G. H. WHITTINGHAM.

MOTOR STARTER.

APPLICATION FILED JUNE 5, 1911.

**1,023,980.**

Patented Apr. 23, 1912.

2 SHEETS—SHEET 1.

Fig. 1.

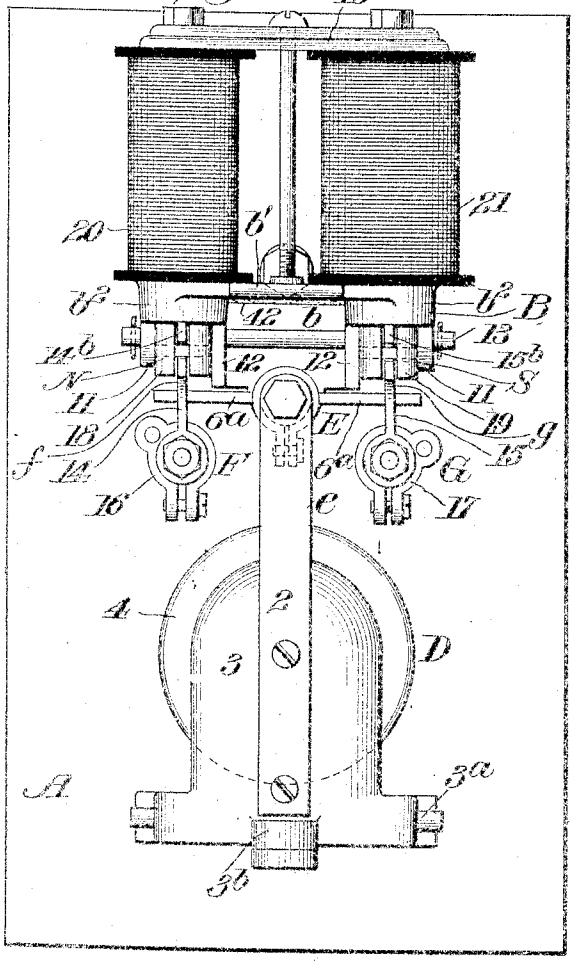



Fig. 2.

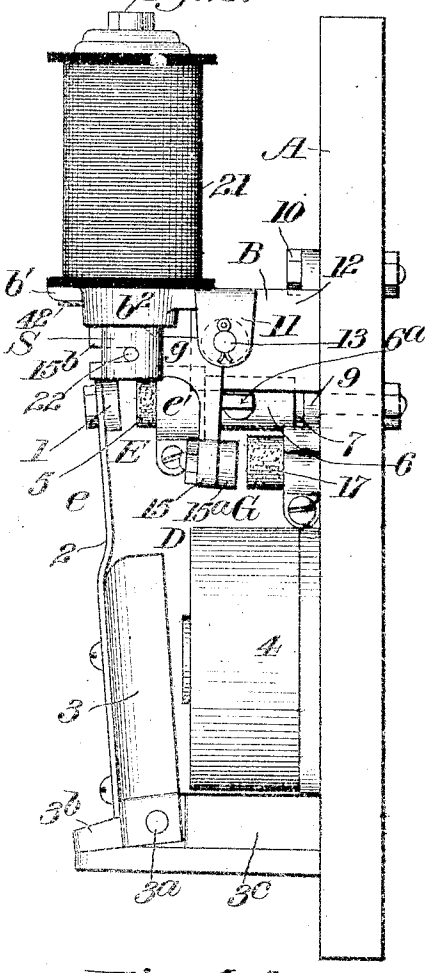



Fig. 3.

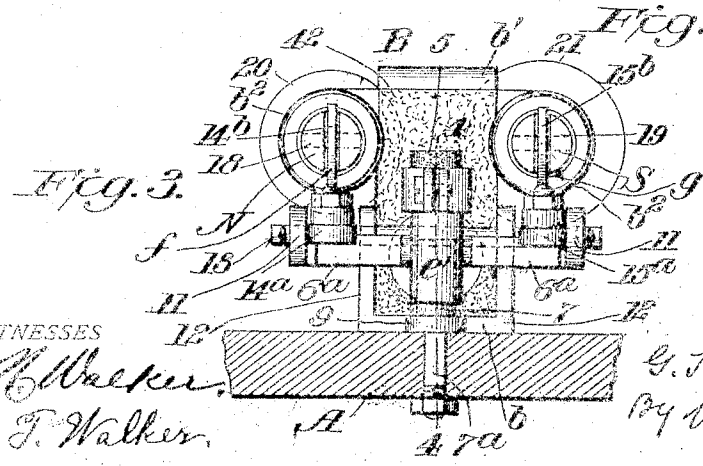
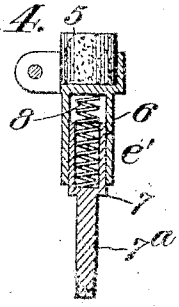



Fig. 4.

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2 SHEETS—SHEET 2.

Fig. 5.

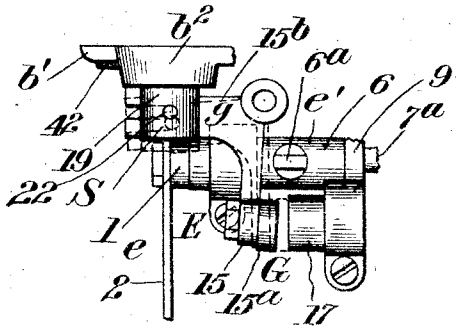
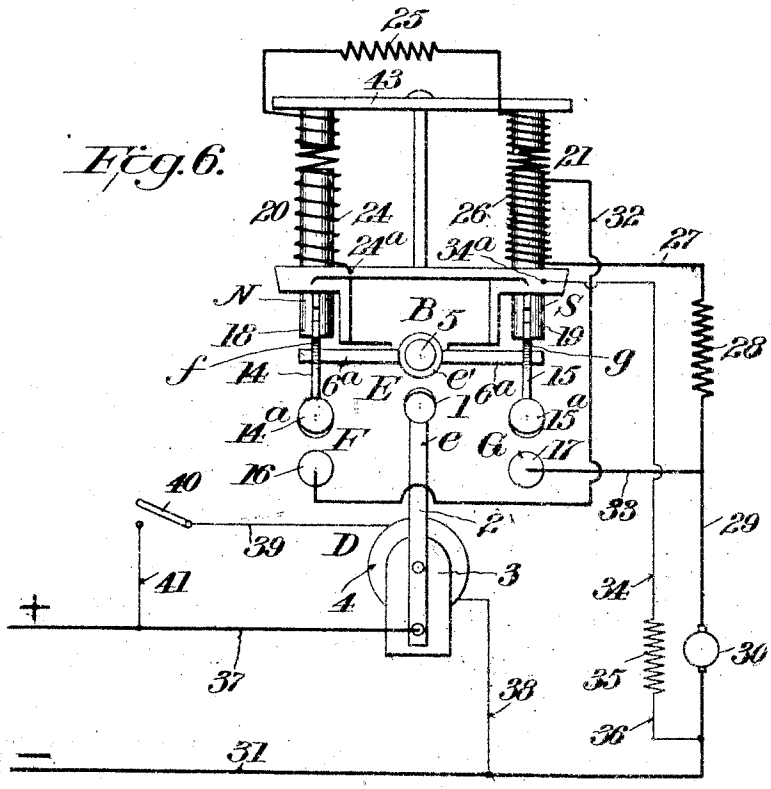



Fig. 6.

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# UNITED STATES PATENT OFFICE.

GEORGE H. WHITTINGHAM, OF PIKESVILLE, MARYLAND, ASSIGNOR TO MONITOR MANUFACTURING COMPANY, OF BALTIMORE, MARYLAND, A CORPORATION OF MARYLAND.

## MOTOR-STARTER.

1,023,980. Specification of Letters Patent. Patented Apr. 23, 1912.

Application filed June 5, 1911. Serial No. 631,399.

*To all whom it may concern:*

Be it known that I, GEORGE H. WHITTINGHAM, a citizen of the United States, residing at Pikesville, in the county of Baltimore and State of Maryland, have invented certain new and useful Improvements in Motor-Starters, of which the following is a specification.

This invention relates to a combined main or supply circuit switch and starting device for electric motors arranged so that they may be controlled from a distant point through a circuit which includes a suitable manually-operated switch, such as a push-button switch, for controlling the flow of current through the last mentioned circuit. In this invention, the main switch and the automatic devices for controlling the elimination of starting resistance from the armature circuit are arranged to coöperate in various ways.

Some features of the invention are applicable to various forms of starters, but the invention is shown herein in connection with a starter of the type illustrated in United States Patent No. 965,649 in which solenoids or magnets having their windings in the armature circuit of the motor are employed as time elements to regulate the cutting out of starting resistance. In this type of starter switches controlled by solenoids in the armature circuit are employed to regulate the cutting out of starting resistance, the switches being normally held open when the motor is stopped by mechanical supporting means, and a holding solenoid or magnet is employed for removing the support when the current is turned on so that the switches may close as the current in the regulating solenoids diminishes. The holding solenoid must not remove the support before current is admitted to the regulating solenoids; otherwise the resistance would be immediately cut out; and it must not sustain the support after the armature circuit has been cut off from the source of supply, as the resistance would then be cut out and the armature would be short-circuited upon the closure of the main switch. As a practical way of avoiding these difficulties, the holding solenoid or magnet usually has its windings connected in series with the armature so that the holding device is energized and deënergized simultaneously with the regulating solenoids when the current is turned on and off.

Starters thus constructed are satisfactory for most purposes but there are situations where the series holding solenoid is apt to become practically deënergized during the operation of the motor and in such case its core is released and the switches controlling the resistance are opened, causing the resistance to be inserted in the armature circuit notwithstanding the main switch is closed and the motor is running. Thus, with certain types of motors now very commonly employed for running individual machines or tools, speed regulation is accomplished by moving the armature endwise into and out of the magnetic field, the field strength of the motor remaining practically constant. When the armature is moved partly out of the field its speed increases, and if it is suddenly moved back, owing to its own inertia and also, perhaps, owing to the inertia of the load, the counter electromotive force of the armature may approximate, for a few moments, the electromotive force of the supply circuit, in which case practically no current will flow through the starter and the holding solenoid will release its core and the resistance will be inserted in the armature circuit until the armature current again rises sufficiently to energize the holding solenoid.

In the present invention the magnet which operates the supply circuit switch also accomplishes the function of removing a spring-pressed support from the resistance-controlling switches, the parts being arranged so that this latter function cannot be performed until the supply circuit is closed, and as the circuit which controls the supply switch magnet is independent of the armature, the magnet will not be deënergized if the armature races and its counter electromotive force equals the electromotive force of the supply circuit. The support, therefore, cannot return and move the resistance controlling switches to include resistance in the armature circuit while the main switch is closed and the motor is running. When the main switch magnet is deënergized, the spring-pressed support returns the resistance controlling switches to normal positions, reinserting the resistance in the armature circuit, before the circuit

through the armature is broken, the main switch then opens suddenly and the arc forming at the terminals of the main switch is then instantly blown out by the magnetic influence of the solenoids which regulate the closing movements of the resistance-controlling switches.

In the accompanying drawing, Figure 1 is a front elevation of the mechanism embodying the invention; Fig. 2 is a side elevation of the same, the parts being in their normal positions; Fig. 3 is a bottom plan view of the mechanism, the switch arm and magnet for closing the supply circuit being omitted; Fig. 4 is a section through the spring-pressed main switch member; Fig. 5 is a side view of portions of the mechanism showing the main switch closed, and a resistance controlling switch open, in full lines, and closed in dotted lines; and Fig. 6 is a diagrammatic view illustrating the circuit connections.

Referring to the drawing A indicates a suitable panel upon which the various parts of the apparatus are mounted, B indicates a bracket or frame secured to the panel and supporting the resistance controlling devices and D indicates an electromagnetic device mounted upon the panel for operating the main switch, indicated at E.

The main switch comprises a member $e$, controlled by the electromagnetic device D and a spring pressed member $e'$ which is adapted to be pressed rearwardly from its normal position, shown in Fig. 2, to the position shown in Fig. 5, by the switch member $e$ when the latter is moved to closed position by the electromagnetic device. The member $e$ comprises a suitable contact 1, mounted upon an arm 2 which is secured to the armature 3. This armature is mounted upon a pivot pin $3^a$ in the frame $3^c$ of the electromagnet 4 and is normally held away from the magnet by gravity, the outward movement of the armature being limited by a toe $3^b$ on the armature which engages the magnet frame. As shown in the diagram, the member $e$ is connected to the supply wire 37 and the electromagnet 4 has its coils connected by conductor 38 to the supply wire 31 and by conductor 39, switch 40 and conductor 41 to the opposite supply wire 37. It will be evident that when the switch 40 is closed the magnet 4 will be energized and will move the switch member $e$ to closed position and that when the switch 40 is opened the magnet will be deënergized and the switch member $e$ will return to normal position, opening the main switch E, this return movement of the member $e$ being assisted by the spring pressed member $e'$. The spring-pressed main switch member $e'$ comprises a suitable contact 5 mounted in the end of a sleeve 6 which telescopes with a tubular post 7 having a threaded shank $7^a$ which extends through a lug 9 on the bracket B and through the panel A, this stud and bolt 10 serving as means for securing the bracket to the panel. A spring 8 is interposed between the stud and sleeve 6, as shown in Fig. 4, and this spring normally presses the member $e'$ toward the opposing member $e$ of the main switch. It will be seen that the member $e'$ is electrically connected to the frame or bracket B and that when the main switch is closed the bracket will be connected to the side 37 of the supply circuit.

The bracket B comprises a back piece $b$, a shelf $b'$ projecting forwardly therefrom, tubular bosses $b^2$ at the ends of the shelf, ears 11 depending from the ends of the shelf and side pieces 12 projecting forwardly beneath the shelf between the ears 11. A rod 13 extends through the ears 11 and side pieces 12, and between said ears and side pieces bell crank switch arms $f$ and $g$ are hung upon the rod 13. The depending arms 14 and 15 of the levers $f$ and $g$ are provided with suitable contact surfaces $14^a$ and $15^a$ adapted to engage stationary contacts 16 and 17, respectively, the latter being connected to successive steps of the starting resistance. The arms $14^b$ and $15^b$ of the bell crank levers are bifurcated and extend through slots in the lower ends of the cores 18 and 19 of solenoids 20 and 21 which are mounted upon the bracket. Pins 22 pivotally connect the forked ends of the levers with the solenoid cores.

The sleeve 6 of the main switch member $e'$ is provided with arms $6^a$ projecting laterally in opposite directions and these arms are normally pressed against the depending switch arms 14 and 15 by the spring 8, thus holding the resistance controlling switches F and G normally open and supporting the cores 18 and 19 of the regulating solenoids 20 and 21 in upper positions. In the open positions of these switches the arms $14^b$ and $15^b$ of the switch levers abut against the bosses $b^2$ of the bracket, which form stops for these switch levers and limit the outward movement of the spring-pressed member $e'$, the arms $6^a$ of which bear against the levers, as stated. The lower edges of the side plates 12 of the bracket extend close to the arms $6^a$ and form guides for preventing the arms from turning with the sleeve 6 out of their proper relation to the depending switch arms 14 and 15.

The solenoids 20 and 21, as hereinafter explained, are connected in the armature circuit and regulate the closing movements of the resistance-controlling switches F and G and they are wound so as to produce opposite poles in the lower ends of the cores 18 and 19. It will be noted that the main switch contacts 1 and 5 are located between the ends of these cores and in the path of

the magnetic flux passing between the cores. The solenoids thus perform the double function of time elements for cutting out the starting resistance and blow-out magnets for extinguishing the arc at the main switch.

The circuit connections and the operation of the device may best be explained by reference to the diagram, Fig. 6. The magnet 4 for operating the main switch member *e* is connected in a circuit independent of the motor circuits, as previously explained, this magnet circuit extending from supply wire 31, through conductor 38, to the magnet 4, thence through conductor 39, switch 40 and conductor 41 to the supply wire 37. When the switch 40, which may be a push button switch, is closed, the magnet 4 moves the main switch member *e* into engagement with the contact on the opposing spring-pressed main switch member *e'* and thus closes the circuit through the regulating solenoids 20 and 21, the starting resistance and the motor at the instant the main switch members are brought into engagement with one another. After the closing of the main switch the spring-pressed member *e'* is pressed rearward by the member *e* and the arms $6^a$ are forced rearwardly from the bell crank switch arms *f* and *g* thus removing the mechanical support from said arms and from the solenoid cores, so that the switches F and G may close unless prevented by the current flowing in the coils of the regulating solenoids 20 and 21. The member *e'* is grounded upon the frame or bracket B so that when the main switch is closed the bracket will be connected to the supply wire 37. The armature circuit of the motor extends from the bracket at the point $24^a$ around the coils 24, of the magnet 20, thence through the section of starting resistance 25, thence through the coils 26 of magnet 21, to conductor 27, thence through another section of starting resistance 28, thence by conductor 29, to the armature 30 of the motor and thence to the supply wire 31. At the instant when the main switch members are closed, therefore, the current will flow through all of the windings of both solenoids and through both sections of resistance to the armature. Current will also flow from the frame B through conductor 34, which is grounded at $34^a$, on the frame, to the shunt field windings 35 of the motor and thence by conductor 36 to the supply wire 31. The solenoid 21 has a greater length of wire in its windings than the solenoid 20 so that the former will sustain its core with a smaller quantity of current than will the solenoid 20. A conductor 32 connects the stationary contact 16 of the switch F to an intermediate point in the windings of the solenoid 21 and a conductor 33 connects the stationary contact 17 with the wire 29. It will be readily understood that in starting, if the current flowing in the armature circuit exceeds a predetermined quantity both solenoids will sustain their cores and maintain the switches F and G open, so that all of the resistance will remain in circuit, but when the current falls to a predetermined amount the solenoid 20, having the shorter length of winding, will first release its core, the downward movement of which will rock the switch arm *f* into position to close the switch F and this will complete a circuit from the frame B through switch arm *f*, contacts $14^a$ and 16 and conductor 32 to a portion of the coils of the solenoid 21, thence through conductor 27, resistance section 28 and conductor 29 to the armature, thus forming a shunt around the solenoid 20, the resistance section 25, and a portion of the windings of the solenoid 21, leaving in the armature circuit only a portion of the windings of the latter solenoid and the section 28 of resistance. After the temporary rise in the armature current which follows the cutting out of the section 25 of resistance, the current flowing in the windings of the solenoid 21 which remain in circuit will sustain the core 19 until the current again falls to a predetermined amount and the latter solenoid will then release its core and the switch member *g* will move with the core to close the contacts 15 and 17. The section 28 of resistance and the coils of the solenoid 21 will thereby be shunted through a circuit which extends from the frame B through the switch member *g* of switch G and conductor 33 to the conductor 29 which leads to the motor. If, now, the manually controlled switch 40 is opened, the magnet 4 will be deënergized and the pressure of the main switch member *e* against the opposing spring-pressed member *e'* will be relieved. The latter member will therefore instantly move forward. As said member moves forward its arms $6^a$ will move the bell crank levers *f* and *g* to open positions, thus again including the coils of the regulating solenoids and the starting resistance in the armature circuit and restoring the solenoid cores to their upper positions. The member *e'*, during this forward movement, presses the member *e* back toward its normal position, said members remaining in contact until after the resistance controlling switches F and G have been opened. The member *e* then suddenly breaks contact with the member *e'* when the latter stops, and any arc which may be drawn between the contact surfaces of the main switch will be instantly blown out by the magnetic influence of the cores of the solenoids. The windings and connections of the solenoids, as shown in the drawing, are such as to produce north and south poles, indicated

by N and S, at the lower ends of the cores 18 and 19 and the arc between the main switch contacts would therefore be deflected upwardly. A sheet of asbestos 42 may be placed under the shelf $b'$ to prevent blistering of the shelf by the arc. By rearranging the connections the arc may be deflected downwardly, if desired. Preferably an iron yoke piece 43 is arranged at the upper ends of the solenoids to reduce the reluctance of the magnetic circuit.

While only two regulating solenoids and two steps of resistance are shown, for the purpose of illustration, it will be understood that for large motors more steps of resistance will be required and that a regulating solenoid will also be required for each step of resistance. In any starter embodying a greater number of regulating solenoids than shown in the drawing, the main switch contacts will be arranged between two solenoids wound so as to produce poles of opposite polarity, for extinguishing the arc.

It will be noted that the resistance and the regulating solenoids are normally in circuit; that the resistance-controlling switches cannot be closed until after the circuit has been completed through the regulating solenoids, the resistance and the armature and that after the motor has been started both the resistance and the regulating solenoids are cut out of circuit. It will also be noted that when the manually controlled switch is opened the resistance and the coils of the regulating solenoids are first re-inserted in the armature circuit, the main switch is then opened, and the arc at the main switch is extinguished by the magnetic influence of the solenoids. The main switch may be closed and opened as often and as rapidly as desired without endangering the motor.

What I claim is:—

1. A starter for electric motors comprising a main switch for opening and closing the supply circuit, a normally open resistance-controlling switch and an electromagnetic device for regulating the closing movement of the latter switch, said device having a core or armature adjacent the contacts of the main switch and serving as a blow-out.

2. A starter for electric motors comprising a main switch for opening and closing the supply circuit, normally open resistance controlling switches, and electromagnetic devices for regulating the closing movements of the latter switches, said devices being arranged and connected so as to produce opposite poles adjacent the contact surfaces of the main switch.

3. A starter for electric motors comprising a main switch for opening and closing the supply circuit, normally open resistance controlling switches, and electromagnetic devices for regulating the closing movements of the latter switches, said devices having windings in the armature circuit of the motor and being arranged and connected so as to produce opposite poles adjacent the contact surfaces of the main switch.

4. A starter for electric motors comprising a main switch for opening and closing the supply circuit, normally open resistance controlling switches, regulating solenoids having their windings in the armature circuit of the motor and having their cores operatively connected to the latter switches, the outer ends of said cores being arranged adjacent to and on opposite sides of the main switch contacts, and the windings of said solenoids being connected so as to produce opposite poles in said ends of the cores.

5. A starter for electric motors comprising normally open resistance-controlling switches, electromagnetic devices having cores or armatures connected to said switches and adapted to regulate their closing movements, and a main switch having its contact surfaces arranged between and adjacent the ends of said cores or armatures.

6. A starter for electric motors comprising normally open resistance-controlling switches, electromagnetic devices having cores or armatures connected to said switches and adapted to regulate their closing movements, a normally open main switch having its contact surfaces arranged between and adjacent the ends of said cores or armatures, and means for controlling the opening and closing movements of said main switch comprising an electromagnetic device and a switch for opening and closing the circuit through said latter device.

7. A starter for electric motors comprising a resistance controlling switch, an electromagnetic device having a core or armature connected to said switch to regulate its closing movement, a spring-pressed member normally holding said switch open, a main switch contact movable with said member and arranged adjacent to and within the magnetic influence of said core or armature, and a magnetically operated main switch member adapted, in its closing movement, to first engage said contact and then move said spring-pressed member to release the resistance-controlling switch, and, in opening, to release the spring-pressed member and then interrupt the supply circuit.

8. A starter for electric motors comprising resistance-controlling switches, electromagnetic devices having cores or armatures connected to said switches and adapted to regulate their closing movements, a spring-pressed member normally holding said switches open, a main switch contact movable with said member and arranged between and adjacent the ends of said cores or

armatures, and a magnetically operated main switch member adapted, in its closing movement, to first engage said contact and then move said spring-pressed member to release the resistance-controlling switches, and, in opening, to release the spring-pressed member and then interrupt the supply circuit.

9. A starter for electric motors comprising resistance-controlling switches, two solenoids for regulating the closing movements of said switches, said solenoids having their windings arranged in the armature circuit of the motor and connected so as to produce opposite magnetic poles in the outer ends of their cores, a spring-pressed member normally holding said switches open, a main switch contact movable with said member and arranged in the path of the magnetic flux passing between said cores, and a coöperating main switch member adapted, in closing, to first engage said contact and then move said spring-pressed member to release the resistance-controlling switches.

10. A starter for electric motors comprising resistance-controlling switches, two solenoids for regulating the closing movements of said switches, said solenoids having their windings arranged in the armature circuit of the motor and connected so as to produce opposite magnetic poles in the outer ends of their cores, a spring-pressed member normally holding said switches open, a main switch contact movable with said member and arranged in the path of the magnetic flux passing between said cores, a coöperating main switch member adapted, in closing, to first engage said contact and then move said spring-pressed member to release the resistance-controlling switches, a magnet for actuating said coöperating main switch member, and a manually operated switch for controlling said magnet.

11. A starter for electric motors comprising resistance-controlling switches, two solenoids for regulating the closing movements of said switches, said solenoids having their windings arranged in the armature circuit of the motor and connected so as to produce opposite magnetic poles in the outer ends of their cores, a spring-pressed member normally holding said switches open, a main switch contact movable with said member and arranged in the path of the magnetic flux passing between said cores, a coöperating main switch member adapted, in closing, to first engage said contact and then move said spring-pressed member to release the resistance-controlling switches, a magnet arranged in a circuit independent of the armature circuit, for actuating said coöperating main switch member, and a switch for opening and closing the circuit through said magnet.

12. A starter for electric motors, comprising a suitable support, two switch levers, adapted to cut out starting resistance, pivoted to said support and having horizontal and vertical arms, vertically arranged solenoids, for regulating the closing movements of said levers, said solenoids having their cores normally resting on the horizontal arms of said levers, a spring-pressed member normally bearing against the vertical arms of said levers and holding the latter in open positions, a main switch contact on said spring-pressed member, a coöperating main switch member, and a magnet for operating said last-mentioned switch member.

13. A starter for electric motors, comprising a suitable support, two switch levers, adapted to cut out starting resistance, pivoted to said support and having horizontal and vertical arms, vertically arranged solenoids, for regulating the closing movements of said levers, said solenoids having their cores normally resting on the horizontal arms of said levers, a spring-pressed member normally bearing against the vertical arms of said levers and holding the latter in open positions, a main switch contact on said spring-pressed member, a coöperating main switch member, and a magnet arranged in a circuit independent of the motor circuits for operating said last-mentioned switch member.

14. A starter for electric motors, comprising a suitable support, two switch levers, adapted to cut out starting resistance, pivoted to said support and having horizontal and vertical arms, vertically arranged solenoids, for regulating the closing movements of said levers, said solenoids having their cores normally resting on the horizontal arms of said levers, a spring-pressed member normally bearing against the vertical arms of said levers and holding the latter in open positions, a main switch contact arranged on said spring-pressed member between the lower ends of said cores, a coöperating main switch member, and a magnet for operating said last-mentioned switch member.

In testimony whereof I affix my signature, in presence of two witnesses.

GEORGE H. WHITTINGHAM.

Witnesses:
M. E. NICOLL,
HERTHA ERNST.