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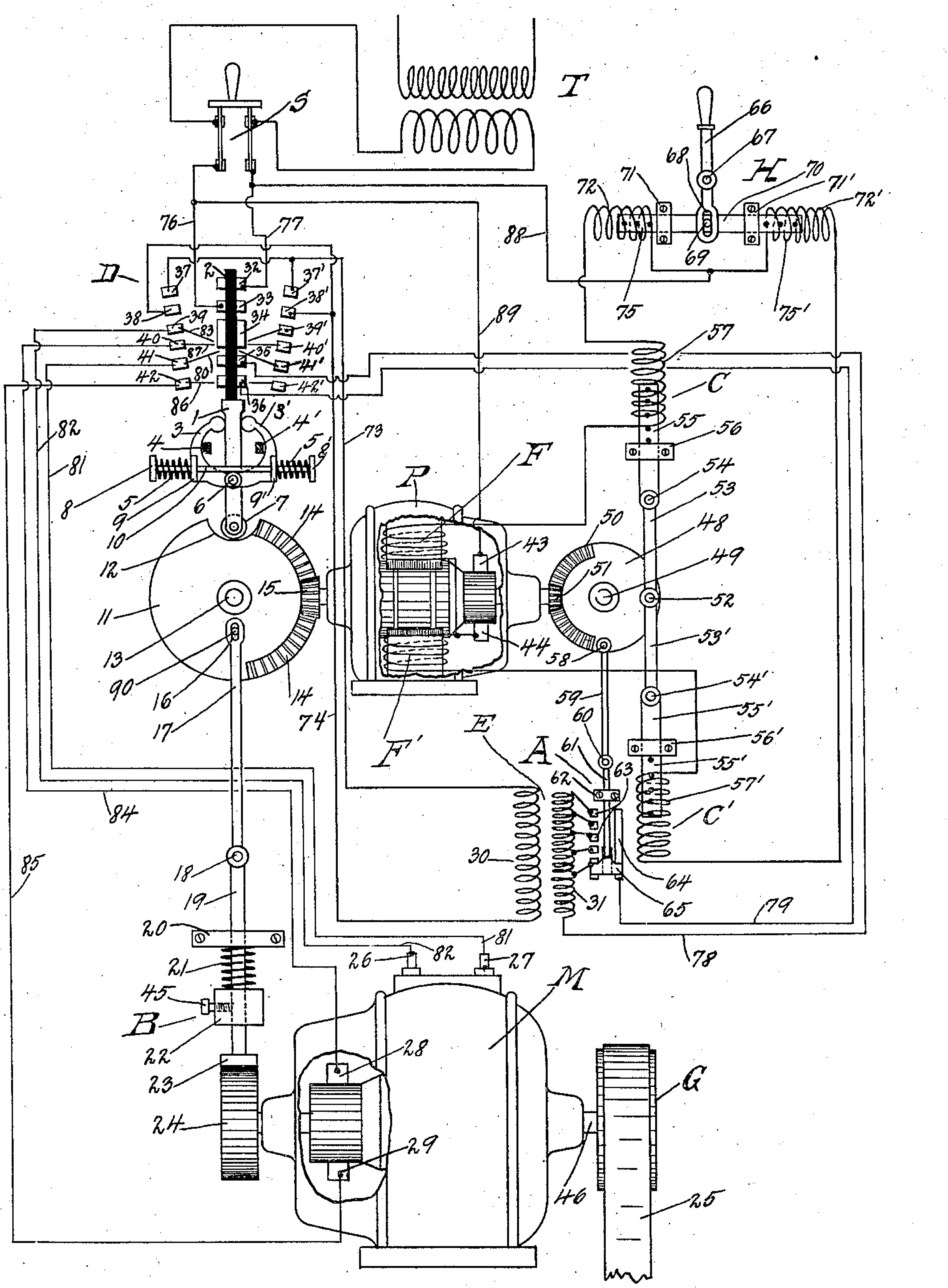
INDUCTIVE MOTOR CONTROLLING APPARATUS.

APPLICATION FILED JULY 17, 1907.

952,650. **Patented Mar. 22, 1910.**



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INDUCTIVE MOTOR-CONTROLLING APPARATUS.

952,650. Specification of Letters Patent. Patented Mar. 22, 1910.

Application filed July 17, 1907. Serial No. 384,294.

To all whom it may concern:

Be it known that I, August Sundh, a citizen of the United States, residing at Yonkers, in the county of Westchester and State of New York, have invented a new and useful Improvement in Inductive Motor-Controlling Apparatus, of which the following is a specification.

My invention relates to the control of alternating-current electric motors and one of its objects is the provision of improved means whereby an alternating-current electric motor may be readily started, stopped and reversed.

A further object of my invention is to provide a system of alternating-current motor-control which shall be substantially noiseless in operation and contain a minimum number of moving contacts.

Other objects will appear more fully hereinafter, the novel combinations of elements being set forth in the claims hereunto annexed.

My invention is adapted to an alternating-current motor-controlling system using alternating-current of any kind or phase, but for purposes of illustration and clearness I show my invention as applied to a single-phase alternating-current motor of the series-commutator type.

Referring to the accompanying drawing, T designates a transformer, by means of which current is supplied to the main line switch S from any suitable source of single-phase alternating current supply.

D designates a circuit-closing switch which comprises a switch arm 1 having a roller 7 at one end and whose other end carries an insulation piece 2, to which is fastened a series of contacts 32, 33, 34, 35 and 36. Stationary contacts 37, 38, 39, 40, 41 and 42 lie in the path of movement in one direction of the contacts carried by the switch arm 1, while stationary contacts 37′, 38′, 39′, 40′, 41′, 42′, lie in the path of movement in the other direction of the contacts carried by the switch arm 1. The switch arm 1 and its connected parts is adapted to swing to the right or left about a fixed pivot 6, and in so doing will bring its connected contacts into electrical engagement with the corresponding stationary contacts above mentioned in a manner hereinafter more fully pointed out. The switch arm 1 is normally held in a vertical position by means of a centering device comprising two arc-shaped levers 3 and 3′ pivoted at one end to a common pivot 6. The other end of each lever bears forcibly against opposite sides of the switch arm 1, due to the action of the compression springs 5 and 5′, respectively. A rod 10 having fixed collars 8 and 8′ at its ends carries the springs 5 and 5′ and passes freely through raised projections 9 and 9′ on the pivoted levers 3 and 3′, respectively.

4 and 4′ are fixed stops which limit the inward movement of the respective levers 3 and 3′.

P designates a pilot motor of the single-phase series-commutator type having bipolar field magnets F and F′ which are wound differentially so that one field magnet neutralizes the effect of its companion magnet when both are equally energized at the same time. The pilot motor armature will rotate in one direction or the other, depending on which field magnet is the more strongly energized. Upon the left-hand end of the pilot motor shaft is a bevel gear 15 which meshes with a segmental bevel gear 14 carried upon a circular plate 11 which is adapted to revolve freely about a fixed pivot 13. At the upper part of this circular plate 11 is a cutaway portion or recess 12 in which lies the roller 7 carried upon the lower end of the switch arm 1. Directly under the pivot 13 is a pin 90 which is secured to the circular plate 11 and lies in a slot 16 at the upper end of a pitman 17. The other end of this pitman is connected at 18 to a brake rod 19 which carries on its other end a brake shoe 23 which is normally in frictional engagement with a brake pulley 24 carried upon one end of the shaft 46 of the main motor M. The brake rod 19 passes loosely through a fixed guide 20 and with it is associated a compression spring 21 which bears against the fixed guide 20 and an adjustable collar 22 by means of which the tension of the spring 21 may be varied and locked in position by the set-screw 45. The tendency of the spring 21 is to firmly apply the brake shoe 23 against the outer periphery of the brake pulley 24. One end of the main motor shaft 46 may be provided with a belt pulley G, for instance, and a belt 25 by means of which power may be transmitted from the main motor M to any desired machine, line shaft or other power-operated device.

The right-hand end of the pilot motor shaft carries a bevel gear 51 which meshes with a segmental gear 50 attached to a circular plate 48 which is loosely pivoted on a fixed pivot 49. Near the outer periphery of the plate 48 and substantially on a horizontal radial line are pivoted at 52 connecting rods 53 and 53′. The other ends of these connecting rods are pivotally connected at 54 and 54′ to laminated magnet cores 55 and 55′ which project into the magnet windings or solenoids 57 and 57′, respectively.

56 and 56′ are stationary guides for the magnet cores 55 and 55′, respectively.

Connected to the circular plate 48 and preferably directly under the pivot 49 is a pitman 59 which is joined at 60 to a vertical rod 61 guided by a fixed guide 62. To the lower end of this vertical rod is connected by insulation a sliding contact piece 65′ which is arranged to travel over and electrically connect a stationary contact strip 64 and stationary contacts 63. These latter contacts 63 are connected by wires to sections of the winding 31 which is the secondary winding of a transformer A. 30 designates the primary winding of this transformer, one terminal of which is connected by the wire 73 to the contacts 37 and 37′ and the other terminal of which is connected by the wire 74 to the contacts 38 and 38′ of the switch D.

H designates a manually-operated master or controlling switch and comprises a handled lever 66 pivoted at 67 and whose lower end is provided with a slot 68 into which extends a pin 69. The latter is rigidly connected to a horizontally slidable bar 70, both ends of which are laminated so as to form two magnet cores 75 and 75′ which project substantially half way into the magnet windings or solenoids 72 and 72′, respectively, and are guided in their movement by stationary guide pieces 71 and 71′.

I will first trace the circuits of the main motor M. In order to close a circuit to the motor, the arm 2 of switch D must be swung to the right or left so that the contacts carried thereon engage the relative co-acting stationary contacts on either side. For the time being we will suppose that this arm has been moved to the left about its pivot 6 until the contact 32 engages or is brought into electrical contact with the stationary contact 37. At the same time the contact 33 engages the contact 38, contact 34 engages both of the contacts 39 and 40, while the contact 35′ engages contact 41, and the contact 36 engages contact 42. This operation closes a circuit through the primary winding 30 of the transformer E as follows: from the main conductor 76, contacts 33 and 38 and wire 74 to the lower terminal of winding 30, through this winding 30 and by wire 73 and contacts 37 and 32 to the main wire 77. Since the primary winding of the transformer E is energized a circuit will be induced in the secondary winding 31, and since this winding is included in a circuit to the motor M the latter will become energized and start to move. The induced motor current will flow from the secondary winding 31 by wire 78, contacts 35 and 41 and wires 80 and 81 to the motor terminal 27 which is one terminal of the series field winding of the motor M. The circuit continues through the series field and by terminal 26, wires 82 and 83 and contacts 39, 34 and 40, to the motor armature by way of the wire 84 and armature brush 28. Passing through the motor armature the circuit continues to the brush 29, wires 85 and 86, contacts 42 and 36, and by the wire 79 to the contact strip 64. Now this contact strip is electrically connected to the lowest contact 63 by means of the sliding contact piece 65, and it is therefore seen that the current that will flow to the motor M is that induced in the lower section of the secondary winding 31, the other sections of this winding being open circuited at the four upper contacts 63. In the present lowermost position of the sliding contact piece 65 the number of active turns in the secondary winding of the transformer E is at a minimum with a corresponding minimum difference of potential available at the motor terminals, and the motor will consequently run at its slowest speed. In order to gradually increase the speed of the motor until the same runs at full normal speed, the rod 61 and its connected sliding contact 65 is lifted, and as the latter moves upwardly over the stationary contacts 63 additional sections of the secondary winding 31 become active in regular order and finally when the sliding contact 65 rests on the uppermost contact 63 the entire winding becomes active and a maximum potential is induced in the secondary winding 31 and the motor runs at full normal speed.

The switch D serves a double purpose, namely, as a circuit-breaking switch, and as a motor-reversing switch. The circuit to the primary winding 30 of the transformer E is the same, no matter in which direction the switch D is operated, since the contacts 37 and 37′ and 38 and 38′ are connected together, respectively, and each pair of contacts is connected to one terminal of the primary transformer winding 30. The reversal of the motor M is accomplished by changing the relative connections between the motor armature and series field windings. This is done by cross-connecting the stationary contacts 39, 41 and 39′, 41′ of the switch D and causing the pivoted switch arm to swing to the right until the contacts carried thereon engage the fixed contacts 37′, 38′, etc. The circuit to the motor M will now be as follows: from the lower terminal of the secondary winding 31, by wire 78, contacts 35 and 41′, and by wires 83 and 82 to the series field terminal 26, through the series field to terminal 27, wires 81 and 80, contacts 39, 34 and 40′, and by the wires 87 and 84 to the motor armature brush 28. Passing through the motor armature, the circuit continues by brush 29, wire 85 and contacts 42′ and 36, wire 79, contact strip 64, and sliding contact 65 to the lowermost contact 63. The induced current set up in the lower section of this secondary winding therefore passes through the series field and armature of the motor M, but while the circuit just traced passes through the motor armature in the same direction as before, the circuit through the series field is in a reverse direction, consequently the motor will run in a reverse direction. The motor may be accelerated as before by causing the sliding contact to move upwardly, thereby increasing the active turns in the secondary winding 31 of the transformer E.

Having shown how the motor may be started and accelerated to full normal speed in either direction, I will now describe the operating circuit and point out its effect on the various parts of the apparatus.

Extending from the main wires 76 and 77 is a branch circuit which may be traced through the wire 89 to the pilot motor brush 43, and through the pilot motor armature to the brush 44. The circuit here divides, one path extending through the series field winding F, solenoids 57 and 72 to the wire 88 and main 77, and the other path being from the brush 44 through the series field winding F′, solenoids 57′ and 72′, to the wire 88 and main 77. The ohmic resistances of these two paths are substantially equal, and the impedance of each solenoid or magnet winding is the same as that of its similar or companion solenoid or magnet winding, since each solenoid or magnet winding contains the same number of turns or coils and embraces the same amount of magnetic or inductive material as does its companion solenoid or magnet winding. The current in each of these paths is therefore the same and each magnet winding will neutralize the effect of its companion magnet winding. The differential windings of the pilot motor will therefore neutralize each other and there will be no tendency for the pilot motor armature to rotate and the entire operating system of circuits is in exact balance.

To explain the operation of the system let the lever 66 be moved to the right and the bar 70 to the left. This will disturb the balance of the operating circuits, since the impedance of the solenoids 72 and 72′ is now no longer equal, due to the fact that a greater portion of the core 75 is now projected into the solenoid 72 and a portion of the core 75′ has been withdrawn from the solenoid 72′. The branch circuit which includes the solenoids 72′, 57′ and the field winding F′ of the pilot motor now receives more current than the parallel circuit through the series field winding F. This is due to the smaller amount of impedance in the circuit including the winding F′. The field winding F′ is then sufficiently energized to overcome the field winding F and cause the pilot motor armature to rotate in a counter-clockwise direction as viewed from the right-hand or commutator end. As the pilot motor rotates the spur gear on the left-hand end of its shaft causes the circular plate 11 to rotate in a counter-clockwise direction. The roller 7 carried by the switch arm 1 will now ride up out of the recess 12 and onto the outer periphery of the circular disk 11. This will swing the upper part of the switch arm 1 to the right and the contacts carried thereon will engage the fixed contacts arranged to coöperate therewith as before pointed out. At substantially the same time that the contacts of the switch D are closed or brought into electrical engagement the pin 90 lifts the pitman 17 and brake rod 19, and the connected brake shoe 23 is moved out of engagement with the friction pulley 24 against the action of the spring 21 and the motor M is free to start, its circuit having been closed by the switch D. The switch D is not closed immediately upon the pilot motor starting, since the roller 7 does not ride up onto the periphery of the circular disk until after the disk has rotated a small distance. Also the brake is not released immediately upon the starting of the pilot motor, lost motion being provided by means of the slot 16 and pin 90, so that as the circular disk 11 starts to rotate the pin rides in the slot a short distance before the pitman 17 and brake rod 19 are actuated, thereby releasing the brake shoe 23. This lost motion in the brake apparatus is so adjusted that the brake shoe will be released or withdrawn from engagement with the friction pulley 24 at substantially the same time that the switch D operates to close the main motor circuit. While this is the preferred arrangement, if desired the brake apparatus may be so adjusted that the brake will be lifted either before or after the switch D has operated to close the main motor circuit. The operation of the pilot motor P not only closes the main motor circuit and releases the brake, but causes the disk 48 which is geared to the pilot motor shaft to rotate in a clockwise direction when the master switch bar 70 is moved to the left. As this disk rotates the sliding contact 65 will be moved upwardly passing over the contacts 63 and contact strip 64 and gradually accelerating the main motor M by reason of the increased potential of the circuit to the motor, due to the adidtional active turns of the transformer secondary 31 as before pointed out. As the pilot motor rotates the disk 48, the solenoid cores 55 and 55′ will be lowered and a portion of the core 55 will be withdrawn from the solenoid 57, while the core 55′ will be moved downwardly farther into the solenoid 57. This will increase the impedance of the solenoid 57′ and decrease the impedance of the solenoid 57. The current in the solenoid 57′ is therefore decreased, while the current in the solenoid 57 is increased, and, since these solenoids are in parallel branch circuits, these branches including in circuit the series field windings F′ and F, respectively, of the pilot motor, it is apparent that the current in the field winding F′ is decreased while that of the field winding F is increased. This will tend to equalize the amount of current flowing in the two circuits and restore the balance in the differential field windings of the pilot motor, thus weakening the field until the torque is balanced by the load on the motor, and the parts are brought to rest. It will thus be seen that as the switch bar 70 is moved to the left, the impedance in the circuit containing the coils 72 and 57 is increased, and that in the circuit containing the coils 72′ and 57′ is decreased, which causes the motor to rotate in a direction to move the cores 55 and 55′ downwardly, decreasing the impedance in the circuit containing the coils 72 and 57 and increasing the impedance in the coils 72′ and 57′ until a balance is restored.

It is readily seen that the operation of the master or controlling switch H will strengthen one or the other of the differentially wound series field windings, which will cause the pilot motor to rotate in a direction which will depend upon which of these field windings is the stronger or more highly energized, and, no matter in which direction the pilot motor rotates, the impedance of the solenoids 57 and 57′ is varied in such manner that the tendency is to strengthen the weaker field winding and weaken the stronger field winding, and so restore the balance which existed in the operating circuit when the master switch H was in its original central position. The pilot motor will not rotate to its full normal extent upon a slight movement of the master switch H, but will respond proportionately to every movement of the switch, whether the same is slightly moved or thrown to the full extent of its movement. If the master switch is moved but a short distance the pilot motor will rotate but a small amount, or until the circuits of each field winding are automatically balanced or very nearly so. Upon further movement of the master switch in the same direction the circuits are again unbalanced and the pilot motor rotates still farther until the circuit is again substantially balanced, when the pilot motor will cease to rotate. Thus the pilot motor responds to the movements of the master switch and by so doing varies the effective windings of the transformer secondary 31, and in this manner varies the speed of the main motor M. When the master switch H is brought back to its central position after having been moved, for example, to the right, the pilot motor and various parts operated thereby will return to their initial or inoperative positions, because the impedance in the circuit containing the field winding F is thereby decreased and the impedance in the circuit containing the winding F′ increased, which reverses the field magnetism with a corresponding reversal of the motor. The increased magnetic pull of the coil 57 on its core 55 and corresponding decreased pull on the core 55′ also help to restore the parts to their normal positions. This is still further aided by the brake spring and the weight of the various parts of the brake mechanism helping to center the pilot motor.

From the foregoing it is clearly seen that we have a system of alternating-current motor-control which contains a minimum number of contacts at which various circuits are made or broken, and at the same time the current consumed in the operating circuits is very small, since after the pilot motor has done its work of closing the reversing switch D and lifting the main motor brake, the current flowing to the pilot motor is automatically reduced to an amount just sufficient to maintain the pilot motor in its operative position corresponding to the position of the master switch H. Furthermore, the main motor is started and automatically speeded up to any desired speed within normal limits without the use of any resistance devices whatever. This alone is a valuable feature of my invention, since it is well known that where a motor is started or controlled by varying the potential of the motor circuit by means of a variable resistance in circuit with it, there is always a great loss of energy in such resistance while the current is passing through it, which is a needless waste of energy and makes any such means of controlling a motor or other translating device less inefficient and more wasteful of current.

While I prefer to accelerate the main motor by varying the effective windings of the secondary of a transformer, in some cases I dispense with this transformer entirely and use in place of the same a suitable resistance, sections of which may be connected to contacts in a well known way, and the motor speed controlled by varying the amount of the resistance. In other instances I control the main motor by using a choking coil in series with the motor and having a movable core which is under the control of the pilot motor and which may be inserted or withdrawn from the choking coil so as to produce a varying potential strength available at the main motor terminals, accompanied by a corresponding motor speed.

Having now described my invention and pointed out the operation of a preferred construction and arrangement of electrical circuits, and not desiring to be limited to specific construction or arrangement of parts, as many changes could readily be made without departing from the spirit or scope of my invention, what I claim as new and desire to have protected by Letters Patent of the United States is:—

1. In a motor-control system, the combination with a source of current supply and a motor having differential field windings, of means to gradually vary the current in said windings and operate the motor, and means operated by the motor to oppose the effect of said first-named means.

2. In a motor-control system, the combination with a motor having differentially-wound field magnets, and means for supplying a variable current to the motor, of means to vary the current in said windings and operate the motor, and means operated by the motor for opposing the effect of said first-named means.

3. In a motor-control system, the combination with a source of current supply and a motor having differentially-wound field magnets, of means for gradually varying the amount of current in said windings and operating the motor, and means operated by the motor to restore the current in said windings to its original strength.

4. In a motor-control system, the combination with a source of current supply and a motor having differential field windings, of means for varying the relative current strengths in said windings, and operating the motor to an extent proportional to such variation, and means operated by the motor to restore the relative current strength in the windings.

5. In a motor-control system, the combination with a source of current supply and a motor having differential field windings in normally balanced circuits, of means for destroying the balance in said circuits, and means operated by the motor to gradually restore the balance in the circuits.

6. In a motor-control system, the combination with a source of current supply and a motor having normally balanced opposing circuits, of means for destroying the balance in said circuits to operate the motor, and means operated by the motor to gradually restore the balance in the circuits.

7. In a motor-control system, the combination with a source of current supply and a motor having normally balanced opposing circuits, of means for increasing the flow of current in one circuit to operate the motor, and means operated by the motor to reduce the current in said circuit.

8. In a motor-control system, the combination with a source of current supply and a motor having normally balanced opposing circuits, of means for increasing the flow of current in one circuit and decreasing it in the other circuit, and means operated by the motor for decreasing the current in the first circuit and increasing it in the other circuit.

9. In a motor-control system, the combination with a source of current supply and a motor having normally balanced opposing circuits, of means for simultaneously increasing and decreasing the flow of current in the respective circuits, and means operated by the motor for restoring the balance in the circuits.

10. In a motor-control system, the combination with a source of current supply and a motor having normally balanced opposing circuits, of means to destroy said balance and operate the motor, and automatically operated independent means to restore said balance.

11. In a motor-control system, the combination with a source of current supply and a motor having normally balanced opposing circuits, of manually-operable means for disturbing the balance in said circuits, and means independent of the manually-operable means for automatically restoring the balance in the circuits.

12. In a motor-control system, the combination with a source of current supply and a motor having normally balanced opposing circuits, of manually-operable means for disturbing the balance in said circuits, and means operated by the motor for restoring the balance in said circuits.

13. In a motor-control system, the combination with a source of variable current supply and a motor having normally balanced opposing circuits, of means for disturbing the balance by varying the inductance in a circuit, and means operated by the motor for restoring the balance.

14. In a motor-control system, the combination with a source of alternating current supply and a motor having normally balanced opposing circuits, of manually-operable means for unbalancing the circuits, and means for restoring the balance without

moving the manual means from its operated position.

15. In a motor-control system, the combination with a source of variable current supply and a motor having differential windings, of impedance coils in the circuits maintaining a balance of the circuits, means for varying the impedance in the coils and disturbing said balance, and means operated by the motor for restoring the balance in the circuits.

16. In a motor-control system, the combination with a source of variable current supply and a motor having differential windings, of impedance coils normally balancing the circuits, manually-operable means for varying the impedance and disturbing the balance, and means operated by the motor for restoring a balance in the circuits.

17. In a motor-control system, the combination with a source of variable current supply and a motor having differential windings, of impedance coils in each circuit maintaining a normal balance of the circuits, manually-operable means for increasing the impedance of a coil in one circuit and decreasing the impedance of a coil in the other circuit, and means operated by the motor for varying the impedance in the other coils to restore a balance of the circuits.

18. In a motor-control system, the combination with a source of alternating current supply and a motor having differential field windings, of inductance coils in each circuit maintaining a balance of the circuits, a magnet core for a coil of each winding, said cores being connected for simultaneous movement, a manually-operable device for moving said cores into position to increase the impedance of one coil and decrease the impedance of the other coil, a magnetic core for another coil of each circuit, and connections between the motor and said last-named cores for moving them into position to restore the balance in the circuits when the manual device has been operated and the motor started.

19. In a motor-control system, the combination with a source of variable current supply and a motor having differential windings, of inductively balanced circuits for said windings, means for destroying the inductive balance of the circuits, and means operated by the motor for varying the inductance in opposition to the first-named means.

20. In a motor-control system, the combination with a source of variable current supply and a motor having differential field windings, of impedance coils in the circuits of the field windings and normally maintaining an inductive balance therein, manually-operable means for varying the impedance of certain of said coils and destroying the inductive balance, and means operated by the motor for varying the impedance in other of said coils and varying the inductance in opposition to the variation caused by the operation of the manually-operable means.

21. In a motor-control system, the combination with a source of current supply, a main motor and a pilot motor, of means for simultaneously increasing the current supply to the main motor and decreasing the supply to the pilot motor.

22. In a motor-control system, the combination with a source of current supply, a main motor and a rotary pilot motor, of accelerating means for the main motor operated by the pilot motor, and means also operated by the pilot motor for reducing the flow of current to the pilot motor.

23. In a motor-control system, the combination with a source of current supply, a main motor and a pilot motor, of means operated by the pilot motor for simultaneously accelerating the speed of the main motor and gradually reducing the supply of power to the pilot motor.

24. In a motor-control system, the combination with a source of current supply, a main motor and a pilot motor, of means operated by the pilot motor for accelerating the speed of the main motor, and automatic means for simultaneously reducing the current supply to the pilot motor.

25. In a motor-control system, the combination with a source of current supply, a main motor and a pilot motor, of an accelerating device for the main motor, operative connections between said device and the pilot motor, manually-operable means for varying the supply of current to the pilot motor, and automatic means for reducing said supply as the accelerating device is operated.

26. In a motor-control system, the combination with a source of current supply, a main motor and a pilot motor, of accelerating means for the main motor operatively connected to the pilot motor, manually-operable means for controlling the current supply to the pilot motor, and automatic means for cutting off said supply when the pilot motor armature has rotated through an arc proportional to the extent of movement of the manually-operable means.

27. In a motor-control system, the combination with a source of variable current supply, a main motor and a pilot motor, of accelerating means for the main motor, operative connections between said means and the pilot motor, means for operating the pilot motor by varying the inductance in its circuits, and automatic means for bringing it to rest by again varying the inductance in its circuits.

28. In a motor-control system, the combination with a source of variable current, a

main motor and a pilot motor having differential field windings, of accelerating means for the main motor, operative connections between said means and the pilot motor, impedance coils in said circuits maintaining a normal balance therein, a manually-operable device, means connected thereto for varying the inductance in said coils in amounts proportional to the extent of movement of said device and thereby operating the pilot motor, and means operated by the pilot motor for restoring the balance in the circuits and bringing the pilot motor to rest after it has rotated an extent proportional to the extent of movement of the manual device.

29. In a motor-control system, the combination with a source of variable current supply, a main motor and a pilot motor, of means connected to the pilot motor for accelerating the speed of the main motor to an extent varying with the extent the pilot motor armature is rotated, a manually-operable device for controlling the pilot motor by varying the inductance in its circuit to any desired extent, and means operated by the pilot motor for varying the inductance in its circuit to stop the pilot motor armature after it has rotated to an extent varying with the extent to which the manual device has been moved.

30. In a motor-control system, the combination with a source of alternating current supply and a transformer, of a main motor in circuit with the secondary of the transformer, a rotary pilot motor, and means operated by the pilot motor for varying the number of active coils in said secondary.

31. In a motor-control system, the combination with a source of alternating current supply and a transformer, of a main motor in circuit with the secondary of the transformer, rotary pilot motor means operated by the pilot motor for varying the number of active turns in the winding of said secondary to an extent varying with the extent of rotation of the pilot motor armature, and manually-operable means for controlling the extent of rotation of the pilot motor armature.

32. In a motor-control system, the combination with a source of current supply, a main motor and a pilot motor, of an accelerating device, operative connections between said device and the pilot motor, a brake operatively connected to the pilot motor, a reversing switch operatively connected to the pilot motor, manually-operable means for varying the inductance in the pilot motor circuits and causing the motor to operate, and means operated by the motor to counteract such variation and bring the motor to rest.

33. In a motor-control system, the combination with a source of variable current and a motor having differential field windings, with the inductance of the field winding circuits normally balanced, of a manual device operable in one direction to vary the relative inductance in said circuits and cause the armature to rotate in one direction, said manual device being operable in the opposite direction to reverse the relative inductance in the circuits and cause the armature to rotate in the reverse direction, and means operated by the motor to restore the balance in said circuits when the armature is rotated in either direction.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses.

AUGUST SUNDH.

Witnesses:
CHAS. M. NISSEN,
NORMAN VEITCH.