C. W. WHEELER.

AUTOMATIC SWITCH MECHANISM.

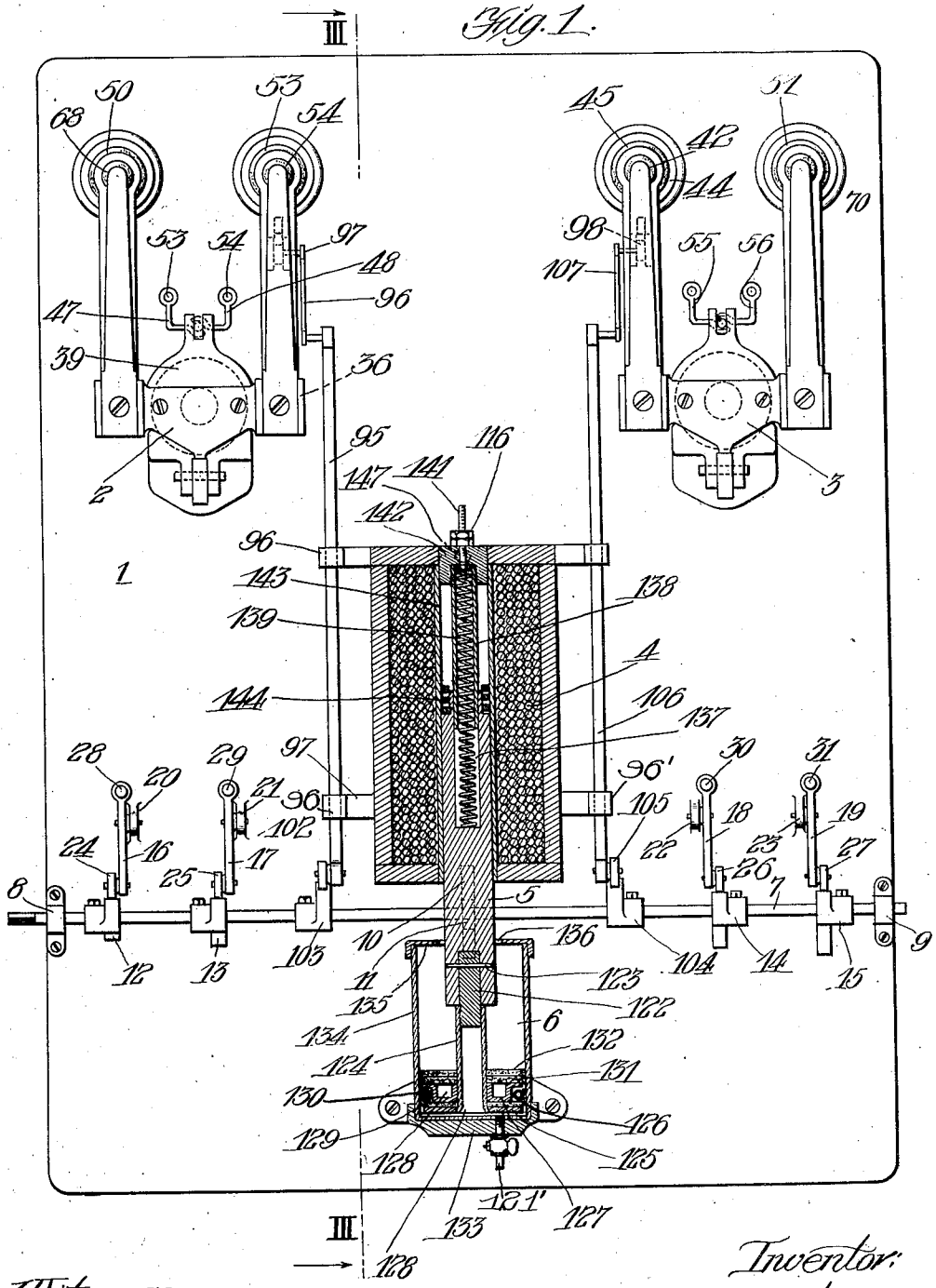
APPLICATION FILED JULY 14, 1909.

1,182,234.

Patented May 9, 1916.

3 SHEETS—SHEET 1.

Fig. 1.



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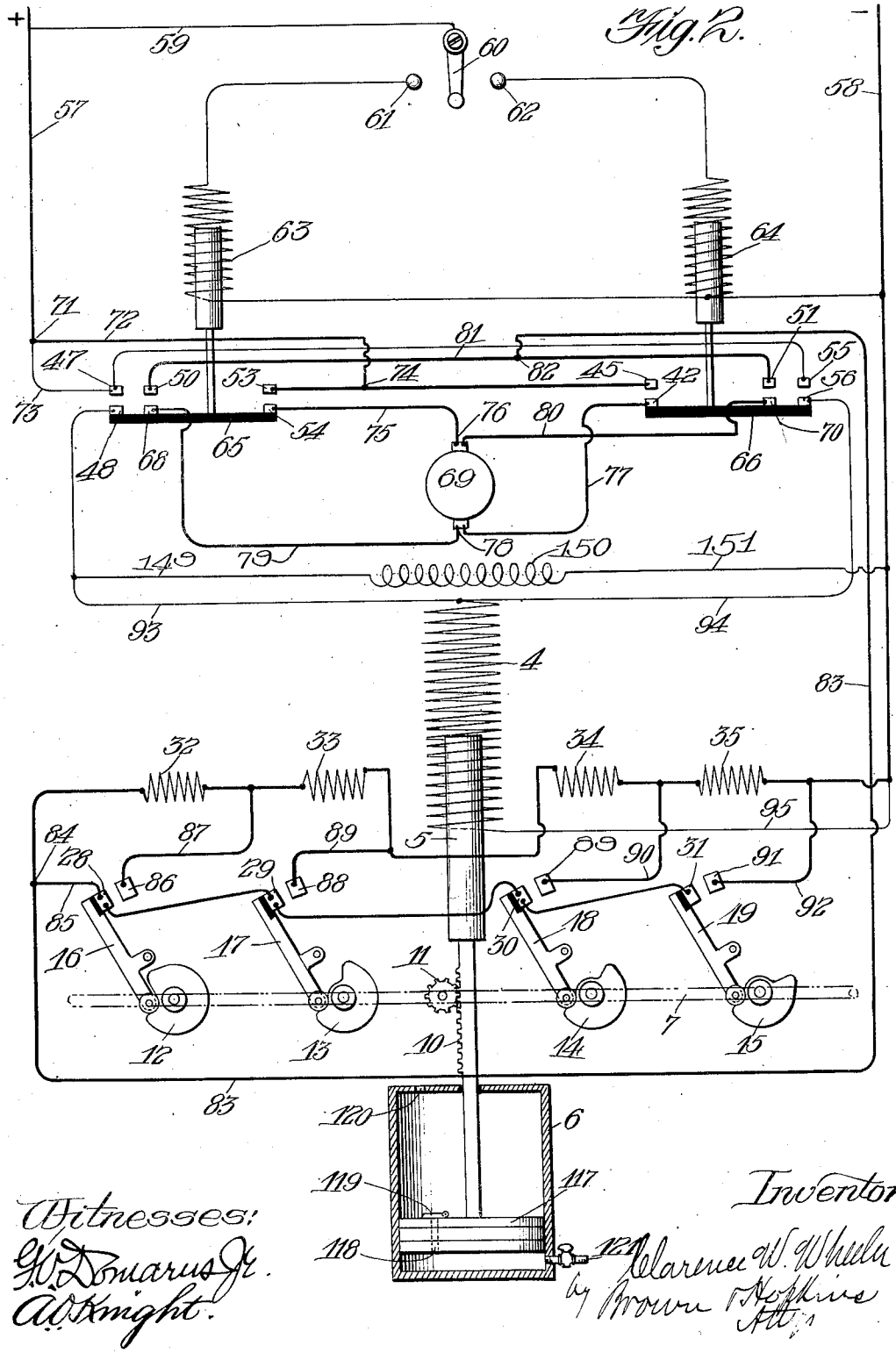
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3 SHEETS—SHEET 2.

Fig. 2.



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3 SHEETS—SHEET 3.

Fig. 3.

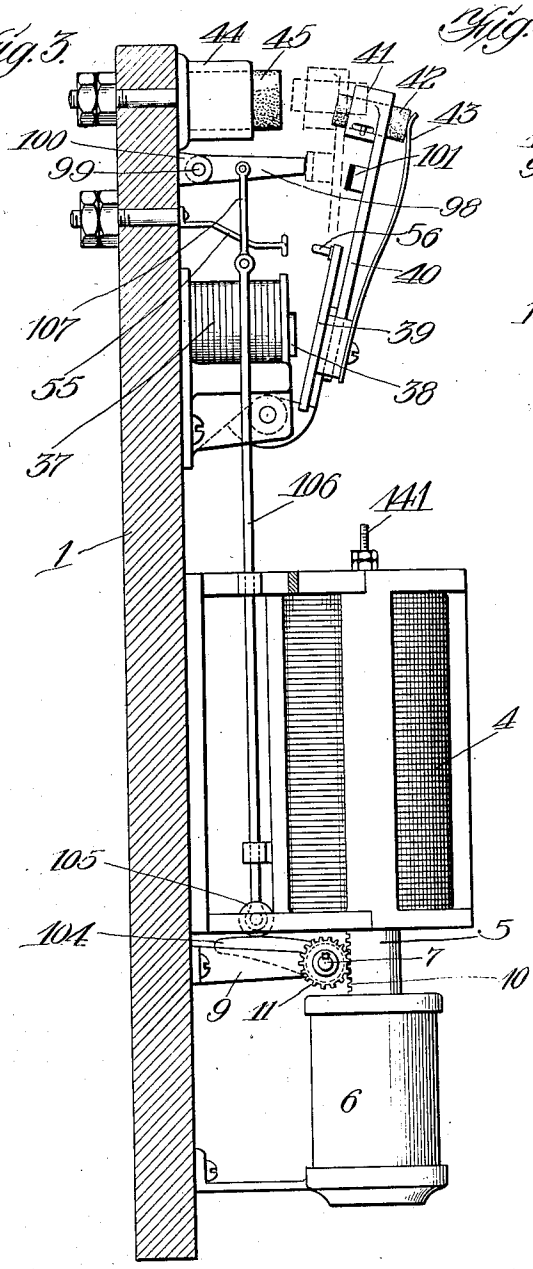
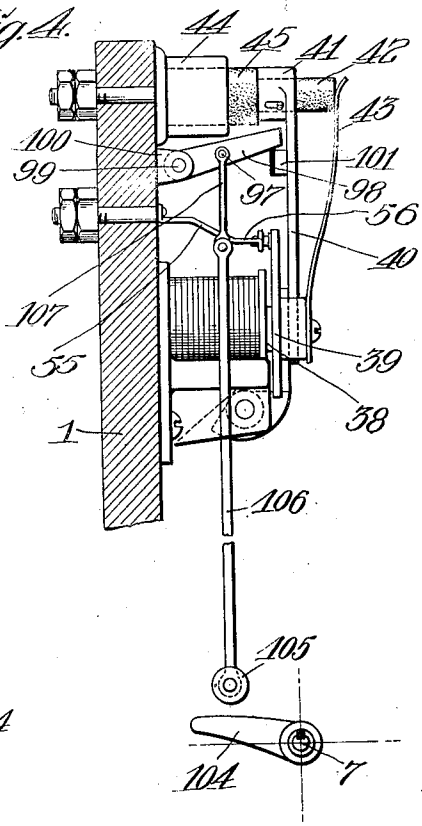


Fig. 4.



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UNITED STATES PATENT OFFICE.

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AUTOMATIC SWITCH MECHANISM.

1,182,234. Specification of Letters Patent. Patented May 9, 1916.

Application filed July 14, 1909. Serial No. 507,474.

To all whom it may concern:

Be it known that I, CLARENCE W. WHEELER, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Automatic Switch Mechanism, of which the following is a specification.

This invention relates to automatic switch mechanism and although it is particularly adapted to electric motor controlling apparatus, it may have a general application.

One of the objects of the invention is to provide electro-mechanical interlocking mechanism to prevent one controlling device from being operated when the other is operated.

A further object of the invention is the provision of means to prevent both portions of an electric reversing switch device from being closed at the same time.

Another object of the invention is the provision of means for effecting a quick reinsertion of the starting resistance of an electric rheostat for motors upon interruption of current supply.

Another object of the invention is the provision of a buffer to relieve the impact of the plunger or core in a solenoid when the plunger approaches the limit of its stroke.

Other objects of the invention will appear hereinafter, the novel combinations of elements being set forth in the appended claims.

Referring to the drawings, Figure 1 is an elevation of a motor control switchboard with electric reversing switches, motor accelerating switches, rheostat solenoid, dash-pot and the interlocking mechanism mounted thereon, the magnet and dash-pot being shown in section to illustrate the details of their interior construction; Fig. 2 is a diagrammatic view of the circuits and connections for the apparatus shown in Fig. 1 to illustrate an application of the invention; Fig. 3 is a side sectional elevation of Fig. 1 on the line III—III, looking in the direction of the arrows; and Fig. 4 is a sectional view similar to Fig. 3, but showing a portion of the reversing switch in closed position, whereas Fig. 3 shows it in open position.

Referring to Fig. 1, 1 designates the control slate on which I have shown mounted electro-magnetic reversing switches 2 and 3, which control the direction of current to the armature of an electric motor in the well known manner. On the lower portion of the slate or switchboard is shown the motor accelerating apparatus comprising the solenoid 4, the plunger 5, and a series of switches connected to sections of the starting resistance. A dash-pot is so arranged as to retard the upward movement of the plunger 5 when the solenoid 4 is energized but permits free and quick downward movement thereof. Journaled in the bearings or brackets 8 and 9, and in this instance immediately behind the plunger 5, is a horizontal rock shaft 7 which is connected by the pinion 11 and the rack 10 to the plunger 5. The pinion 11 being connected to the shaft 7 to rotate therewith and the rack 10 being on the back of the plunger 5, whenever the plunger moves up or down the shaft 7 is rotated. Rigidly and adjustably secured to said rock shaft 7 are cams 12, 13, 14 and 15, with which are respectively associated the rollers 24, 25, 26 and 27 which in turn are connected to the lower ends of the accelerating switch levers 16, 17, 18 and 19. As shown in Fig. 2, the cams on the rock shaft are set at different angular positions so that they will successively operate the respective accelerating switches to cut out the starting resistance step-by-step from in circuit with the motor armature. The accelerating switch levers 16, 17, 18 and 19 are intermediately pivoted to the front of the slate 1 in brackets 20, 21, 22, and 23 respectively and are provided at their upper ends respectively with insulated contacts 28, 29, 30 and 31, as indicated in Figs. 1 and 2.

Referring to Fig. 2 it will be seen that when the lever 60 is moved on to contact 61 or 62 a circuit will be closed between the + and − mains, 57 and 58, respectively, through the conductor 59, lever 60, contact 61 or 62, and magnet 63 or 64. If the magnet 63 is energized the cross-piece 65 will be lifted and the three auxiliary switches closed. The heavy lines represent the armature circuit which may be traced from the + main at 71, through conductor 72 to junction 74, thence through contacts 53, 54, conductor 75, brush 76, armature 69, brush 78, conductor 79, contacts 68, 50, conductor 81 to junction 82, thence by conductor 83, starting resistance sections 32, 33, 34 and 35 to the − main. The shunt field circuit is closed

through conductor 73, contacts 47, 48, conductor 149, winding 150, conductor 151 to the — main. The motor may now start at slow speed. At the same time that the shunt field circuit is closed a circuit is also closed through conductor 93, accelerating solenoid 4, and conductor 95 to the — main. The plunger 5 is then lifted slowly against the action of the dash-pot 6, its upward speed depending upon the adjustment of the valve 121. As will be seen, the piston 117 is perforated at 118 but it is close fitting so that little or no air may escape around it and no air can pass through it when the piston is being lifted, by reason of the upwardly opening valve 119. The air above the piston escapes through the opening 120 or through the space between the dash-pot piston rod and the opening through which it extends. When the plunger 5 is thus lifted the rack 10 turns the pinion 11 and rocks the shaft 7 and therefore also the cams 12, 13, 14 and 15. The shapes of these cams or the amount of cutaway portions they have determines the operation of the accelerating switches. As shown in this instance, the lever 16 will first be moved and the contact 28 moved against the contact 86, thus cutting out the section 32 and causing the motor to increase in speed. Thereafter the cam 13 will move the lever 17 and connect the contacts 29 and 88, thus short circuiting the section 33. The cam 14 then moves lever 18 to connect the contacts 30 and 89 and cut out the section 34. Finally the cam 15 moves the lever 19 to connect the contacts 31 and 91 and cut out the section 35 when the motor will attain full speed. If the lever 60 is moved on to contact 62 the solenoid 64 will receive current and the switch controlled thereby will be closed, which will also effect the starting of the motor but in the reverse direction, and it will be accelerated as before.

It is evident that if both reversing switches should be operated at the same time, the mains will be short circuited and the main line fuses will blow or the generator will be injured unless sufficient resistance is in circuit. I therefore provide a mechanical interlock which will effectually prevent both reversing switches from being operated at the same time. The arrangement of this interlocking device with the accelerating apparatus is such that the armature of the motor will be protected upon quick reversal of current therethrough by compelling the starting resistance to be re-instated before the direction of current through the motor armature can be reversed. I have also provided spring mechanism within the accelerating magnet to give the plunger a quick initial impulse upon being released and to keep it moving rapidly after being started. In addition to these means to insure a quick reinsertion of the starting resistance I may also provide a dash-pot of improved construction.

The interlocking apparatus is shown in Figs. 1, 3 and 4, and in this instance comprises vertical rods 95 and 106 suitably guided in brackets 96, 96′ extending from the frame of the magnet 4. The upper ends of these rods are connected by the links 96, and 107, respectively, to forwardly projecting obstructing levers which are pivoted to the front of the slate 1 behind each reversing switch. The lower ends of the vertical rods 95 and 106 are provided with rollers 105 which rest on wiper cams 103 and 104 which are secured to the shaft 7. When the magnet 4 is deënergized and the core 5 is in its lower position, the wiper cams 103 and 104 hold the rods 95 and 106, respectively, in their upper positions, where the lever 98 will be inclined upwardly as shown in Fig. 4 and the block 101 on the reversing switch lever 40 may move under it.

Since the interlocking devices on each side of the accelerating magnet 4 are similar in construction and operation it will suffice to describe only the one on the right hand side of Fig. 1 as shown in Figs. 3 and 4. When the winding 37 receives current, its fixed pole 38 will attract the armature 39 and consequently move the lever 40 on its pivot toward the slate 1. It will be seen that the lever 40 carries on its inner side a block 101 which can move to its innermost position when the lever 98 is inclined upwardly which is the case when the plunger 5 is in its lowermost position while the magnet 4 is deënergized. In such event the carbon 42 in the socket 41 is moved against the carbon 45 in the holder 44, the spring 43 relieving the impact. It will be noticed that the lever 98 is pivoted at 99 to the bracket 100 which is fixed to the board 1. At the same time that the contacts 42 and 45 are connected the contacts 55 and 56 are connected to close the shunt field and the accelerating magnet circuit.

Upon the closing of one reversing switch, therefore, the motor will begin to rotate and the magnet 4 will lift its plunger against the retarding action of the dash-pot. The wiper cams 103 and 104 will immediately move down leaving the lever 98 resting on the block 101 and the rod 106 suspended, if the contact 42 has been moved into engagement with the contact 45. The opposite rod 95 will descend, however, until it rests just behind the block in front of it, as shown in Fig. 3. It is evident that if it is attempted to operate the other reversing switch at this time the block carried by its lever will abut against the horizontal lever and the switch cannot be closed. It should also be particularly noted that the switch cannot be closed until the magnet 4 is deenergized and the wiper cam 103 has been

returned to initial position, or nearly so, thus insuring the reinsertion of all or nearly all the starting resistance before the connections can be established for effecting the reversal of the motor.

If before the motor comes to rest the reversing connections are established and the armature resistance is out of circuit, the motor armature will be in danger of being burned out. The interlocking device described necessitates the reinsertion of the starting resistance before the motor can be reversed. To further insure the reinsertion of the starting resistance I provide a heavy spring 144 on top of the core 5 which will give the core a quick initial downward impulse when the magnet 4 is deënergized and besides prevents sticking of the top of the iron plunger 5 against the bottom of the iron cap 142, although the spring 144 is itself preferably made of iron. This spring is preferably flat on top and closely coiled. The iron cap 142 may be held in place by an iron projection 147 fitting into a recess in the iron frame of the magnet. By reason of this iron cap, the plunger may be held in its upper position with less expenditure of electric energy than it takes to pull it up and therefore after the plunger has reached its upper limit of travel a high resistance may be inserted in series with the magnet winding by a switch similar to the accelerating switches, both to reduce the consumption of current and to effect a quick deënergization of the magnet 4 when the current is cut off. It should also be noted that by having the spring at the inner end of the plunger 5 or at the bottom of the cap 147 the noise due to the impact of the upper end of the plunger against the bottom of the iron cap is considerably decreased. Usually as the upper end of the plunger approaches near to the bottom of the cap the attractive force is much increased and the tendency is for the plunger to make a quicker final movement and strike the iron cap or iron frame of the magnet with sufficient force to produce a noisy clank. Due to this increased pull at the final movement of the plunger, the latter and the parts connected thereto need not be increased in weight permanently to effect a quick return of the plunger when the magnet is deënergized and therefore the latter need not be as strong. However, the compression of the heavy spring at the final movement is like automatically adding weight to the plunger at the proper time, to become effective when the magnet is deënergized.

To further insure the continuance of the downward travel of the core 5 after being started quickly I have provided a long spring 139 fitting in a recess 137 in the upper portion of the plunger 5 and in a tube 138, fitting at its closed upper end in a recess in the bottom of the cap 142 and extending downwardly into the recess 137 in which it may slide.

The upper end of the tube 138 is provided with a screw-threaded stem 141 extending through an opening in the iron cap 142. By means of nuts 116 the tube 138 may be held securely against the iron cap 142. The longer spring 139 is preferably made of brass, as also the tube 138. I prefer also to have the tube 138 fit loosely in the recess 137 and the plunger 5 loosely in the tube 143 so that there will be little tendency for the downward movement of the plunger to be retarded at this point. However, so long as the downward movement of the plunger is not retarded by friction between the tube 138 and the plunger 5 and between the latter and the tube 143, these parts may be air tight fitting and the elasticity of the air under pressure when the plunger is up may be depended on as a further means to quickly return the plunger, in some instances, particularly when the operations are frequent and there is insufficient time for the air to escape.

The dash-pot 6 comprises a cylinder 134 closed at its bottom, where it is connected to the bracket 133 which is fastened to the front of the board 1. The top of the cup 134 is closed by the cover 135 which is provided with a central opening 136, through which extends the lower end of the plunger 5. Connected to the lower end of the plunger 5 by a pin 123 is a rod 122, the lower end of which is screw-threaded into the upper end of the tube 124 to the bottom of which at 128 is secured the plate 125 of less diameter than the inner diameter of the cylinder 134. Just above the horizontal washer 125, which is rigid with the tube 124, is a cup-shaped leather valve 126. A laterally expanding spring 130 presses the peripheral upwardly extending portion of the leather cup against the inner surface of the cylinder 134. The leather 126 is held firmly in place by the annular frame 127 which also serves to maintain the spring 130 in proper position. Above the annular frame 127 one or more washers of felt may be placed, soaked in oil and fitting loosely against the inner surface of the dash-pot to keep the same oiled to slide freely and to keep the leather from drying out.

When the magnet 4 is energized the plunger 5 is lifted, and with it the dash-pot piston, the air pressing the leather cup 126 firmly against the inner surface of the cylinder 134, the air being drawn slowly through the restricted opening 121′. During the upward movement of the piston the felt washers 131 and 132 wipe the inner surface of the cylinder 134 and some of the oil is absorbed by the leather piston, thus keeping it

flexible and causing it to fit air tight within the cylinder 134. Furthermore, because the leather is kept flexible the spring 130 may easily press the cylindrical portion of the leather cup against the inner surface of the cylinder 134. When, however, the magnet 4 is deënergized and the plunger is moved down the spring fitting loosely in position will permit free play of the leather valve by allowing the air to flow freely past the same. Free downward movement may also be obtained by the dash-pot shown in Fig. 2 but in such case the piston is close fitting to secure the proper retardation on the upward stroke and may retard also on the downward stroke due to friction of gumming of oil or from other causes. In Fig. 1, however, the piston on the down stroke is in reality of less diameter than on the up stroke and in any event allows a quick downward movement of the piston and therefore a quick re-insertion of the starting resistance.

Aside from the feature of prevention of the reversal of connections until after re-insertion of the starting resistance it is also important to effect a quick re-insertion of the starting resistance if the current in the mains should be temporarily interrupted. Usually motors are operated on circuits which also supply incandescent lamps and since the latter are connected in parallel with the motor armature they will act as an electro-dynamic brake to stop the motor armature very quickly if the source of supply from central station should be interrupted. Should the current at central station be turned on again immediately after the motor stopped and before the starting resistance is re-inserted, there would be danger of burning out the motor armature. By the use of my quick acting devices, however, the armature resistance is re-inserted very quickly and before the current can again be turned on, although the motor armature may have been stopped.

From the foregoing description it will be obvious that the construction disclosed in the drawings comprises an electrically-operated main-line switch, a series of subsidiary switches, a rotary shaft carrying cams for operating said subsidiary switches, an electro-magnet for rotating the shaft, and an interlocking device between the main-line switch and the subsidiary switches necessitating the opening of a predetermined number of said subsidiary switches before the main-line switch can again be closed. The electro-magnet referred to operates the subsidiary switches in succession through the intermediary of the rack, pinion, rotary cam shaft, cams, and pivoted levers. The electro-responsive subsidiary switch is arranged substantially parallel to the main switch. The electromagnetically-operated controlling device, or the rheostat-operating member, comprises a plurality of switch members arranged to be operated in a definite sequence and is particularly adapted for controlling the cutting out and the insertion of starting resistance of an electric motor, step by step. The mechanical interlocking device is constructed and arranged to prevent the operation of the main-line switch to close it while a predetermined number of said subsidiary switches are closed. This interlocking device is operated through the medium of the rotary cam shaft. The cam shaft also carries cam mechanism for engaging the interlocking device to operate it for the purpose set forth. This interlocking device normally extends out of the path of the main-line switch, and through the medium of the cam shaft and the additional cam mechanism the interlocking device is moved into interlocking position when the subsidiary switch is closed. That is to say, the interlocking device is such that it is held out of interlocking engagement with the main-line switch when the cam shaft occupies the position in which the subsidiary switch is open and is moved into interlocking position when the cam shaft is moved to close the said subsidiary switch. This mechanical interlock between the main-line switch and the subsidiary switch necessitates the opening of the latter prior to the closure of the main-line switch, but permits the main switch to open regardless of the position of said subsidiary switch. The interlocking device is normally biased to a position to prevent closure of the main switch, but when the revoluble cam which is movable with the rheostat operating member actuates the interlocking device the main switch is permitted to close. But before the main-line switch can be closed after it has once been opened the interlocking device must be actuated which is done by the return of the rheostat-operating member to full off position. By referring particularly to Fig. 3 it will be seen that this interlocking device is biased to a position in the path of the main switch to prevent closure thereof, and when the revoluble cam 104 is moved by the return of the plunger 5 to its initial position the interlocking device is moved out of the path of said main switch, as shown in Fig. 4, and by referring to Fig. 2 it will be evident that this occurs when all or nearly all of the subsidiary switches are opened. It will also be seen that the mechanical interlocking device is controlled by the electromagnetically operated controlling device having a plurality of switch members arranged to be operated in definite sequence, and that the interlock necessitates the opening of a predetermined number of said switch members prior to the closure of the main switch. This insures a reinsertion of sufficient starting resistance

after the main-line switch is opened to protect the motor in case the main-line switch is again closed within a short space of time after it has been opened.

Obviously those skilled in the art may make various changes in the details and arrangements of parts without departing from the spirit and scope of the invention as defined by the claims and I desire therefore not to be limited to the precise details of construction herein disclosed.

What I claim and desire to have protected by Letters Patent of the United States is—

1. In controlling apparatus, the combination with a rheostat electro-magnet, of separate electric reversing switches, and mechanical interlocking means between said rheostat electro-magnet and said reversing switches to prevent both reversing switches from being closed at the same time.

2. In motor-controlling apparatus, the combination with a motor, of automatic reversing mechanism therefor, mechanical interlocking means associated with said reversing mechanism, and electro-magnetic means for effecting the acceleration of the motor and the operation of said interlocking mechanism.

3. In motor-controlling apparatus, the combination with an electric motor, of automatic reversing switch mechanism therefor, starting resistance, automatic means for controlling said resistance, and mechanical devices for preventing the operation of the reversing switch mechanism until the starting resistance is restored.

4. In motor-controlling apparatus, the combination with a motor and electro-magnetic reversing switches therefor, of automatic accelerating means, and mechanical interlocking devices controlled by said accelerating means to prevent reversal of the motor at a predetermined period of operation of the accelerating means.

5. In motor-controlling apparatus, the combination with an electric motor and electro-magnetically operated reversing switches therefor, of starting resistance for the motor, automatic accelerating means for cutting out said resistance, and mechanical means for preventing reversal of the motor connections until after substantially all the starting resistance has been re-inserted.

6. In motor-controlling apparatus, the combination with an electric motor and reversing switches therefor, of sectional starting resistance in series with the motor armature, a plurality of switches connected to said sectional starting resistance, a rock-shaft device controlling said switches, and a magnet for actuating said rock-shaft device to operate said switches successively to cut out said resistance step-by-step.

7. In motor-controlling apparatus, the combination with an electric motor, of electro-magnetically operated reversing switches therefor, starting resistance for the motor, means for cutting out said resistance, and mechanical interlocking mechanism operated by said cutting-out-means to prevent reversal of the motor while the starting resistance is out of circuit.

8. In motor-controlling apparatus, the combination with an electric motor and electro-magnetic reversing switches therefor, of starting resistance, means for cutting out said resistance step-by-step to gradually increase the speed of the motor, and mechanical interlocking mechanism controlled by said cutting-out means to prevent the reversal of connections by the reversing switches until the starting resistance is re-inserted to protect the motor armature.

9. In motor-controlling apparatus, the combination with a motor and automatic reversing switches therefor, of automatic accelerating means, and mechanical devices controlled by the accelerating means to prevent the closure of one reversing switch while the other is in closed position.

10. In motor-controlling apparatus, the combination with a motor and reversing switches therefor, of starting resistance, accelerating switches, a rock shaft connected to said switches, automatic means for actuating said rock shaft to operate the accelerating switches, and interlocking devices operated by said rock shaft to prevent the reversal of the motor while the starting resistance is out of circuit.

11. In motor-controlling apparatus, the combination with a motor and reversing switches therefor, of sectional starting resistance, accelerating switches, a rock shaft, cams on said rock shaft for operating said accelerating switches, means for actuating said shaft, interlocking devices associated with said reversing switches, and additional cams on said rock shaft to operate said interlocking devices.

12. In motor-controlling apparatus, the combination with an electric motor and reversing switches therefor, of sectional starting resistance, accelerating switches, an electro-magnet, operating connections between said electro-magnet and said accelerating switches, auxiliary electric switches operated by said reversing switches for controlling the energization of said electro-magnet, and mechanical interlocks controlled by said operating connections for preventing reversal of the motor while the starting resistance is out of circuit.

13. In motor-controlling apparatus, the combination with a motor and electro-magnetic reversing switches therefor, of a rheostat electro-magnet, and mechanical interlocking mechanism operated by said electro-magnet to prevent sudden reversal of the motor.

14. In motor-controlling apparatus, the combination with an electric motor, of accelerating apparatus therefor comprising starting resistances, switches, a magnet and connections, and means within said magnet for quickly re-inserting the starting resistance upon the deënergization of said magnet.

15. In a motor controlling apparatus, the combination with a rheostat, of a solenoid, a plunger movable in said solenoid and operatively connected to said rheostat, means for retarding the movement of the plunger to attracted position, a spring mechanism within the solenoid for effecting a quick return of the plunger to initial position and a quick restoration of said rheostat to initial position.

16. In a motor controlling apparatus, the combination with starting resistances, of resistance-varying mechanism, a solenoid, a plunger or core movable in said solenoid and connected to said resistance-varying mechanism, and a heavy and comparatively strong spring at the inner end of the plunger to effect a quick return of the plunger to initial position when the solenoid is deënergized and thereby quickly restore the starting resistance-varying mechanism to initial position.

17. In a motor controlling apparatus, the combination with an electric motor rheostat, of a solenoid having an iron cap, a plunger operable in said solenoid and operatively connected to said motor rheostat, and a spring between the inner end of the plunger and the iron cap to effect a quick return of the plunger when the solenoid is deënergized to restore the rheostat quickly to initial position when the current is cut off.

18. In motor-controlling apparatus, the combination with a solenoid, of a plunger or core movable therein, a short and strong spring above the plunger within the solenoid, and a long and light spring extending through the short spring and also within the solenoid.

19. In motor-controlling apparatus, the combination with a solenoid, of a plunger or core therefor having a longitudinal recess in its upper portion, a short strong spring connected to the inner end of the plunger, an iron cap recessed at its inner central portion, a tube fitting into the iron cap recess at one end and sliding into the plunger recess at its other end, and a comparatively long light spring in the tube and the plunger recess.

20. In motor-controlling apparatus, the combination with a solenoid, of a plunger or core, a dash-pot cup, a piston connected to said plunger and comprising a peripheral valve of flexible material, devices of less diameter than the inner diameter of the dash-pot cup for holding said flexible material in position, and a spring for closing said valve.

21. In motor-controlling apparatus, the combination with an electric motor, of reversing switches therefor, starting resistance, accelerating switches, a solenoid, connections between said solenoid and said accelerating switches, interlocking mechanism to prevent the connections to the motor to reverse the same from being made until the starting resistance is re-inserted, spring mechanism within the solenoid to assist gravity in returning the plunger, connections and accelerating switches to initial position when the solenoid is sufficiently deenergized, and a dash-pot device retarding the movement of the plunger to attracted position but permitting quick downward movement thereof.

22. The combination with an electric switch, of an electromagnet comprising a solenoid and a plunger, a rock shaft geared to said plunger, a wiper cam on said rock shaft, a sliding rod actuated by said wiper cam, and an abutment pivoted back of said electric switch and connected to said sliding rod.

23. The combination with a main-line switch, of an electromagnet, a rock shaft operated by said electromagnet, a wiper cam on said rock shaft, a sliding rod actuated by said wiper cam, and mechanism connected to said rod for preventing the main-line switch from closing except when said rock shaft is in a predetermined position.

24. The combination with an electric switch, of an electromagnet comprising a solenoid and a plunger, a rock shaft geared to said plunger, a wiper cam on said rock shaft, a vertical sliding rod, a lever abutment pivoted back of said electric switch, and a link connecting said lever to said vertical sliding rod.

25. The combination with a pair of electromagnetic reversing switches, of a rheostat electromagnet comprising a solenoid and a plunger, a rock shaft geared to said plunger, a pair of wipers on said rock shaft, a pair of vertical sliding rods mounted on the frame of said rheostat electromagnet, forwardly extending levers one pivoted back of an arm of each of said electromagnetic switches, and link connections between said sliding rods and said pivoted lever, said wipers and sliding rods being so related that the pivoted levers will prevent the closure of either or both of said electromagnetic reversing switches except when the plunger is in initial position or nearly so.

26. The combination with an electric switch comprising a switch arm, a lever pivoted back of said arm, an abutment connected to the rear surface of said arm, an electromagnet, and mechanical connections between said electromagnet and said pivoted

lever to hold the latter out of the path of said abutment when said electromagnet is deënergized, but permitting said pivoted lever to be automatically placed in the path of said abutment to prevent said electric switch from being closed when the parts operated by said electromagnet are restored to initial position.

27. The combination with a main-line switch, of an electromagnet, a rock shaft, a cam on said rock shaft, a vertical sliding rod mounted on the frame of said electromagnet, a lever pivoted back of a part of said main-line switch, a link connecting said lever to said sliding rod, and an abutment connected to the aforesaid part of the main-line switch for engaging said pivoted lever to prevent the main-line switch from being closed except when the electromagnet is deenergized and the rock shaft and cam are restored to substantially initial position.

28. The combination with a pair of reversing switches each comprising a pivoted arm, of a rheostat electromagnet, a rock shaft operatively connected to said electromagnet, a pair of wiper cams on said rock shaft, a pair of vertical sliding rods mounted in guides on the frame of said rheostat electromagnet in position for operation by said wiper cams, a pair of pivoted levers one associated with each of said reversing switches, link connections between said pivoted levers and said sliding rods, and abutments one on each of said arms of the reversing switches for engaging said pivoted levers to prevent either or both of said reversing switches from being closed except when the core of said rheostat electromagnet is in initial position or nearly so.

29. The combination with an electric switch, of an electromagnet, a sliding rod, guides carried by the frame of said electromagnet for said rod, operating connections between said electromagnet and said sliding rod, and means operated by said sliding rod for preventing said switch from being closed except when said operating connections are restored to initial position or nearly so.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, on this 6th day of July, A. D. 1909.

CLARENCE W. WHEELER.

Witnesses:

CHARLES H. SEEM,

J. H. JOCHUM, Jr.