C. T. HENDERSON.

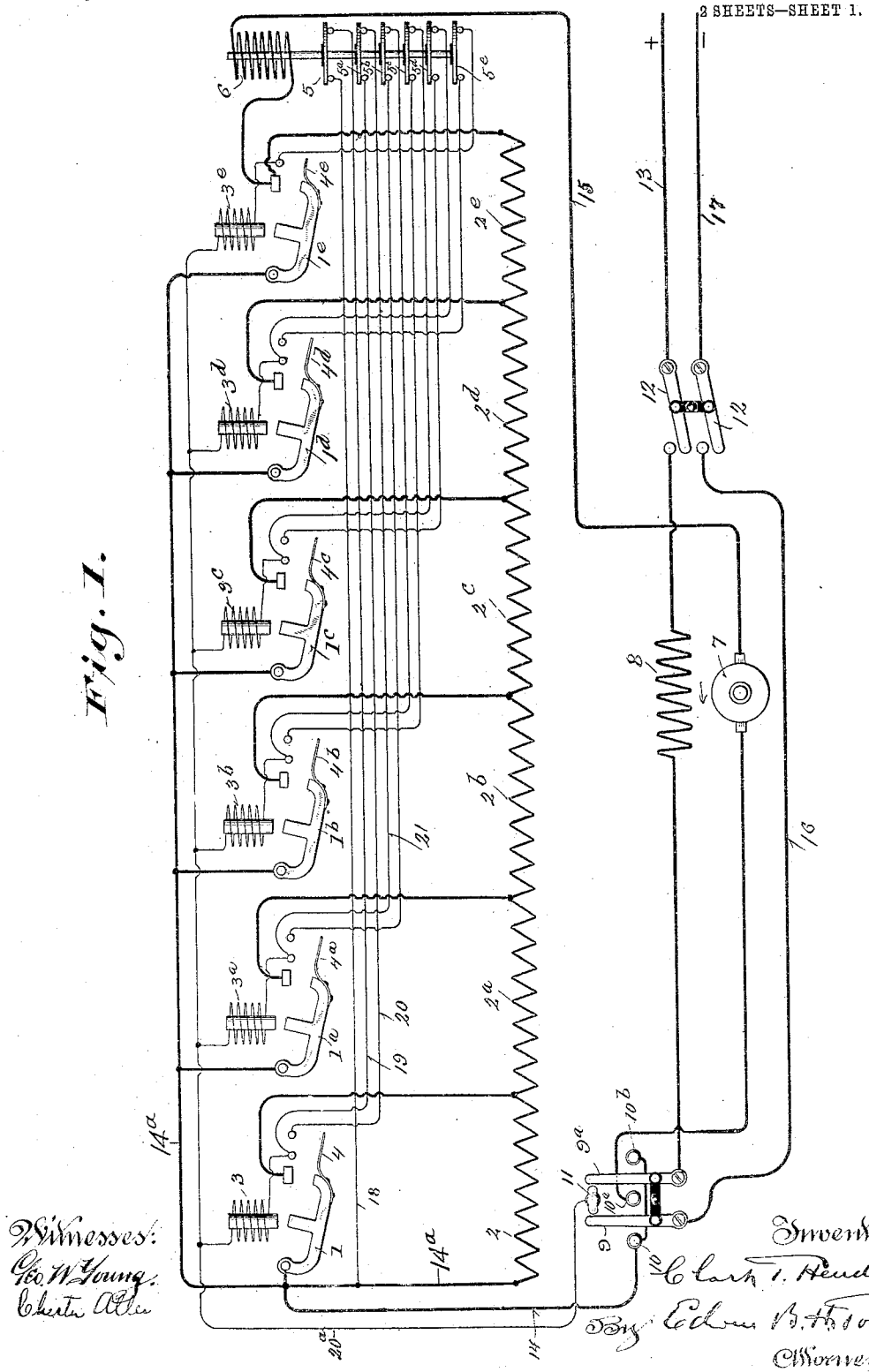
MOTOR STARTER.

APPLICATION FILED JAN. 13, 1906.

969,866. Patented Sept. 13, 1910.

2 SHEETS—SHEET 1.

Fig. 1.



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2 SHEETS—SHEET 2.

Fig. 2.

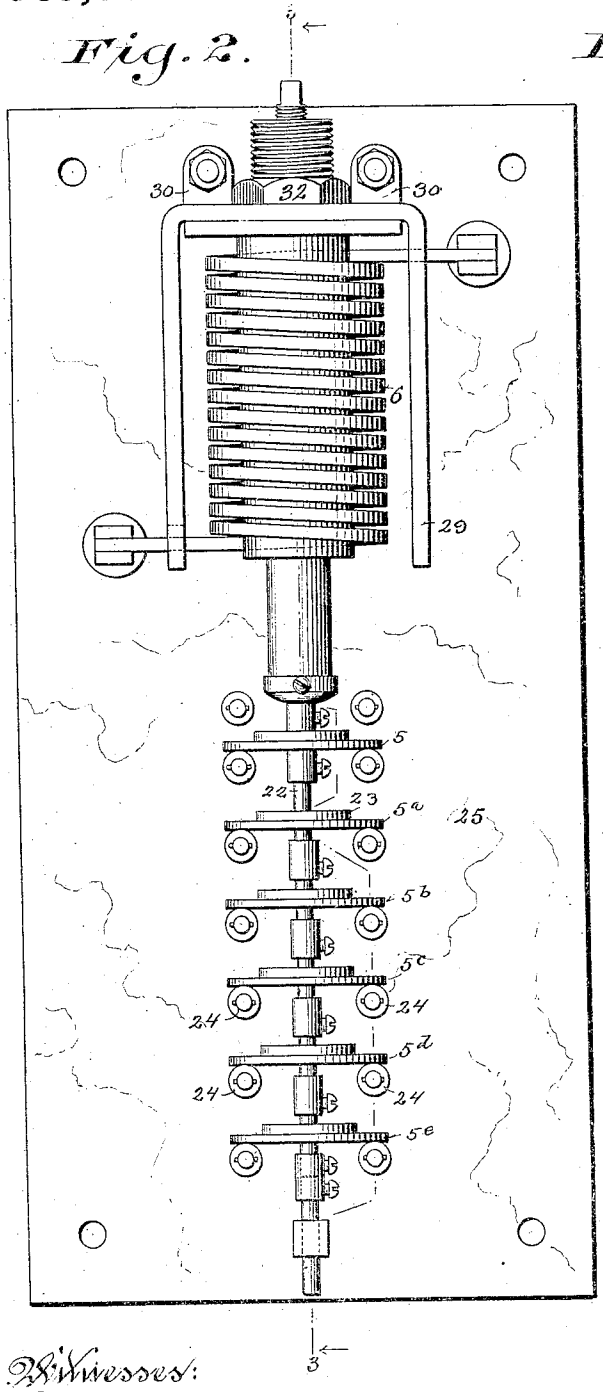
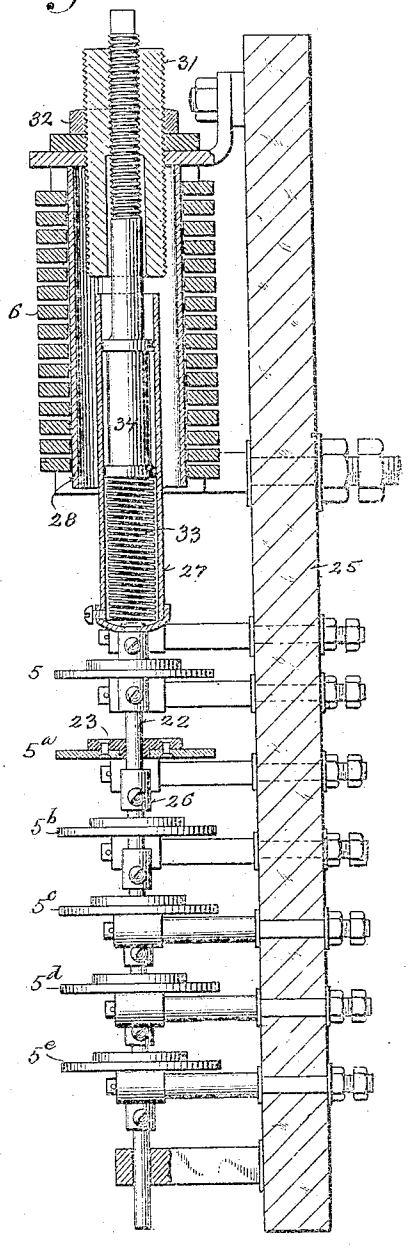


Fig. 3.



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UNITED STATES PATENT OFFICE.

CLARK T. HENDERSON, OF PITTSBURG, PENNSYLVANIA, ASSIGNOR TO THE CUTLER-HAMMER MANUFACTURING COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF WISCONSIN.

MOTOR-STARTER.

969,866. Specification of Letters Patent. Patented Sept. 13, 1910.

Application filed January 13, 1906. Serial No. 295,969.

To all whom it may concern:

Be it known that I, CLARK T. HENDERSON, a citizen of the United States, residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented new and useful Improvements in Motor-Starters, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawing, forming a part of this specification.

My invention relates to improvements in motor starters.

The particular form of starter to which my invention especially relates is provided with a plurality of electromagnetic windings which actuate accelerating switches to remove the starting resistance from the circuit of the motor. These windings are provided with means by which the first winding closes the circuit of the second winding, the second winding closes the circuit of the third winding, and so on through the series of windings until all of the windings have responded, thereby closing the accelerating switches one after the other.

The object of my invention is to provide certain improvements in means for preventing the operating windings of the starter from responding in too rapid succession.

According to the preferred form of my invention, I preferably provide an electro-responsive relay device which is adapted to arrest the operation of the accelerating switches temporarily whenever the motor current rises to a predetermined degree. The accelerating switches are thus prevented from removing the starting resistance from circuit too quickly. The relay device is preferably provided with a plurality of relay switches which are arranged in the circuits of the operating windings, one relay switch being provided for each winding. These switches are preferably operated by means of a series electromagnet which is arranged in the circuit of the motor. Whenever the motor current rises to a predetermined degree, the series electromagnet responds, thereby causing the relay switches to be opened to arrest the further operation of the accelerating switches until the motor accelerates sufficiently to bring the motor current to a normal value. The starter is thus automatically controlled to prevent the starting resistance from being removed from circuit so rapidly as to subject the motor to an excessive current. I preferably so arrange each operating winding in circuit that its relay switch will be short circuited by its accelerating switch after it has responded. The windings that have responded are thus rendered independent of the relay switches, and therefore the relay device may respond without interfering with said windings.

For the purpose of explaining my invention, I shall describe the motor starter which is illustrated in the accompanying drawing.

Figure 1 is a diagrammatic view of the starter, as arranged with a motor. Fig. 2 is an elevation of my preferred form of relay device, and Fig. 3 is a sectional view on the line 3—3 of Fig. 2.

I preferably provide my starter with a plurality of accelerating switches or contactors 1, 1^a, 1^b, 1^c, 1^d and 1^e, which are adapted to short-circuit starting resistance steps 2, 2^a, 2^b, 2^c, 2^d and 2^e, respectively. These switches are operated by means of solenoids or electromagnetic windings 3, 3^a, 3^b, 3^c, 3^d and 3^e, respectively, which are preferably arranged in parallel in a controlling circuit. The accelerating switches are preferably provided with auxiliary contacts or switches 4, 4^a, 4^b, 4^c, 4^d and 4^e, respectively, which are adapted to close the circuits of the operating windings. In order to set the starter in operation, I close the controlling circuit to complete the circuit of the first winding. The winding 3 will thereupon respond, thereby causing the auxiliary contact 4 to close the circuit of the winding 3^a. Each operating winding thus causes the circuit of the next winding to be closed. In consequence, the operating windings respond one after the other, thereby closing the accelerating switches successively to remove the starting resistance from circuit. If each operating winding were permitted to respond under all conditions as soon as its circuit is closed by the preceding winding, the accelerating switches might be closed in such rapid succession that the starting resistance would be removed from circuit before the motor develops enough counter electro motive force to protect it from an excessive current. I preferably prevent such results by means of a relay device which is adapted to arrest the progressive operation of the operating windings while the motor current exceeds a predetermined value. In accordance with the preferred

form of my invention, I preferably provide the relay device with a plurality of relay switches 5, 5^a, 5^b, 5^c, 5^d and 5^e, one for each winding. Those relay switches are actuated by means of a series relay magnet 6 which is preferably arranged in circuit in series with the armature of the motor. Whenever the motor current rises to a predetermined degree, the series relay magnet 6 will respond, thereby opening the relay switches. The progressive action of the windings will thus be arrested until the motor current subsides to a normal amount. If the motor be started under a heavy load, the series relay magnet will respond to the increase in the motor current immediately following the removal of each resistance step from circuit, and in consequence the relay switches will be opened after each winding responds to prevent the next winding from responding until the motor current decreases. It will of course be understood that each accelerating switch or contactor may be constructed in any suitable way.

Inasmuch as the accelerating switch 1 together with the auxiliary switch 4 short-circuits its relay switch 5, when said switches close, the operating winding 3 is rendered independent of said relay switch as soon as the resistance step 2 is removed from circuit. It has heretofore been the practice to insert a resistance in the circuit of the operating winding when the accelerating switch closes, thereby reducing the energizing current of said winding before the switch becomes firmly closed or sealed. In consequence, the main contact, as well as others, sometimes vibrated and chattered thereby rendering the switch unstable in operation. According to my invention, I do not reduce the energizing current of the operating winding, at least not before the switch becomes sealed. In consequence, the operating winding will positively close the accelerating switch. The movable contacts will yield after the same engage the stationary contacts until the switch becomes sealed. Inasmuch as the accelerating switch 1 short-circuits the relay switch 5 as soon as it removes the resistance step 2 from circuit, it is insured that the operating winding 3 will become independent of the said relay switch before the relay device may respond. In consequence, the relay device will not interfere with the operation of the accelerating switch after the operating winding responds, notwithstanding the fact that the relay device may respond the instant the resistance step is removed from circuit. I provide a relay switch for each operating winding so as to obviate the necessity of insulating the auxiliary contact from the accelerating switch, and also of causing said auxiliary contact to shift the operating winding from one circuit to another. I thus overcome various difficulties that would otherwise arise both in the operation and construction of the accelerating switch. All of the accelerating switches or contactors preferably operate upon the principles which have just been set forth.

The starter is shown in the drawing as connected in circuit with a motor having an armature 7 and a field 8. I preferably provide a reversing switch by means of which the direction of the motor may be controlled and the automatic starter may be set in operation. The reversing switch, which is illustrated in the drawing, is provided with contact arms 9, 9^a contact buttons 10, 10^a, 10^b, and a contact segment 11. Of course, the reversing switch may be of any form, and other means may be employed to set the starter in operation. I preferably control the supply circuit by means of a switch 12.

If the reversing switch be moved to the right, it will close the motor circuit from the positive main 13 through switch 12, field 8, switch arm 9^a, contact button 10^b, conductors 14 and 14^a, resistance steps 2, 2^a, 2^b, 2^c, 2^d and 2^e, series relay magnet 6, conductor 15, armature 7, contact button 10^a, switch arm 9, conductor 16 and switch 12 to the negative main 17. Accordingly the motor will be started with all of the starting resistance in circuit. The reversing switch will also close the controlling circuit from the conductor 14 through conductors 14^a and 18, relay switch 5, conductor 19, winding 3, conductor 20 and segment 11 to the switch arm 9. The winding 3 will therefore be the first to respond, thereby causing accelerating switch 1 to short-circuit the resistance step 2. Of course, if the motor current be too large when the motor circuit is first closed, the relay switch 5 will be opened thereby preventing the accelerating switch 1 from closing until the motor current decreases sufficiently for said relay switch to be closed.

If the motor be started under a heavy load, the motor current will rise precipitately immediately after the accelerating switch 1 short-circuits the resistance step 2, thereby causing the series relay magnet 6 to respond. The relay switches 5, 5^a, 5^b, 5^c, 5^d and 5^e will then be opened thus making it impossible for the succeeding solenoid 3^a to respond, as its circuit will be open at the switch 5^a. When the motor current decreases sufficiently for the relay magnet to release the relay switches, the controlling circuit will be closed from the conductor 14 through accelerating switch 1, auxiliary switch 4, conductor 20, relay switch 5^a, conductor 21 and winding 3^a to the conductor 20^a. In consequence, the winding 3^a will respond, thereby causing the accelerating switch 1^a to short-circuit the resistance step 2^a. The relay switch 5^a will be short-circuited on the closing of the accelerating

switch 1^a and the auxiliary contact 4^a so as to make the winding 3^a independent of said relay switch. Immediately after the removal of the resistance step 2^a from circuit, the series relay magnet will respond to the increase in the motor current, thereby causing the relay switch 5^b to open the circuit of the winding 3^b. It will be observed that whenever the motor current becomes too great, the accelerating switches will be temporarily arrested from further operation. However, as soon as the motor current becomes normal again, the accelerating switches may proceed to operate. I therefore automatically control my starter so that it will remove the starting resistance from circuit in accordance with the speed of the motor.

If the motor be started under a light load, or without any load, several of the windings may respond in rapid succession without the relay switches being opened, as the speed of the motor will increase so rapidly that the motor current cannot rise sufficiently to make the series relay magnet respond.

Without further setting forth the operation of the starter, it will be noted that the first winding causes the circuit of the second winding to be closed, the second winding causes the circuit of the third winding to be closed and so on through the series of windings, thereby making the windings 3, 3^a, 3^b, 3^c, 3^d and 3^e respond one after the other. The accelerating switches will therefore be closed successively to remove resistance steps, 2, 2^a, 2^b, 2^c, 2^d and 2^e from circuit one by one. Furthermore, it will be noted that the relay switches 5, 5^a, 5^b, 5^c, 5^d and 5^e will be opened whenever the motor current increases to a predetermined value, thereby arresting the progressive operation of the accelerating switches until the motor current subsides to a normal amount. The starter is thus automatically controlled to prevent the starting resistance from being removed from the circuit so rapidly as to subject the motor to an abnormal current. Of course, I am aware that the relay device may be constructed and operated in various ways to accomplish the purposes for which it is provided. The direction of the motor may be reversed by shifting the position of the reversing switch so that the arm 9 engages contact button 10 and the arm 9^a engages contact button 10^a and segment 11, in which event the motor circuit will be closed from the positive main 13, through switch 12, field 8, arm 9^a, contact button 10^a, armature 7, series relay magnet 6, resistance steps 2^e, 2^d, 2^c, 2^b, 2^a and 2, conductors 14^a and 14, contact button 10, switch arm 9, conductor 16, and switch 12 to the negative main 17.

I have illustrated in Figs. 2 and 3 the way in which I may construct my relay device. I preferably provide a rod 22 upon which are loosely mounted the relay switches 5, 5^a, 5^b, 5^c, 5^d and 5^e, said switches preferably being formed by circular disks or plates which are insulated from said rod by means of washers 23. The relay switches are adapted to engage contacts or terminals 24, which are preferably mounted upon an insulating base 25. The rod 22 is preferably provided with collars 26 by means of which it may raise the relay switches from the contacts 24. The series relay magnet 6 preferably surrounds a tubular plunger or core 27, to which the rod 22 is attached. An insulating sheath 28 is preferably placed between the relay magnet and the plunger. The relay magnet is preferably mounted within a frame 29, which is suspended from the base by means of brackets 30. Of course, it will be understood that it is unnecessary for all of the relay switches to be opened whenever the motor current abnormally increases. If merely the relay switch of the winding that should next respond, be opened, the operation of the starter would be properly arrested. A sleeve 31 of magnetic material is preferably threaded through the frame, and it extends downwardly into the relay magnet 6 to approach the upper end of plunger 27. The position of the sleeve may be adjusted so as to vary the air gap between the same and the plunger. I am thus enabled to make the relay magnet raise the plunger at different currents. The sleeve is preferably provided with a set nut 32. A spring 33 is preferably arranged within the plunger, it being placed between the bottom thereof and a non-magnetic rod 34 which may serve to guide the plunger. The spring opposes the upward movement of the plunger, and therefore urges the relay magnet to release said plunger. The rod 34 is preferably threaded through the sleeve 31 so that the tension of the spring may be regulated thereby. I am thus enabled to make the relay magnet release the plunger at different currents. It will be noted that I so construct my relay device that I may adjust the same to open and close the relay switches at such currents as the circumstances may require.

It will be understood that the apparatus which is illustrated in the drawings, has been selected merely for the purpose of explaining certain requirements of my invention, and that various changes may be made therein without in any way passing from the purview of the claims appended hereto.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. In combination, a plurality of electromagnetic windings arranged to be energized successively, a plurality of relay switches, one for each winding, adapted to arrest the successive operation of said windings, and a

single device for actuating said relay switches.

2. In combination, a plurality of electromagnetic windings, means for causing each winding to close the circuit of the next winding so as to make said windings operate successively, a plurality of relay switches, one for each winding, adapted to arrest the successive operation of said windings, and an electromagnet for actuating all of said relay switches.

3. In combination, a plurality of successively operating electromagnetic windings, a plurality of relay switches, one for each winding, adapted to arrest the successive operation of said windings, an electromagnet for actuating said relay switches, and means for rendering each winding independent of its corresponding relay switch after the winding operates.

4. In combination, a plurality of electromagnetic windings, a switch actuated by each of said windings to close the circuit of the next winding so as to make said windings operate successively, a plurality of relay switches, one for the circuit of each winding, an electromagnet for opening said relay switches to arrest the successive operation of said windings, and means for short-circuiting each relay switch after its corresponding winding responds so as to render said winding independent of its corresponding relay switch.

5. In a motor starter, in combination, a plurality of electromagnetic windings, a resistance controlled thereby, means for causing said windings to operate successively, a plurality of relay switches, one for each winding, said relay switches being so arranged in circuit that the same may arrest the successive operation of said windings, an electromagnet for actuating said relay switches, said magnet being responsive to the motor current.

6. In combination, a plurality of electromagnetic windings, means for making said windings respond successively, switches actuated by said windings, a plurality of relay switches, one for each winding, said relay switches being so arranged in circuit that the same may be actuated to arrest the successive operation of said windings, and an automatic device for actuating said relay switches.

7. In a motor starter, in combination, a plurality of electromagnetic windings, a resistance controlled thereby, means for causing said windings to operate successively, a plurality of relay switches, one for each winding, said relay switches being so arranged in circuit that the same may arrest the successive operation of said windings, an electromagnet for actuating said relay switches, said magnet being responsive to the motor current, and means for rendering each winding independent of its corresponding relay switch after it responds.

8. In a motor starter, in combination, a plurality of electromagnetic windings, a resistance controlled thereby, means for making said windings respond successively, a plurality of relay switches, one arranged in the circuit of each winding, an electromagnetic winding for actuating said relay switches to arrest the successive operation of said windings, said magnet being responsive to the motor current, and means for making each winding independent of its corresponding relay switch after it responds.

9. In a motor starter, in combination, a plurality of electromagnetic windings, a resistance controlled thereby, a switch contact operated by each winding to close the circuit of the succeeding winding so as to make said windings respond successively, a plurality of relay switches, one of said switches being arranged in the circuit of each winding, and a single electromagnet for actuating said switches to arrest the successive operation of said windings, said magnet being responsive to the motor current.

10. In a motor starter, in combination, a plurality of electromagnetic windings, a starting resistance controlled thereby, means for causing said windings to respond successively, a plurality of relay switches, one for each winding, said relay switches being so arranged in circuit that the same may arrest the successive operation of said windings, and a device adapted to actuate said relay switches whenever the motor current rises to a predetermined degree.

11. In a motor starter, in combination, a plurality of accelerating switches, a resistance controlled thereby, a plurality of electromagnetic windings, one for each switch, means for causing said windings to operate said switches successively, a plurality of relay switches, one for each winding, means for operating said relay switches to arrest the successive operation of said accelerating switches, said means being responsive to the motor current and means for rendering each winding independent of its corresponding relay switch after it responds.

12. In a motor starter, in combination, a plurality of accelerating switches, a starting resistance controlled thereby, a plurality of electromagnetic windings, one for operating each switch, and a switch contact actuated by each winding to close the circuit of the next winding so that said accelerating switches will be actuated successively, a plurality of relay switches, one for the circuit of each winding, an electromagnet for actuating said relay switches to arrest the successive operation of said accelerating switches, said magnet being arranged in circuit to be responsive to the motor current.

13. In a motor starter, in combination, a

plurality of accelerating switches, a starting resistance controlled thereby, a plurality of electromagnetic windings, one for operating each switch, an auxiliary switch actuated by each winding to close the circuit of the next winding so that said accelerating switches will be actuated successively, a plurality of relay switches, one for the circuit of each winding, an electromagnet for actuating said relay switches to arrest the successive operation of said accelerating switches, said magnet being responsive to the motor current, and each accelerating switch and its corresponding auxiliary being adapted to short-circuit its corresponding relay switch.

14. In a motor starter, in combination, a plurality of successively operating electromagnetic windings, a plurality of relay switches, one for each winding, adapted to arrest the successive operation of said windings, and an electromagnet for actuating said relay switches, said magnet being connected in circuit to respond whenever the motor current rises above a predetermined value.

15. In a motor starter, in combination, a plurality of successively operating electromagnetic windings, a starting resistance controlled thereby, a plurality of relay switches, one for each winding, adapted to arrest the successive operation of said windings, and an electromagnet for actuating said relay switches, said magnet being connected in circuit to respond whenever the motor current rises above a predetermined value.

16. In combination, a plurality of successively operating electromagnetic windings, a starting resistance controlled thereby, a plurality of relay switches, one for each winding, adapted to arrest the successive operation of said windings, means for rendering the windings that have responded independent of said relay switches, and an electromagnet for actuating said relay switches, said magnet being connected in circuit to respond whenever the motor current rises above a predetermined value.

17. In a motor starter, in combination, a plurality of successively operating electromagnetic windings, a starting resistance controlled thereby, a plurality of relay switches, one for each winding, adapted to arrest the successive operation of said windings, means for short-circuiting said relay switches so as to render the windings that have responded independent of said relay switches, and an electromagnet for actuating said relay switches, said magnet being connected in circuit to respond whenever the motor current rises above a predetermined value.

18. In a motor starter, in combination, a plurality of electromagnetic windings, a plurality of accelerating switches, one for each winding, actuated by said windings, a starting resistance, an auxiliary contact actuated by each winding to close the circuit of the succeeding winding so as to make said windings respond successively, a plurality of relay switches, one for the circuit of each winding, and an electromagnet for actuating said relay switches, said magnet being connected in circuit to respond whenever the motor current rises above a predetermined value, and each accelerating switch and its corresponding auxiliary contact being adapted to short-circuit its corresponding relay switch.

19. In combination, a motor, a starting resistance therefor, a plurality of electromagnetic windings, means actuated by said windings to control said starting resistance, means for causing said windings to respond successively, a plurality of relay switches, one for the circuit of each winding, and an electromagnet for actuating said relay switches, said magnet being arranged in circuit in series with said resistance and the motor armature, and a reversing switch adapted to close the motor circuit and also the controlling circuit so as to set said motor in operation.

20. In combination, a plurality of successively operating electromagnetic windings, a plurality of relay switches, one for each winding, adapted to arrest the successive operation of said winding, an electromagnet for actuating said relay switches, and means for adjusting the action of said magnet upon said relay switches to accomplish the purposes set forth.

21. In combination, a resistance, a plurality of successively operating electromagnetic switches for controlling said resistance, a plurality of relay switches, one for each of said resistance switches, arranged in circuit in vertical alinement, to control the operation of said resistance switches, a single magnet connected in circuit with the motor and adapted to operate said relay switches to arrest the successive operation of said resistance switches if the current rises above a predetermined amount, and means for rendering the resistance switches that are closed independent of their corresponding relay switch.

22. In a motor controller, in combination, a resistance, a plurality of switches for controlling said resistance, a plurality of electromagnetic windings for actuating said switches successively, a plurality of relay switches, one for the circuit of each winding, and an electromagnet for actuating all of said relay switches to arrest the successive operation of said resistance controlling switches whenever the motor current rises above a predetermined value.

23. In a motor controller, in combination, a resistance, a plurality of switches for controlling said resistance, a plurality of electromagnetic windings for actuating said

switches successively, a plurality of relay switches, one for the circuit of each winding, an electromagnet for actuating all of said relay switches to arrest the operation of the first mentioned switches, and electrical connections whereby each of the first mentioned switches short-circuits its corresponding relay switch after it is closed to render its operating winding independent of its relay switch.

24. In a motor controller, in combination, a plurality of switches adapted to be closed successively, a plurality of electromagnetic windings for actuating said switches, each switch being adapted to close the circuit of the next succeeding winding, a plurality of relay switches, one for the circuit of each winding, and an electromagnet for actuating all of said relay switches to arrest the successive operation of said first mentioned switches whenever the motor current rises above a predetermined value.

25. In a motor controller, in combination, a plurality of switches, a plurality of electromagnetic windings for actuating said switches, a resistance controlled by said switches, each of several of said switches being provided with means for causing the energization of the winding of another one of said switches whereby said switches are actuated successively, a series relay having multiple contacts, one for the winding of each of said switches, and also having an electromagnet connected in circuit to operate all of said contacts to arrest the operation of said switches whenever the motor current rises above a predetermined value, and electrical connections whereby each of said switches, after it is closed, short-circuits its corresponding contact on said relay to render its operating winding independent of said contact.

26. In a motor controller, in combination, a plurality of switches, a plurality of electromagnetic windings for actuating said switches, a resistance controlled by said switches, a series relay having multiple contacts, one for the winding of each of said switches, and also having a series electromagnet for operating all of said contacts whenever the motor current rises above a predetermined value, electrical connections whereby each of several of said switches closes the circuit of another switch to cause said switches to operate successively, and other electrical connections whereby each of said switches, after it is closed, short-circuits its corresponding relay switch to render its operating winding independent of its relay switch.

In witness whereof, I have hereunto subscribed my name in the presence of two witnesses.

CLARK T. HENDERSON.

Witnesses:
ANNA E. BARTHELMES,
LESTER C. HART.