No. 728,975. PATENTED MAY 26, 1903.

W. H. POWELL.

SYSTEM OF MOTOR CONTROL.

APPLICATION FILED FEB. 27, 1902.

NO MODEL.

Fig. 1.

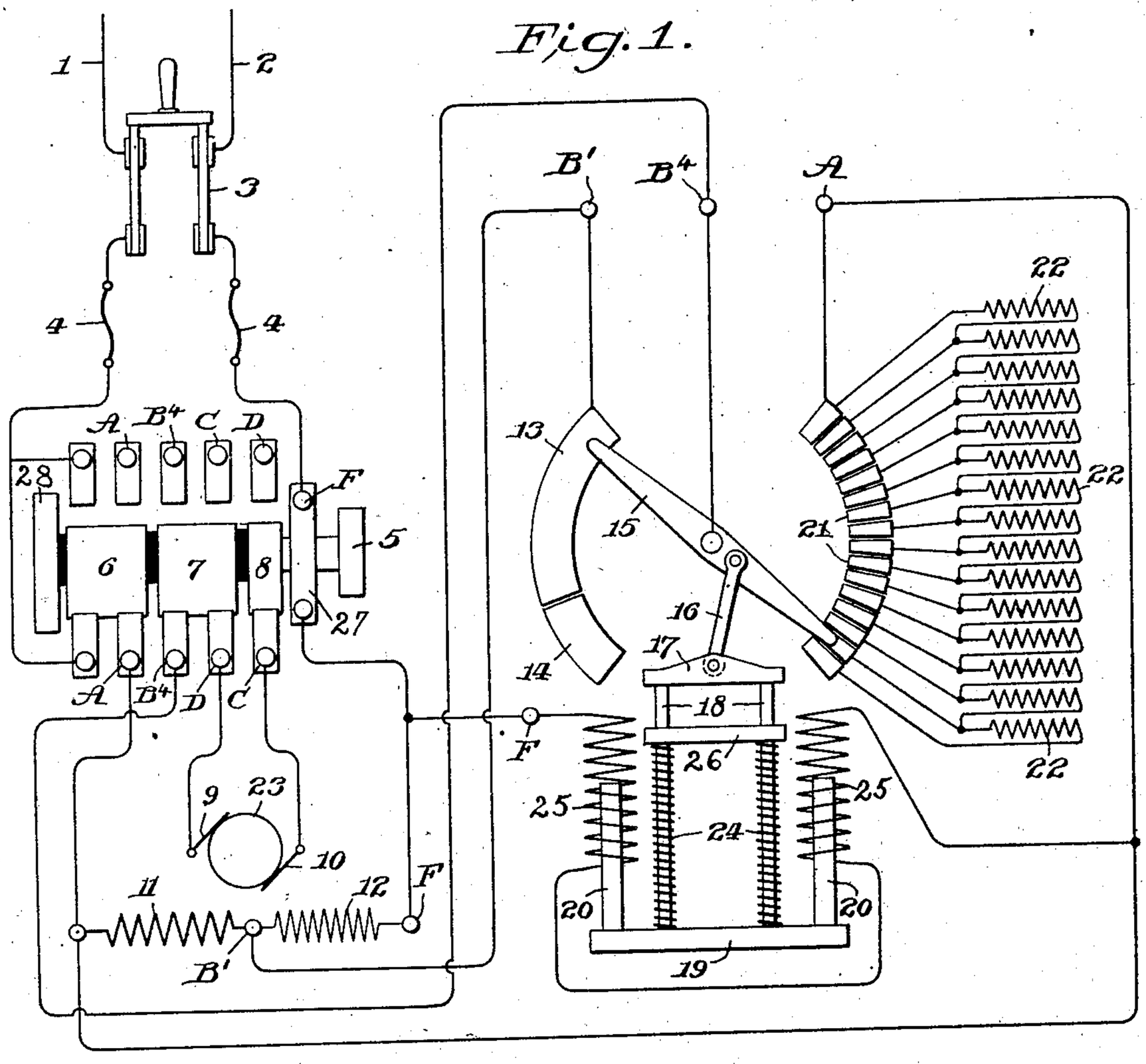


Fig. 2.

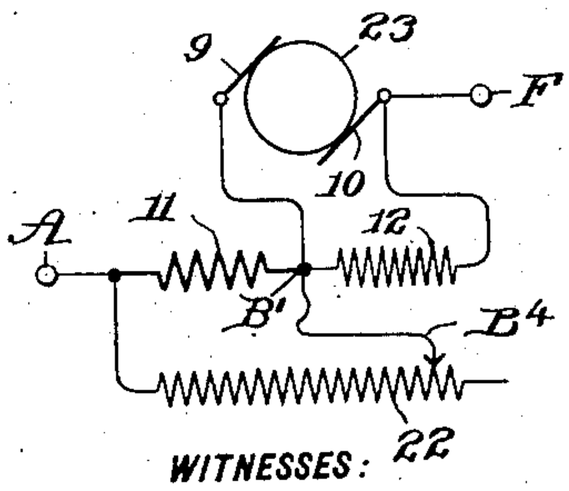


Fig. 3.

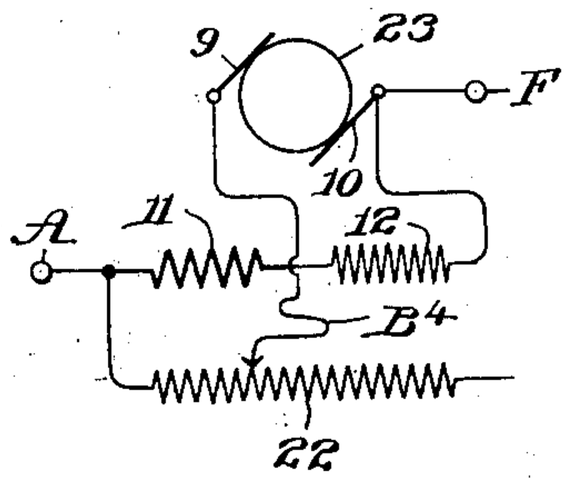
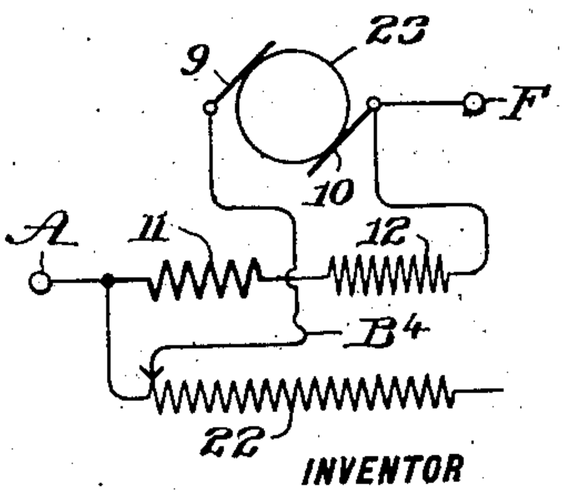


Fig. 4.



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No. 728,975. Patented May 26, 1903.

UNITED STATES PATENT OFFICE.

WILLIAM H. POWELL, OF ERIE, PENNSYLVANIA, 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. 728,975, dated May 26, 1903.

Application filed February 27, 1902. Serial No. 95,873. (No model.)

To all whom it may concern:

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

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

It consists, further, in 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 acceleration period until full speed is attained.

It consists, further, in 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 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, the variation in the connections of the several field-windings, whereby after full speed has been attained all the field-conductors remain 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 on the field, to reduce the amount of space required for the field-windings, with a resultant decrease in sizes 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 circuits 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 or 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 represents a series or 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 junction 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 bridge-piece 6 puts finger A into communication with service-wire 1. Member 7 bridges finger 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 its 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-finger 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 by 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.

In my application filed July 11, 1902, Serial No. 115,119, is claimed the apparatus for putting into practice the herein-described system of motor control.

What I claim is—

1. The method of accelerating a motor, which consists in passing a current through the armature; generating an initial field of excessive strength; gradually reducing the strength of said field by reducing the resistance in shunt to a field-winding and gradually reducing the loss in effect of said winding by an increase in effect of another winding.

2. The method of accelerating a motor, which consists in passing a current through the armature; generating an initial field of excessive strength; gradually reducing the strength of said field by reducing the resistance in shunt to a field-winding and partially compensating for the loss in effect of said winding by an increase in effect in another winding.

3. The method of accelerating a motor, which consists in passing current through the armature; generating an initial field of excessive strength; and reducing the strength of said field by the resultant effects of cumulative windings of which a portion is decreasing in its effect while another is increasing in its effect.

4. The method of accelerating a motor, which consists in passing current through the armature; generating an initial field of excessive strength; reducing the strength of said field by the resultant effects of cumulative windings of which a portion is decreasing in its effect at certain rates while another is increasing in its effect at lower rates; and finally merging said windings into a single winding.

5. The method of accelerating a motor, which consists in passing a current through the armature; generating an initial field of excessive strength; and gradually reducing the strength of said field both by reducing the resistance in shunt to a field-winding and by the increase in the counter electromotive force of the armature.

6. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing force by the increase of counter electromotive force of the armature, and increasing another magnetizing force.

7. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing force and increasing a magnetizing force by the increasing counter electromotive force of the armature.

8. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing force by the increasing counter electromotive force of the armature, and increasing a magnetizing force by the increasing counter electromotive force of the armature.

9. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing force by the increasing counter electromotive force of the armature, and gradually increasing a magnetizing force by the increasing counter electromotive force of the armature.

10. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing force by progressively robbing a winding of current, and increasing a magnetizing force.

11. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing force by progressively shunting a winding, and increasing another magnetizing force.

12. The method of control, which consists in generating a magnetic field, passing a current through an armature, reducing a magnetizing force by progressively shunting a winding, and increasing another magnetizing force by the increasing counter electromotive force of the armature.

13. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing force both by robbing a winding of current and by the increase of the counter electromotive force of the armature, and increasing a magnetizing force.

14. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing

force both by robbing a winding of current and by the increase of the counter electromotive force of the armature, and increasing a magnetizing force by the increase of the counter electromotive force of the armature.

15. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing force both by robbing a winding of current and by the increase of the counter electromotive force of the armature and gradually increasing a magnetizing force.

16. The method of control, which consists in generating a magnetic field, passing current through an armature, reducing a magnetizing force both by robbing a winding of current and the increase of the counter electromotive force of the armature, and increasing a magnetizing force by the increase of the counter electromotive force of the armature.

17. The method of control which consists in generating a magnetic field, passing a current through an armature, and varying the strength of said field by robbing a winding of current, simultaneously subjecting a winding to the potential difference existing across the terminals of said armature, increasing the potential at the terminals of said armature, merging said windings into a single winding, and subjecting said winding to the full potential of the supply-circuit.

18. The method of control which consists in passing current through an armature, generating a magnetic field, changing the strength of said field by diminishing a magnetizing force and simultaneously increasing a magnetizing force by subjecting a winding to the increasing potential difference at the terminals of said armature.

19. The method of control which consists in passing current through an armature, diminishing a magnetizing force by robbing a winding of current, increasing a magnetizing force by the increasing counter electromotive force of said armature, merging said magnetizing forces into a single force, and increasing the potential across the armature-terminals.

20. The method of control which consists in passing current through an armature, generating a magnetic field, decreasing the strength of said field by diminishing a magnetizing force and simultaneously increasing a magnetizing force by subjecting a winding to the increasing potential difference at the terminals of said armature.

21. The method of control which consists in passing current through an armature, diminishing a magnetizing force, partially compensating the decrease in said magnetizing force by increasing another magnetizing force, and merging said magnetizing forces into a single magnetizing force.

22. The method of control which consists in passing current through an armature, diminishing a magnetizing force partially compensating the decrease in said magnetizing force by increasing another magnetizing force, due to the counter electromotive force of said armature, and merging said magnetizing forces into a single magnetizing force.

23. The method of control which consists in passing current through an armature, generating a magnetic field, and varying the strength of said field by the partial compensation for a diminishing magnetizing force by an increasing magnetizing force.

24. The method of control which consists in passing current through an armature, generating a magnetic field, and diminishing the strength of said field by diminishing a magnetizing force and partially compensating for said diminishing force by an increasing magnetizing force.

25. The method of control which consists in passing current through an armature and a resistance, generating a magnetic field, changing the strength of said field by diminishing a magnetizing force by robbing a winding of current by means of said resistance, and by increasing a magnetizing force to partially compensate for said diminishing magnetizing force.

26. The method of control which consists in passing current through an armature and resistance, progressively diminishing said resistance, generating a magnetic field, changing the strength of said field by diminishing a magnetizing force in proportion to the diminishing potential difference across said resistance, partially compensating for said diminishing magnetizing forces, by an increasing magnetizing force, merging said magnetizing forces into a single magnetizing force, and reducing said resistance to zero.

27. The method of control which consists in passing current through an armature, generating a magnetic field, changing the strength of said field by decreasing a magnetizing force and partially compensating said decreasing force by increasing a magnetic force by the increasing counter electromotive force of the armature.

28. The method of starting a load from rest which consists in generating a magnetic field, passing current through an armature, decreasing the strength of said field, during the starting period by varying the effect of cumulative magnetizing forces, merging said magnetizing forces into a single force, and gradually increasing the potential difference at the armature-terminals.

29. The method of control which consists in passing current through an armature, generating a magnetic field of diminishing strength by smoothly-varying cumulative magnetizing forces, and merging said magnetizing forces into one of constant value.

30. The method of control which consists in passing current through an armature generating a magnetic field of diminishing strength by smoothly-varying cumulative magnetizing forces, merging said magnetiz-

ing forces into one of constant value, and increasing the potential at the armature-terminals.

31. The method of control which consists in passing current through an armature, generating a magnetic field of diminishing strength by smoothly-varying cumulative magnetizing forces, and increasing the potential at the armature-terminals.

32. The method of control which consists in passing current through an armature, generating a magnetic field, and smoothly varying the strength of said field by gradually diminishing a magnetizing force by partially compensating for said diminishing force by an increasing magnetizing force.

33. The method of control which consists in passing current through an armature, generating a magnetic field, and smoothly varying the strength of said field by gradually diminishing a magnetizing force, and by partially compensating for said diminishing force by an increasing magnetizing force due to the counter electromotive force of the armature.

34. The method of starting a motor from rest under load, which consists in generating a magnetic field of excessive strength, passing a current through said armature, diminishing the strength of said field, by diminishing a magnetizing force and partially compensating said diminishing force by increasing a magnetizing force.

35. The method of starting a motor from rest under load, which consists in generating a magnetic field of excessive strength, passing a current through said armature, diminishing the strength of said field by diminishing a magnetizing force and partially compensating said diminishing force by increasing a magnetizing force due to the counter electromotive force of the armature.

36. The method of control which consists in passing current through an armature and a series field-winding, reducing the effect of said winding by diminishing a resistance in shunt therewith, and simultaneously subjecting a winding to the potential difference at the terminals of said armature.

37. The method of control which consists in passing current through an armature and a series field-winding, reducing the effect of said winding by diminishing a resistance in shunt therewith, and simultaneously subjecting a winding to the potential difference at the terminals of said armature, and merging said windings into a single winding.

38. The method of control which consists in passing current through an armature and through a series winding and resistance parallel with each other, diminishing said resistance, and simultaneously subjecting another winding to the increasing potential difference at the terminals of said armature.

39. The method of control which consists in passing current through an armature and through a series winding and resistance in parallel with each other, diminishing said resistance, and simultaneously subjecting another winding to the increasing potential difference at the terminals of said armature, and merging said windings into a single winding.

40. The method of control which consists in passing current through an armature and through a series winding and resistance in parallel with each other, diminishing said resistance and simultaneously subjecting another winding to the potential difference at the terminals of said armature, and merging said windings into a single winding, and subjecting said resulting single winding to the potential difference of the supply-circuit.

41. The method of control which consists in passing current through an armature, and a series field-winding, subjecting a shunt-winding to the potential difference at the armature-terminals, and finally throwing said windings into series with each other.

42. The method of control which consists in passing current through an armature and a series field-winding, subjecting a shunt-winding to the potential difference at the armature-terminals, throwing said windings into series with each other, and subjecting said resulting winding to the potential difference of the supply-circuit.

43. The method of control which consists in passing current through an armature and through a series winding and resistance in parallel relation with each other, and subjecting another winding to the potential difference at the armature-terminals.

44. The method of control which consists in passing current through an armature and through a resistance, and simultaneously increasing a magnetizing force due to the counter electromotive force of said armature.

45. The method of control which consists in passing current through an armature and through a series field-winding and resistance in parallel with each other, reducing said resistance and simultaneously subjecting another winding to the potential difference at terminals of said armature.

46. The method of control which consists in passing current through an armature and through a series field-winding and resistance in parallel relation with each other, subjecting a shunt-winding to the effect of the counter electromotive force of the armature, diminishing said resistance, throwing said series and shunt windings into series relation, subjecting said resulting single winding to the potential difference of the supply-circuit and reducing said resistance to zero.

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