No. 728,976. PATENTED MAY 26, 1903.

W. H. POWELL.

SYSTEM OF MOTOR CONTROL.

APPLICATION FILED JULY 11, 1902.

NO MODEL.

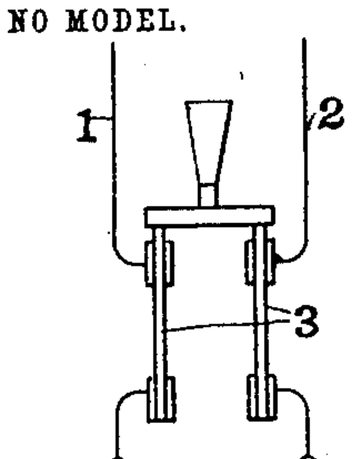


Fig 1.

Fig 2

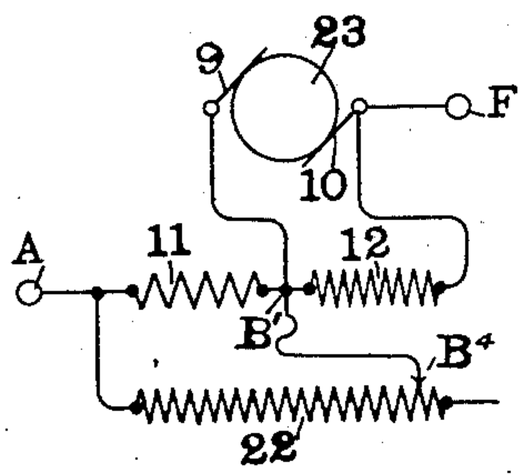


Fig 3

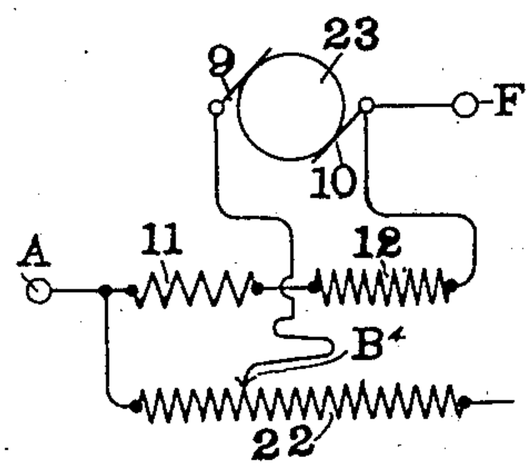
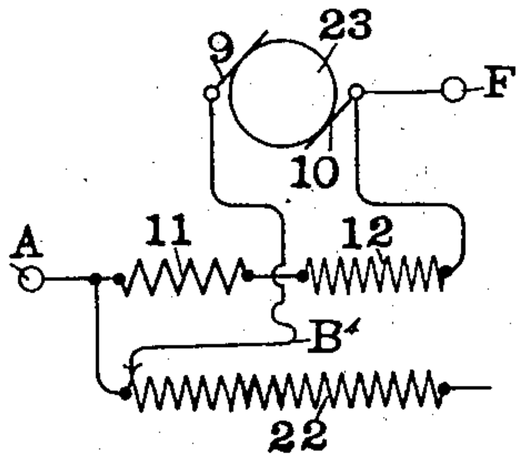


Fig 4



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No. 728,976. Patented May 26, 1903.

UNITED STATES PATENT OFFICE.

WILLIAM H. POWELL, OF AMPERE, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE KEYSTONE ELECTRIC COMPANY, OF ERIE, PENNSYLVANIA, A CORPORATION.

SYSTEM OF MOTOR CONTROL.

SPECIFICATION forming part of Letters Patent No. 728,976, dated May 26, 1903.

Original application filed February 27, 1902, Serial No. 95,873. Divided and this application filed July 11, 1902. Serial No. 115,119. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM H. POWELL, a citizen of the United States, residing at Ampere, New Jersey, have invented a new and useful System of Motor Control, of which the following is a specification.

My invention resides in controlling electric motors, more especially those required to start from rest under full load—such, for example, as elevator and railway motors and automobile-motors.

It consists, further, in means for generating and maintaining during the starting period an excessive strength of magnetic field and gradually without sudden variations reducing the strength of the field during the accelerating period until full speed is attained.

It consists, further, in means for correlating different portions of the field-winding in such manner that as the speed of the motor increases one portion of the winding becomes less effective while another becomes more effective, complete compensation between the effects of the several windings being approximated as closely as desired.

It consists, further, in means for decreasing the effect of one field-winding by shunting it with a gradually-decreasing resistance, while increasing the effect of another winding at a rate depending upon the rate of increase of the counter electromotive force of the armature as it increases in speed.

My invention comprises, further, means for the variation in the connections of the several field-windings, whereby after full speed has been attained all the field-conductor remains in service.

The objects of my invention are to simplify the number and arrangement of field connections beyond what has heretofore been the practice, to reduce the amount of copper in the field, to reduce the amount of space required for the field-windings, with a resultant decrease in size and weight of metal in the magnetic circuits, to attain a smooth acceleration curve resulting from a uniform or gradual variation of field strength, to minimize the starting current both to save cost of energy and to prevent an excessive drop in pressure of the supply-circuit, and to insure minimum fluctuation in current during the period of acceleration.

For a detailed description of my invention reference is to be had to the accompanying drawings, in which—

Figure 1 is a diagram of the circuit of the motor and its associated controlling system. Fig. 2 is a simplified diagram of the condition of the circuits during the first part of the acceleration period. Fig. 3 is a simplified diagram of the condition of the circuits during a later period in the acceleration. Fig. 4 is a simplified diagram of the condition of the circuits when full speed has been attained.

1 and 2 are the service-wires, which supply current to the motor system through the cut-out 3.

4 4 represent fusible cut-outs in circuit between the cut-out 3 and the reversing-switch, which comprises bridging members 6, 7, and 8, insulated from each other and mounted upon a shaft which is actuated through the medium of sprocket wheel or pulley 5 from the elevator-car or any other desired locality. The shaft carrying the members 6, 7, and 8 has its bearings in members 27 and 28. The member 27 is in electrical communication with the service-wire 2 and also with the member 8 on the shaft of the reversing-switch. The members 6, 7, and 8 engage spring-fingers mounted upon the base of the switch and which are represented at A, B^4, C, and D, and also fingers at the left of the figure, which are in electrical communication with the service-wire 1. The fingers C and D are the terminals for the armature-circuit, and upon the two sides of the rotating barrel of shaft the fingers C and D are differently arranged to secure a reversal of the direction of current through the motor-armature upon reversal of the position of the bridging members. The fingers C and D connect, respectively, with brushes 10 and 9 of the armature 23.

11 is a series of coarse-wire winding upon the field of the motor, and 12 is a shunt or

fine-wire winding on the same field. These windings are so connected in circuit that at all times their ampere-turns are cumulative.

B′ B^4 F A represent binding-posts, and wherever occurring like posts are connected together by conductors of practically negligible resistance.

At the juncture of coils 11 and 12 is a binding-post B′, from which leads a conductor to a second post, similarly designated, and which is connected to a segment 13 in the automatic controller. From the finger B^4 on the switch extends a conductor to binding-post B^4 upon the automatic controller, and from posts A and F upon the switch extend conductors to posts A and F at the motor-windings and likewise upon the automatic controller.

In the controller A and F connect to the terminals of the solenoid-coils 25, which are therefore in shunt across the line and whose purpose is to draw in the cores 20, connected together through yoke 19. Extending vertically over and above yoke 19 are two parallel rods 18, guided through member 26, which is rigid with the frame of the controller. The upward motion of the cores 20 is resisted by springs 24, which serve also to restore the controller to its initial position upon opening the circuit at the reversing-switch. To the rods 18 is connected the member 17, from which extends the link 16, pivoted to the controller-arm 15. It is apparent, therefore, that upon the energization of coils 25 the thrust in the member 16 causes a rotation of the controller-trailer 15. In its rotary motion member 15 passes over the segments 21, forming the terminals of the various sections of resistances shown at 22, and it also remains in contact for a greater portion of its travel with the segment 13 aforementioned and eventually rests at its one end upon the dead contact 14.

The method of operation is as follows: With the cut-out 3 closed, as shown, the operator rotates the reversing-switch into the position shown in Fig. 1, so that the bridge-piece 6 puts finger A into communication with service-wire 1. Member 7 bridges B^4 and D, and member 8 puts finger C into communication with binding-post F or service-wire 2. At this instant the arm 15 of the controller begins to rotate, due to the energization of coils 25. In so doing it maintains a connection between the common connection of coils 11 and 12 and the brush 9 of the motor. Its rotary movement also gradually diminishes the amount of resistance 22, and after further progress one end of the trailer 15 rests upon dead contact 14 and eventually all the resistance 22 is out of circuit.

The operation of my system is more readily understood from an inspection of Figs. 2, 3, and 4. In Fig. 2 is represented the condition of the circuits with the controller in the position shown in Fig. 1 and until it is about to break contact between the members 15 and 13. With this state of affairs current is received, for example, from binding-post F, passes through the armature 23 from brush 10 to 9, where it divides into parallel paths through coarse field-winding 11 and the resistance 22. The armature at this time is at rest, is therefore generating no counter electromotive force, and the only difference of potential existing between brushes 9 and 10 is that due to the drop in pressure caused by the current flowing through the resistance of the armature. This, even with large currents flowing, is very slight, and therefore coil 12 has but a faint magnetizing effect. At this time, however, coil 11 is carrying a large current and is generating an excessive strength in the magnetic field, which, along with a large current flowing in the armature, produces an excessive torque sufficient to start the load. The amount of current through coil 11 is dependent at any instant upon the position of trailer 15 with respect to the contacts 21. In other words, the effect of coil 11 in magnetizing the fields depends upon the drop of potential in the resistance 22. As trailer 15 rotates the amount of resistance in parallel to coil 11 gradually diminishes, with the effect of robbing said coil of more and more current, which in consequence causes a decrease in ampere-turns. Before trailer 15 has progressed any considerable distance over the contacts 21 the armature has begun to rotate and has begun to generate a counter electromotive force, which results in a rise of potential across the terminals of the coil 12, and in consequence said coil increases in its effect in magnetizing the field. Thus it is seen that as coil 11 diminishes in its effect from its initial maximum coil 12 gradually increases in its effect and compensates or in practice partially compensates for the loss in effect of coil 11, the result being a magnetic field whose strength is dependent upon the sum of the ampere-turns of coils 11 and 12, which sum, however, gradually diminishes. Coils 11 and 12 may, if desired, be so proportioned that a complete compensation for the loss of effect of coil 11 is obtained, or coil 12 may be so proportioned as to more than compensate for the loss in effect of coil 11, in which case the field would be strengthened and the speed of the motor decreased. This process of interaction between the two windings continues until trailer 15 leaves segment 13 of the controller and is upon segment 14, when the connection at B′ in Fig. 2 is broken and we have the state of affairs shown in Fig. 3. Here coil 11 is no longer in shunt to the remaining resistance 22, but has been thrown into series with coil 12, and the difference of potential at the terminals of the two windings together is now equal to full-line pressure, and there remains in series with the armature a portion of the resistance 22. A slight further travel of the trailer 15 cuts out the remaining portion of resistance 22, and

there then exists across the armature 23 and the field-windings the full-line potential, and we have the condition of the circuits represented in Fig. 4. With this state of the circuits the armature is rotating at full speed.

In practice this system may be applied to the bipolar or multipolar types of motors, and it is preferable that a portion of winding 11 and a portion of winding 12 be on each pole of the machine. As an example it may be stated that in a motor of a certain size at starting the coil 11 furnished twelve thousand ampere-turns and with the same load and after attaining full speed the ampere-turns of coils 11 and 12 together amounted to six thousand eight hundred, so that considering the saturation of the field at starting the initial strength of field is many times that required for full-speed running.

It is to be noticed that the diminution of the effect of coil 11 is due not only to the decrease in resistance 22 in shunt with it, but also to the counter electromotive force of the armature after it has begun to move and which is in series with said coil 11 and resistance 22 during the first part of the starting period.

To reverse the direction of rotation of the motor, wheel 5 is simply rotated until the bridging members 6, 7, and 8 bear a relation to the upper contact-fingers that they are shown to bear with the lower ones in Fig. 1.

It is to be understood that my invention is in no way limited to the precise arrangement of circuits or apparatus used, inasmuch as those skilled in the art may greatly vary the same without departing from the spirit of my invention.

This application is a division of my application, Serial No. 95,873, filed February 27, 1902.

What I claim is—

1. In a system of motor control, an armature, a field-magnet, a resistance in shunt to a winding of said field-magnet, means for diminishing said resistance, and a second winding normally connected directly across the armature.

2. In a system of motor control, an armature, a shunt-winding initially connected across the terminals of said armature, a winding initially in series with said armature, and means for subsequently merging said windings into a single winding.

3. In a system of motor control, an armature, a shunt-winding initially connected across the terminals of said armature, a winding initially in series with said armature, and automatic means for merging said series and shunt windings into a single winding.

4. In a system of motor control, an armature, a shunt-winding initially connected across the terminals of said armature, a series winding, and means for merging said windings into a single shunt-winding.

5. In a system of motor control, an armature, a shunt-winding initially connected across the terminals of said armature, a series winding cumulative with said shunt-winding, and means for merging said windings into a single winding.

6. In a system of motor control, an armature, a shunt-winding initially connected across the terminals of said armature, a series winding, a resistance initially in series with said armature, and means for reducing said resistance and merging said windings into a single winding.

7. The combination of an armature, a series field-winding, a shunt field-winding initially connected across the armature-terminals, a resistance in shunt to said series winding, means for reducing said resistance and merging said windings into a single winding.

8. The combination of an armature, a winding initially connected across the terminals of said armature, a winding initially in series with said armature, a resistance in shunt to said series winding, and means for reducing said resistance and merging said windings into a single shunt-winding.

9. The combination of an armature, a shunt-winding initially connected across the terminals of said armature, a winding initially in series with said armature, a resistance in shunt to said series winding, and automatic means for reducing said resistance to zero and merging said windings into a single winding.

10. The combination of an armature, a series field-winding, and shunt field-winding initially connected across the terminals of said armature, a resistance in shunt to said series winding, means for reducing said resistance, and means for connecting said series and shunt windings in series with each other.

11. The combination of an armature, a series winding, a shunt-winding, a resistance normally in shunt to said field-winding and automatic means for reducing said resistance and connecting said series and shunt windings in series with each other.

12. The combination of an armature, a series field-winding, a shunt field-winding, an automatic rheostat, the resistance of said rheostat in shunt to said series winding, and means for connecting said series and shunt windings in series with each other.

13. The combination with an armature, of a shunt-winding initially connected across the terminals of said armature, a winding of large cross-section initially in series with said armature, a resistance in shunt with said series winding, and means for reducing said resistance and merging said windings into a single winding.

14. The combination of an armature, a winding of relatively small cross-section initially connected across the terminals of said armature, a winding of greater cross-section, a resistance in shunt with said winding of greater cross-section, and means for reducing

said resistance and merging said windings into a single winding.

15. The combination of an armature, a relatively high-resistance winding initially connected across the terminals of said armature, a winding of relatively low resistance initially in series with said armature, a resistance initially in series with said armature, and means for reducing said resistance and merging said windings into a single shunt-winding.

16. An automatic controller, which comprises a resistance, means for reducing said resistance to zero, and a contact initially common to a winding initially in shunt with a motor-armature and a winding initially in series with a motor-armature, and means for subsequently interrupting communication between said contact and a terminal of the motor-armature.

17. An automatic controller, which comprises a sectional resistance, a traveling contact-arm, a contact common to a series winding, a shunt-winding and a terminal of an armature, normally engaged by said traveling contact-arm, means for operating said arm whereby said resistance is reduced to zero and contact broken between said traveling arm and the aforementioned contact.

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Witnesses:
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