is completed, thus resisting the movement of the armature z of the motor. The magnet coils w and w' are energized and hold the switches v and v' respectively to close the contacts 10^a and 15^d, and the contacts 10^c and 10^b; and the coils w and w' have an energy over the effect of

coils *rm* and *rm'* respectively, when switches *v* and *v'* have position shown in drawing (Fig. 2) thus preventing the operator from again closing switches *v* and *v'* until motor armature *z* has come to rest. In similar manner the operation of the switch *d* upon the contact *a'* operates the switch having the solenoid *rm'* and the switch having the solenoid *ac*, closing the motor circuits through the line to the switch *v'*, the line 6, the switch *r'*, the line 8 the armature *z* of the motor, the line 15, the switch f^a to the line 1; moving the armature *z* of the motor in the opposite direction to the one formerly described. As the cores *pc* and *pc'* are by the movement of the core *c* and the connection *ap* moved away from the cores *cr* and *cr'*, the field of the respective solenoids *rm* and *rm'* is weakened. And if the solenoid *rm* be energized only when the switch *r* is closed upon the contacts 13^a and 8^c, and from any cause the solenoid *rm* becomes energized while the switch *r'* is closed upon the contacts 15^c and 6^b, the field of the solenoid will be too weak to operate the switch *v'*. By use of any suitable lever as *q* the operation of the switch *r* to close upon the contacts 13^a and 8^c can be arranged to prevent the operation of the switch *r'* to close upon the contacts 8^b and 6^a in case there is any derangement of the mechanism.

Having thus described my invention, I am aware that more or less imperfect mechanical step-switches have been used before my invention thereof, but

What I claim and desire to secure by Letters Patent is:—

1. In a regulating step-switch, a magnetic circuit, a movable member actuated by said magnetic circuit and adapted to vary the intensity of the field of said magnetic circuit, and a series of unequally disposed switches within the operating range of said field.

2. In a regulating step-switch, a magnetic circuit, a movable member actuated by said magnetic circuit and adapted to vary the intensity of the field of said magnetic circuit and a series of unequally disposed switches within the range of said field adapted to be successively operated by such variation of the intensity of said magnetic field.

3. In a regulating step-switch, a solenoid, a core operated by said solenoid and movable to change the intensity of the field of the magnetic circuit of such solenoid and a series of switches disposed at varying distances within the operating range of said field adapted to operate successively by such change of intensity of said field.

4. The combination of, an operating circuit, a solenoid therein, a core moved by the magnetic circuit of said solenoid to change the intensity of the field of said solenoid to operate in succession a series of switches disposed at varying distances within the range of operation of said field, and circuits controlled by said series of switches.

5. The combination of, an operating circuit, a solenoid therein, a core moved by the magnetic circuit of said solenoid to change the intensity of the field of said solenoid to operate in succession a series of switches disposed at varying distances within the range of operation of said field.

6. The combination of, an operating circuit, a solenoid therein, a core moved by the magnetic circuit of said solenoid to change the intensity of the field of said solenoid to operate in succession a series of switches disposed at varying distances within the range of operation of said field, and means for retarding the movement of said core.

7. The combination of, an operating circuit, a solenoid therein, a core moved by the magnetic circuit of said solenoid to change the intensity of the field of the solenoid to operate in succession a series of switches disposed at varying distances within the range of operation of said field, circuits controlled by said series of switches, and means for retarding the movement of said core.

8. In an automatic step-switch, the combination of an operating circuit, a magnetic circuit created thereby, a stationary pole piece and a movable member in said magnetic circuit, a series of switches disposed at varying distances from said stationary pole piece adapted to be magnetically operated in succession by the gradual movement of said movable member to change the intensity of the field of said magnetic circuit.

9. In a regulating step-switch, a magnetic circuit, a movable member actuated by said magnetic circuit and adapted to vary the intensity of the field of said magnetic circuit and a series of unequally disposed switches within the range of said field adapted to be successively operated by such variation of the intensity of said magnetic field, and a switch upon said movable member short-circuiting said series of switches.

10. In a regulating step-switch, a magnetic circuit, a movable member actuated by said magnetic circuit and adapted to vary the intensity of the field of said magnetic circuit and a series of unequally disposed switches within the range of said field adapted to be successively operated by such variation of the intensity of said magnetic field, and reversing switches.

11. The combination of an operating circuit, a solenoid therein, a stationary core, a movable core operated by the magnetic field of said solenoid with means for regulating the approach of said cores to magnetically operate at intervals, a series of switches disposed within the range of the field of said cores.

12. The combination of a solenoid having

a stationary core and a movable core operated by said solenoid with means for regulating the movement of said movable core to operate in succession a series of switches and a secondary switch operated by a secondary solenoid and a core attached to and moving with the movable core of said first mentioned solenoid.

13. The combination of a regulating step-switch having a solenoid, a stationary core, a movable core, a series of unequally disposed switches and reversing switches having actuating solenoids with cores movable with the core of said step-switch to vary the intensity of the field of said reversing switches.

14. The combination of a regulating step-switch having a solenoid, a stationary core, a movable core, a series of unequally disposed switches and reversing switches having actuating solenoids with cores movable with the core of said step-switch to vary the intensity of the field of said reversing switches and auxiliary switches operated by the solenoids of said reversing switches.

15. In a regulating step-switch, a magnetic circuit, a movable member actuated by said magnetic circuit and adapted to vary the intensity of the field of said magnetic circuit, and a series of unequally disposed switches within the operating range of said field, and a secondary magnetic circuit and a movable pole piece attached to and moving with said movable member to vary the intensity of said secondary magnetic circuit and a switch operated by said secondary magnetic circuit.

16. In a regulating step-switch, the combination of an operating circuit, a solenoid, a stationary core, a movable core, a series of unequally disposed switches, reversing switches, and a secondary solenoid having a core movable with the core of said step-switch and a secondary switch operated by said secondary solenoid, said secondary switch and said series of switches operating respective circuits.

17. The combination of an operating circuit, reversing switches and a solenoid therein, a stationary core in said solenoid and a core operated by said solenoid and movable to operate in succession a series of switches and a secondary switch operated by the magnetic field of a secondary solenoid in said operating circuit and a core moved in said secondary solenoid.

18. The combination of an operating circuit, a step-switch therein having a movable core, means for retarding the movement of said core, a secondary solenoid in said operating circuit, a core movable in said secondary solenoid and connected with said first mentioned movable core and an auxiliary switch operated by said secondary solenoid and core and a motor circuit controlled by said auxiliary switch and step-switch.

19. The combination of a regulating step-switch having a mechanically retarded movable core and magnetically operating a series of switches in succession, reversing switches, and auxiliary switches operated by said reversing switches and means for rendering said auxiliary switches inoperative.

20. The combination of an operating circuit, a regulating step-switch therein, a means for short circuiting said step-switch, reversing switches, auxiliary switches operated by said reversing switches, a means for rendering said auxiliary switches inoperative and a motor circuit controlled by said step-switch, reversing switches and auxiliary switches.

21. The combination of an operating circuit, reversing switches and a series of switches successively operated by varying the intensity of a magnetic field created by said operating circuit, auxiliary switches operated by said reversing switches and means to mechanically interlock said reversing switches, and a motor circuit controlled by said switches.

22. The combination of an operating circuit, reversing switches and a regulating step-switch having a series of switches successively operated by varying the intensity of a magnetic field created by said operating circuit, auxiliary switches operated by said reversing switches and a secondary switch operated by said operating circuit in conjunction with the movement of the movable pole piece of said step-switch, all of said switches operating to control a power circuit.

23. The combination of an operating circuit, a step-switch operated by said operating circuit and having a series of magnetically operated switches, reversing switches, auxiliary switches operated by said reversing switches, a secondary switch operated by said operating circuit and the movement of the core of said step-switch, a power circuit controlled by said step-switch, reversing switches, auxiliary switches and secondary switch and a dynamic brake resistance in said power circuit.

24. The combination of an operating switch, an operating circuit, a regulating step-switch, reversing switches, auxiliary switches operated by said reversing switches, solenoids holding said auxiliary switches inoperative when improperly disposed, a secondary switch operated by the operating circuit and the core of said step-switch and the motor circuit controlled by said regulating step-switch, reversing switches, auxiliary switches and secondary switch.

25. The combination of an operating switch, an operating circuit having equaliz-

ing resistances therein, a step-switch, reversing switches, auxiliary switches operated by said reversing switches, solenoids rendering the said auxiliary switches inoperative when improperly disposed, speeding resistance and a motor circuit regulated by said resistance.

26. The combination of an operating switch, an operating circuit, reversing switches, a step-switch having a movable core, a secondary solenoid in the operating circuit, the core of said secondary solenoid arranged to move with the core of said step-switch and a switch in the motor circuit operated by said secondary solenoid, a motor circuit, resistances and means for short circuiting said step-switch and reversing switches.

27. The combination of a regulating step-switch, having a movable member, and reversing switches, said reversing switches having pole pieces movable with the movable member of said step-switch to vary the magnetic field of said reversing switches.

28. The combination of a regulating step-switch, having a movable member, and reversing switches, said reversing switches having pole pieces movable with the movable member of said step-switch to vary the magnetic field of said reversing switches and auxiliary switches.

29. The combination of a regulating step-switch, having a movable member, and reversing switches, said reversing switches having pole pieces movable with the movable member of said step-switch to vary the magnetic field of said reversing switches and auxiliary switches and means for rendering the same inoperative.

30. The combination of a regulating step-switch, having a movable member, and reversing switches, said reversing switches having pole pieces movable with the movable member of said step-switch to vary the magnetic field of said reversing switches and auxiliary switches adapted to simultaneously break a motor circuit and make a dynamic brake circuit.

31. The combination of a regulating step-switch, having a movable member, and reversing switches, said reversing switches having pole pieces movable with the movable member of said step-switch to vary the magnetic field of said reversing switches and auxiliary switches adapted to simultaneously break a motor circuit and make a dynamic brake circuit and means for holding auxiliary switches inoperative while current flows in such dynamic brake circuit.

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