R. P. JACKSON.

SYSTEM OF CONTROL.

APPLICATION FILED OCT. 20, 1904.

990,985. **Patented May 2, 1911.**

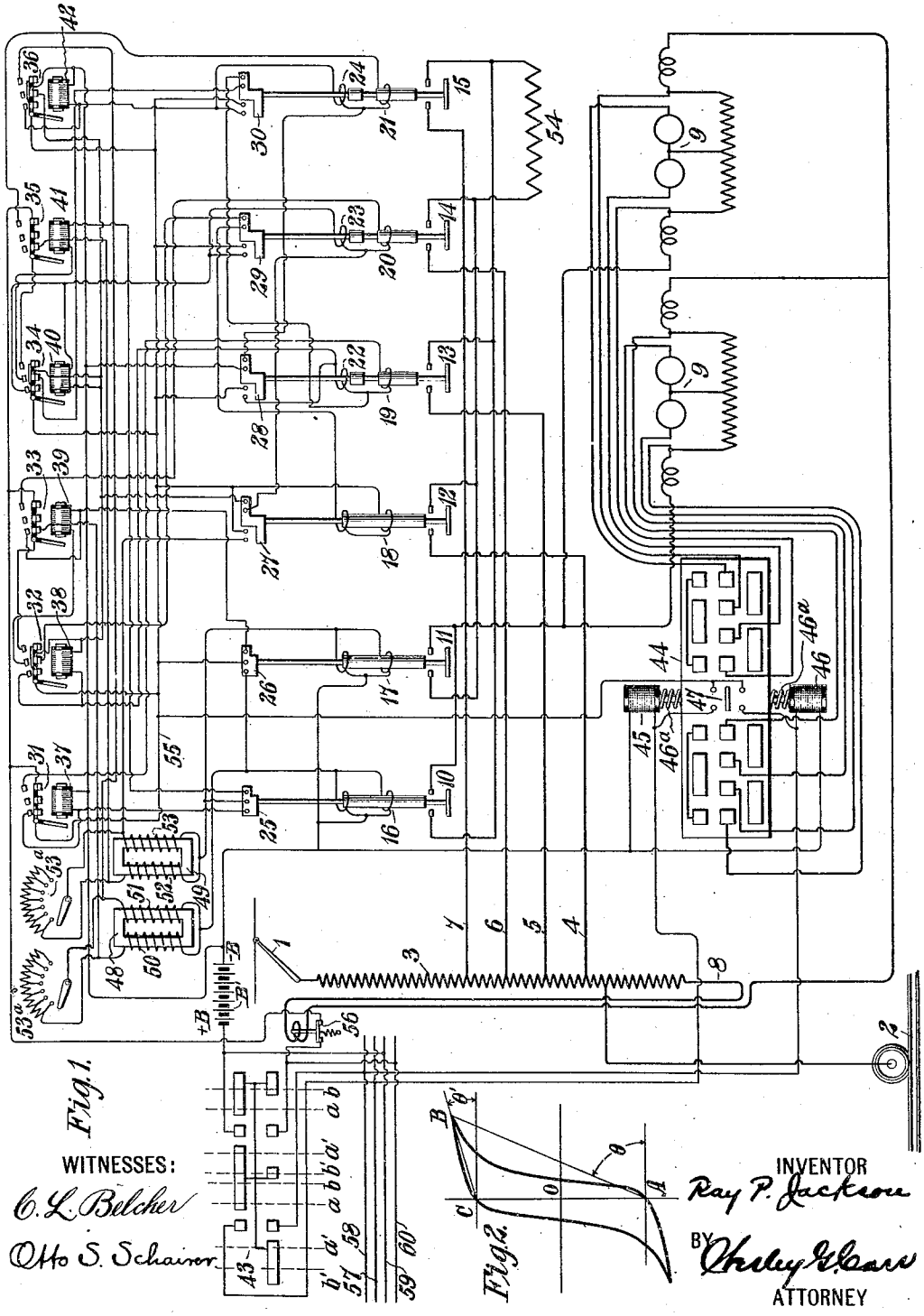

Fig. 1.

Fig. 2.

WITNESSES:

C. L. Belcher

Otto S. Schairer

INVENTOR

Ray P. Jackson

BY Thos. G. Orr

ATTORNEY

UNITED STATES PATENT OFFICE.

RAY P. JACKSON, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

SYSTEM OF CONTROL.

990,985. Specification of Letters Patent. Patented May 2, 1911.

Application filed October 20, 1904. Serial No. 229,337.

To all whom it may concern:

Be it known that I, RAY P. JACKSON, a citizen of the United States, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Systems of Control, of which the following is a specification.

My invention relates to systems of control for electrical translating devices, and particularly to such systems as are employed in the control of electrical railway motors.

My invention has for its object to provide a system which involves either automatic or non-automatic acceleration in the speed of the motors when starting, and which avoids the use of the complicated and finely adjusted interlocking switches which have heretofore been employed for the purpose of introducing the proper time periods between the operations of certain of the controlling devices.

My invention provides for speed acceleration of translating devices by the use of a series of main switches, a series of interlocking switches that are respectively operated by the main switches, and a series of electro-magnetically-operated relay switches which govern the operation of the main switches, the operating circuits of said relay switches being interdependent and being governed by a master switch and by the interlocking switches. The time period between the successive operations of certain of the switches is increased by the introduction into the circuits of certain of the controlling switches, at the proper instants, of devices having high inductance, and by so arranging the circuit connections that a reversal of the direction of the magnetic fluxes in the iron cores of these devices occurs each time the devices are included in the circuits. In this novel manner the residual magnetism is utilized and a greater time period is obtained than would otherwise be possible without the use of comparatively large and expensive devices.

My invention is illustrated in the accompanying drawings, in which—

Figure 1 is a diagrammatic view of a system of control constructed in accordance therewith, and Fig. 2 is a curve of magnetic hysteresis, for the purpose of showing the operation of the time-period adjusting devices.

As here shown, alternating current electrical energy is supplied from a trolley 1 and track 2 to an auto-transformer winding 3, which is conveniently subdivided by means of leads 4, 5, 6 and 7, between which and terminal 8 of the auto-transformer winding 3, motors 9 or other suitable translating devices are adapted to be connected by means of circuit-changing switches 10 and 11 and main circuit-closing switches 12, 13, 14 and 15. It is to be understood, however, that the system which will be hereinafter described is not limited in its application to the control of devices that are operated by any particular character of energy, but that, if desired, direct current energy may be supplied to the motors 9, the operation of the remainder of the system remaining the same.

The circuit-changing switches 10 and 11 and the circuit-closing switches 12, 13, 14 and 15 are respectively provided with operating magnet coils 16, 17, 18, 19, 20 and 21 and the switches 13, 14 and 15 are respectively provided with magnet coils 22, 23 and 24, which retain the switches in their closed positions after they have been closed by the corresponding operating magnet coils 19, 20 and 21. In order that all of the switches and their operating means may be alike, the operating magnet coils 16, 17 and 18 of the switches 10, 11 and 12 comprise two parallel-connected coils similar to those shown in connection with the switches 13, 14 and 15.

Interlocking switches 25, 26, 27, 28, 29 and 30 are operated respectively by the movement of the switches 10, 11, 12, 13, 14 and 15, these switches being arranged to prevent the circuit-changing switches 10 and 11 from closing simultaneously and also to prevent simultaneous closure of alternate circuit-closing switches 12 and 14 and 13 and 15.

Corresponding to each of the main switches are electrically operated relay switches 31, 32, 33, 34, 35 and 36, the circuits of operating magnet coils 37, 38, 39, 40, 41 and 42 for which are governed by the operation of certain of the said relay and interlocking switches and by means of a master switch 43.

It will be noted that while the contact terminals of the relay switches are variously connected in circuit and that some of them have no circuit connections, they are all made structurally alike in order to facilitate and cheapen manufacture.

Interposed in the circuits of the motors 9 is an electro-magnetically-operated reversing switch 44, the circuits of the operating magnet coils 45 and 46 of which are governed by the master switch 43. The reversing switch 44 is normally maintained in open position by means of springs 46[a] and is moved to either its forward or its reverse position only when the corresponding magnet coil 45 or 46 is energized. The reversing switch 44 carries an interlocking switch 47, which is provided for the purpose of preventing the operation of the main switches or of the relay switches until the reversing switch has been thrown to either its forward or its reverse position.

Means for delaying the flow of current to certain of the operating magnet coils comprises two iron cores 48 and 49, which are respectively provided with windings 50 and 51, and 52 and 53. The circuit connections are so arranged that the coils upon each iron core are energized alternately and the directions of the magnetic fluxes are reversed each time a coil is energized, whereby the residual magnetism of the iron core is utilized. The time required for the current in each of the coils 50, 51, 52 and 53 to rise to its maximum value is approximately proportional to the inductance of such winding and the inductance is proportional to the permeability of the iron core. Permeability is a relation between the flux density in a magnetic circuit and the ampere turns required to produce the flux density, and this relation may be illustrated by a curve the abscissæ of which are proportional to the ampere turns and the ordinates of which are proportional to the flux densities. At any point of this curve the relation is expressed by the tangent of the angle formed between the abscissa and a line drawn from the origin through that point. It is obvious, therefore, that the time required for the current to rise to its maximum value is approximately proportional to the value of the tangent of this angle. A curve of hysteresis represents a cycle of these relations beginning with the maximum positive value of the flux density, passing through zero value to the maximum negative value and back again through the zero value to the maximum positive value. Such a curve is shown in Fig. 2 and lines A—B and C—B are drawn in this figure from the points of zero magetization, or the points at which the values of the ampere turns are zero, to the point at which the flux density is at its maximum positive value. The angles θ and θ' are formed between these lines and horizontal lines. The lengths of the lines O—A and O—C are proportional to the residual magnetism. If, after the flux density has been at its maximum negative value, it is desired to magnetize the iron core to the maximum positive value of the flux density, the values of the flux density, for increasing values of the ampere turns, will follow the portion of the curve between A and B, and the time required for the current to rise to its maximum value will be approximately proportional to the value of the tangent of the angle θ. If, however, the value of the flux density in the iron core, just previous to de-magnetization, has been at its maximum positive value, the time required for the current to again rise to its maximum positive value will be proportional to the tangent θ', since the values of the flux density for increasing values of the ampere turns will follow the portion of the curve between C and B. It is evident, then, that, if the iron cores 48 and 49 are magnetized alternately in opposite directions, a greater time period is required for the current to rise to its maximum value than would be the case if the iron cores were magnetized always in the same direction, and this time is greater in proportion as tangent θ is greater than tangent θ'. The time period may be varied by adjusting the rheostats 53[a], which may be connected in shunt to the windings 50 and 51, and 52 and 53, substantially as shown.

In position a of the master switch 43, a circuit is completed from the positive terminal +B of the battery B′, through the master switch 43 and the reversing switch operating magnet coil 45 to the negative terminal —B of the battery. The reversing switch is then thrown to a position corresponding to forward motion of the car and the interlocking switch 47 is closed, so as to complete a circuit from the battery terminal +B, through the master switch 43, interlocking switch 47, conductor 55, interlocking switch 26 and the operating magnet coil 16 of the switch 10 to the battery terminal —B, and also a circuit through the operating magnet coil 18 of the switch 12, interlocking switch 29 and the relay switches 32 and 36, to the battery terminal —B. The energizing of the magnet coils 16 and 18 effects closure of the switches 10 and 12 and the circuits of the motors 9 are completed through a portion of the auto-transformer winding 3, lead 4, switch 12, resistance 54, switch 10, the motors 9 and reversing switch 44. The operation of the switch 12 moves the interlocking switch 27 and completes a battery circuit from conductor 55 through the winding 53 and operating magnet winding 17, There is a relay in the flow of the current to the magnet coil 17 caused by the impedance of the winding 53, but when the said coil is fully energized, switch 11 closes and operates the interlocking switch 26, thereby cutting the resistance 54 out of the motor circuit and breaking the circuit of the operating magnet coil 16. The switch 10 opens and interlocking switch 25 closes, thereby cutting the winding 53 out of the

circuit which includes the magnet coil 17 and completing the circuit of that coil from conductor 55 through relay switch 31, etc., and also completing the battery circuit from conductor 55 through interlocking switch 27, winding 53, interlocking switch 25 and the operating coil 37 of the relay switch 31. Energizing the coil 37 operates the relay switch 31, but operation of more of the devices is impossible until the master switch 43 is moved to the position *b*.

A switch 56, which is closed only when less than a predetermined amount of current traverses the motor circuits, may be interposed in the auxiliary circuits so that energy cannot be supplied to any of the operating devices while an excessive amount of current is being supplied to the motors.

If the master switch 43 is moved to the position *b* and the limit switch 56 is closed, energy may be supplied from the battery B through the relay switch 31, operating magnet coil 19, interlocking switch 30, and relay switches 34 and 36. Switch 13 now closes and operates the interlocking switch 28, thereby completing the battery circuit from conductor 55 through the interlocking switch 28, retaining magnet coil 22, interlocking switch 30 and relay switches 34 and 36, and also a circuit from conductor 55 through the operating magnet coil 38 of the relay switch 32 and the relay switch 36. As soon as relay switch 32 is operated, the circuit through operating magnet coil 18 is broken and the switch 12 opens. The motor circuit is then established through a portion of the auto-transformer winding 3, lead 5, switch 13, resistance 54, switch 11, the motors and the reversing switch. The operation of the relay switch 32 also completes a battery circuit from conductor 55 through the relay switches 32 and 33, winding 50 and operating magnet coil 16 of the switch 10, the passage of the current to the winding 16 being delayed, as before described, by the winding 50. The switch 10 closes and interlocking switch 25 opens, thereby cutting resistance 54 out of the motor circuits and breaking the circuit through the operating magnet coil 17 of the switch 11, which is then released. If the master switch 43 is returned to position *a*, the operation of the devices ceases; but if the master switch is left in position *b*, the devices continue to operate automatically until the last running position of the motors is reached. As soon as switch 11 is opened and interlocking switch 26 is closed, a battery circuit is completed from conductor 55 through the interlocking switch 26 and operating magnet coil 39 of relay switch 33 and the relay switches 32 and 36. The operation of the relay switch 33 completes a battery circuit through limit switch 56, relay switch 33, operating magnet coil 20 of the switch 14, interlocking switch 27 and relay switch 36. When interlocking switch 26 is closed and relay switch 33 is operated, the circuit through the operating magnet coil 16 is changed so that winding 50 is not included in the battery circuit, but a circuit is established through the interlocking switch 26. Energizing the operating magnet coil 20 closes the switch 14 and operates the interlocking switch 29. A battery circuit is now completed from conductor 55 through the interlocking switch 29, retaining magnet coil 23, interlocking switch 27 and relay switch 36, and another circuit is also established from the conductor 55 through the interlocking switch 29, operating magnet coil 40 of the relay switch 34 and relay switch 36. The relay switch 34 is now operated and the circuits through the operating and retaining magnet coils 19 and 22 are broken and the switch 13 opens. The motor circuit is now through a portion of the auto-transformer winding 3, the lead 6, switch 14, resistance 54, switch 10, the motors and the reversing switch. As soon as the relay switch 34 is operated, a battery circuit is completed from the conductor 55 through the relay switches 34 and 35, winding 52 and operating magnet coil 17 of the switch 11, the current being delayed, as before described, by means of the winding 52. The closing of the switch 11 cuts the resistance 54 out of the motor circuit and operates the interlocking switch 26, which breaks the circuit through the operating magnet coil 16, releasing the switch 10. Interlocking switch 25 is then closed. As soon as the switch 10 opens, the interlocking switch 25 is included in the circuit of the operating magnet coil 17, and a battery circuit is also completed from the conductor 55 through relay switch 31, interlocking switch 25, operating magnet coil 41 of the switch 35 and relay switches 34 and 36. The operation of the relay switch 35 cuts the winding 52 out of the battery circuit, and further operation of the devices may again be prevented by returning the master switch 43 to the position *a*; but if the master switch remains in position *b*, the operation of the devices continues automatically. The operation of the relay switch 35 also completes a battery circuit through limit switch 55, relay switch 35, operating magnet coil 21 of the switch 15 and interlocking switch 28. The switch 15 is now closed and the interlocking switch 30 operated, thereby completing a battery circuit from the conductor 55 through the interlocking switch 30, retaining magnet winding 24 and interlocking switch 28, and also a battery circuit through the interlocking switch 30 and operating magnet coil 42 of the relay switch 36. The operation of the relay switch 36 opens the circuits of the operating magnet coils 38, 39, 40 and 41, thereby releasing the cor-

responding relay switches and breaking the circuits of the magnet windings 21 and 23. The motor circuit is now through a portion of the auto-transformer winding 3, the lead 7, switch 15, resistance 54, switch 11, the motors and the reversing switch. The operation of the relay switch 36 also completes a battery circuit from the conductor 55 through the switch 36, winding 51 and operating magnet coil 16. The switch 10 now closes and the circuit of the operating magnet coil 17 is broken by the operation of the interlocking switch 25. The switch 11 opens, thereby cutting the resistance 54 out of the motor circuit, and the interlocking switch 26 is operated and shunts the winding 51. The system has now reached the limit of its operation and the motors are connected for full speed running conditions. It is to be noted that, under these conditions, none of the windings 50, 51, 52 and 53 are included in the circuits, and also that only the relay switch-operating coils 37 and 42 are included in the circuit, the result being that a minimum amount of energy is utilized for maintaining the devices in their proper positions for full-speed running. It is also to be noted that windings 50, 51, 52 and 53 are short-circuited or cut out of circuit immediately after they have served their purpose in delaying the operation of certain of the devices of the system, and also that a minimum number of relay operating coils are in circuit whenever the motors are connected for running conditions.

A distinct advantage which may be derived from the use of my system is that the number of train wires; *i. e.*, those conductors necessarily carried from car to car of a train when the system is employed for control of trains, is reduced to a minimum and none of these need carry current of dangerous voltages. The train conductors comprise one for each of the forward and reverse positions of the reversing switches 57 and 58, respectively, and two other conductors 59 and 60.

While, as here shown, my system is employed for the control of alternating current motors, and while some of the arrangements of the controlling devices are specific as applied thereto, I desire it to be understood that the system is capable of modification within the scope of the invention for use in the control of any translating devices other than motors and without regard to the character of the energy supplied to them. It will be also understood that the number of both circuit closing switches and circuit changing switches may be different from what I have shown and described in order to provide a different number of voltage steps by means of different subdivisions of the resistance and the transformer winding.

I claim as my invention:

1. In a system of control, the combination with a translating device, a plurality of circuits therefor, switches in said circuits, and operating magnet windings for said switches, of means for connecting said windings in circuit successively and means for delaying the flow of current to each of one or more of said windings after its electrical circuit has been established.

2. In a system of control, the combination with a translating device, a plurality of circuits therefor, switches in said circuits, and operating magnet windings for said switches, of means for establishing the circuits of said windings successively and means for delaying the rise of the current to its maximum value in each of one or more of said windings after its electrical circuit has been established.

3. In a system of control, the combination with a translating device, a plurality of circuits therefor, switches in said circuits, and operating magnet windings for said switches, of means for establishing the circuits of said windings successively and means for delaying the operation of each of one or more of said switches after the electrical circuit has been established through the corresponding operating winding.

4. In a system of control, the combination with a translating device, a plurality of circuits therefor, main switches in said circuits and operating magnet windings for said main switches, of interlocking switches operated by said main switches, relay switches, and means for delaying the rise of the current to its maximum value in one or more of said operating windings after electrical circuits have been established through those windings.

5. In a system of control, the combination with a translating device, a plurality of circuits therefor, main switches in said circuits and operating magnet windings for said main switches, of interlocking switches operated by said main switches, relay switches, and means controlled by said interlocking and relay switches for delaying the rise of the current to its maximum value in one or more of said operating windings after electrical circuits have been established through those windings.

6. In a system of control, the combination with a translating device, a plurality of circuits therefor, and main switches in said circuits, of interlocking switches operated by said main switches, relay switches and means for interposing a time interval between the operations of certain of said switches.

7. In a system of control, the combination with a translating device, a plurality of circuits therefor, and main switches in said circuits, of interlocking switches operated by said main switches, relay switches and means

governed by said interlocking and relay switches for interposing a time interval between the operations of certain of said switches.

8. In an electrical circuit, means for delaying the flow of current in that circuit, comprising a magnetizable core, one or more windings thereon and means for utilizing the residual magnetism of the core for increasing the delay in the flow of current.

9. In an electrical circuit, means for delaying the rise of current to its maximum value in that circuit, comprising a core, means for magnetizing said core, and means for utilizing the residual magnetism of the core for increasing the said delay.

10. A time-period adjusting device for electrical circuits, comprising a core, magnetizing windings therefor and means for connecting said windings in circuit alternately.

11. A time-period adjusting device for electrical circuits, comprising a magnetizable core, windings thereon, and means for connecting the said windings in circuit alternately in such manner that the direction of the magnetic flux in the core is reversed each time a winding is energized.

12. A time-period adjusting device for electrical circuits, comprising an iron core, a winding or windings thereon, and means for so connecting said winding or windings in circuit that the direction of the flux in the iron core is reversed each time a winding is energized.

13. In a system of control, the combination with a translating device, a plurality of circuits therefor, and electrically operated switches in said circuits, of interlocking switches operated thereby and an electrically operated relay switch corresponding to each of the main switches.

14. In a system of control, the combination with a translating device, a plurality of circuits therefor, and electrically operated switches in said circuits, of interlocking switches operated thereby, an electrically operated relay switch corresponding to each of the main switches, and a master switch.

15. In a system of control, the combination with a translating device, a plurality of circuits therefor, and electrically operated switches in said circuits, of interlocking switches operated thereby, an electrically operated relay switch corresponding to each of the main switches, an electrically operated reversing switch and a master switch which governs the circuits of the relay switches and of the reversing switch.

16. In a system of control, the combination with a translating device, a plurality of circuits therefor, and electrically operated main switches in said circuits, of interlocking switches operated thereby, electrically operated relay switches and time-period adjusting devices in the operating circuits of said main switches.

17. In a system of control, the combination with a main source of supply of electrical energy, a translating device operated therefrom, and a plurality of circuits for said device, of a reversing switch, operating magnet coils therefor, an interlocking switch operated thereby, main switches governing the circuits of said device, operating magnet coils therefor, retaining magnet coils for certain of said main switches, interlocking switches operated by said main switches, electrically operated relay switches, means for delaying the flow of current to certain of said operating coils, an auxiliary source of electrical energy, and a master switch which governs the operating circuits of said reversing switch and said relay switches.

18. In a system of control, the combination with a main source of supply of electrical energy, a translating device operated therefrom, a plurality of circuits for said device, a reversing switch, and main switches governing the circuits of said device, of electrically operated relay switches, and means operated by the said reversing switch for preventing the operation of the said relay switches until the reversing switch has been moved to its forward or to its reverse position.

19. In a system of control, the combination with a translating device and a transformer winding which is subdivided by means of leads, of a set of switches in said leads, a resistance connected between terminals of alternate switches of the set, auxiliary switches connected to said resistance, and means for delaying the closure of the auxiliary switches.

20. In a system of control, the combination with a translating device and a transformer winding which is subdivided by means of leads, of a set of switches in said leads, a resistance connected between terminals of alternate switches of the set, auxiliary switches connected to the said resistance, and means for interposing a time period between the operations of the auxiliary switches.

21. In a system of control, the combination with a translating device and a transformer winding which is subdivided by means of leads, of a set of main switches in said leads, a resistance connected between terminals of alternate switches of the set, auxiliary switches connected to said resistance, means for delaying the closure of the auxiliary switches, and means for opening each auxiliary switch, except the one last closed, before the next main switch is closed.

22. In a system of control, the combination with a translating device and a transformer winding which is subdivided by

means of leads, of a set of switches in said leads, means for preventing simultaneous closure of alternate switches of the set, a resistance connected between terminals of said switches, auxiliary switches having terminals connected to the said resistance, and means for interposing a time period between the operations of the auxiliary switches.

23. In a system of control, the combination with a subdivided transformer winding, and a translating device, of means for connecting the same between points of subdivision of said winding, a resistance, means for connecting the same first between leads from successive points of subdivision of the transformer winding and then in series with one of said leads, means for cutting the said resistance out of the circuit of said translating device and means for delaying the operation of the aforesaid means.

24. In a system of control, the combination with a variable-voltage source of electrical energy and a translating device, of independently operated switches for connecting the translating device to said source for successive voltage values, a resistance, switches for connecting the same in the circuit of the said translating device, switches for disconnecting the same from the said circuit, and magnetic means for delaying the operation of said switches.

25. In a system of control, the combination with a source of variable voltage electrical energy and a translating device, of a plurality of switches for connecting the translating device with said source, a resistance, switches for connecting said resistance in and disconnecting it from the circuit of said translating device, and means for delaying the disconnection of the resistance from the said circuit.

26. In a system of control, the combination with a source of variable-voltage electrical energy and a translating device, of a set of switches for connecting the translating device to successive voltage points of said source, a resistance connected between successive switches of said set, switches having terminals connected to said resistance, and means for delaying the closure of the last named switches.

27. In a system of control, the combination with a source of variable-voltage electrical energy and a translating device, of a set of switches for connecting the translating device to said source, means for preventing simultaneous closure of alternate switches of said set, a resistance connected between successive switches of said set, switches having terminals connected to said resistance, and means for delaying the closure of the last named switches.

28. In a system of control, the combination of a plurality of electrically controlled circuit-closing switches, a plurality of electrically controlled circuit-changing switches, automatic means for causing the circuit-changing switches to close successively, and means for introducing a time element into the operation of said circuit-changing switches while their controlling circuits are closed.

29. In a system of control, the combination of a set of main circuit-closing switches, circuit-changing switches, automatic means for causing successive closure of the circuit-changing switches intermediate the operation of each two successive main switches, means for delaying the closure of the circuit-changing switches, and means for causing each circuit-changing switch, except the one last closed, to open before the next main switch is closed.

30. In a system of control, the combination of a set of main circuit-closing switches, circuit-changing switches, automatic means for causing successive closure of the circuit-changing switches intermediate the operation of each two successive main switches, means for interposing a time period between the closures of the circuit-changing switches, and means for causing each circuit-changing switch, except the one last closed, to open before the next main switch is closed.

31. In a system of control, the combination of a set of main circuit-closing switches, means for preventing simultaneous closure of alternate switches of said set, circuit-changing switches, means for causing successive closure of the circuit-changing switches, and means for interposing a time period between the closures thereof.

32. In a system of control, the combination of a set of main circuit-closing switches, means for preventing simultaneous closure of alternate switches of said set, circuit-changing switches, means for causing successive closure of the circuit-changing switches intermediate the operation of each two successive main switches, automatic means for interposing a time period between the closures thereof, and means for causing each circuit-changing switch, except the one last closed, to open before the next main switch is closed.

33. In a system of control, the combination of a set of main circuit-closing switches, automatic means for effecting successive closure thereof and means for preventing simultaneous closure of alternate switches of said set.

34. In a system of control, the combination of a set of main circuit-closing switches, automatic means for effecting successive closure thereof, means for preventing simultaneous closure of alternate switches of said set, and circuit-changing switches.

35. In a system of control, the combination of a set of main circuit-closing switches, automatic means for effecting successive clo-

sure thereof, means for preventing simultaneous closure of alternate switches of said set, circuit-changing switches, and means for effecting successive closure of the circuit-changing switches.

36. In a system of control, the combination of a set of main circuit-closing switches, means for effecting successive closure thereof, means for preventing simultaneous closure of alternate switches of said set, circuit-changing switches, means for effecting successive closure of the circuit-changing switches, and automatic means for interposing a time period between the closures thereof.

37. In a system of control, the combination of a set of main circuit-closing switches, means for effecting successive closure thereof, means for preventing simultaneous closure of alternate switches of said set, circuit-changing switches, means for effecting successive closure of the circuit-changing switches intermediate the closure of each two successive main switches, automatic means for interposing a time period between the closures thereof, and means for causing each circuit-changing switch, except the one last closed, to open before the next main switch is closed.

38. In a system of control, the combination of a set of main circuit-closing switches, corresponding terminals of alternate switches of said set being electrically connected together, automatic means for effecting successive closure of said switches and means for preventing simultaneous closure of alternate switches of the set.

39. In a system of control, the combination of a set of main circuit-closing switches, corresponding terminals of alternate switches of the set being electrically connected together, automatic means for effecting successive closure of said switches, means for preventing simultaneous closure of alternate switches of the set, and circuit-changing switches.

40. In a system of control, the combination of a set of main circuit-closing switches, corresponding terminals of alternate switches of the set being electrically connected together, automatic means for effecting successive closure of said switches, means for preventing simultaneous closure of alternate switches of the set, circuit-changing switches, and means for effecting successive closure thereof.

41. In a system of control, the combination of a set of main circuit-closing switches, terminals of alternate switches of the set being electrically connected together, means for effecting successive closure of said switches, means for preventing simultaneous closure of alternate switches of the set, means for effecting successive closure thereof, circuit-changing switches, means for effecting successive closure thereof, and automatic means for interposing a time period between the closures thereof.

42. In a system of control, the combination of a set of main circuit-closing switches, terminals of alternate switches of the set being electrically connected, means for effecting successive closure of said switches, means for preventing simultaneous closure of alternate switches of the set, circuit-changing switches, means for effecting successive closure thereof intermediate the operation of each two successive main switches, automatic means for interposing a time period between the closures thereof, and means for causing each circuit-changing switch, except the one last closed, to open before the next main switch is closed.

43. In a system of control, the combination of a set of main circuit-closing switches, terminals of alternate switches of the set being connected together, automatic means for effecting successive closure thereof, means for preventing simultaneous closure of alternate switches of the set, and a resistance connected between the terminals of successive switches of the set.

44. In a system of control, the combination of a set of main circuit-closing switches, terminals of alternate switches of the set being connected together, automatic means for effecting successive closure thereof, means for preventing simultaneous closure of alternate switches of the set, a resistance connected between the terminals of successive switches of the set, and circuit-changing switches having terminals connected to the said resistance.

45. In a system of control, the combination of a set of main circuit-closing switches, terminals of alternate switches of the set being connected together, automatic means for effecting successive closure thereof, means for preventing simultaneous closure of alternate switches of the set, a resistance connected between the terminals of successive switches of the set, circuit-changing switches having terminals connected to the said resistance, and means for effecting successive closure of the circuit-changing switches.

46. In a system of control, the combination of a set of main circuit-closing switches, terminals of alternate switches of the set being connected together, means for effecting successive closure thereof, means for preventing simultaneous closure of alternate switches of the set, a resistance connected between the terminals of successive switches of the set, circuit-changing switches having terminals connected to the said resistance, means for effecting successive closure of the circuit-changing switches, and automatic means for interposing a time period between the closures thereof.

47. In a system of control, the combina-

tion of a set of main circuit-closing switches, terminals of alternate switches of the set being connected together, means for effecting successive closure thereof, means for preventing simultaneous closure of alternate switches of the set, a resistance connected between the terminals of successive switches of the set, circuit-changing switches having terminals connected to the said resistance, means for effecting successive closure of the circuit-changing switches intermediate the closure of each two successive main switches, automatic means for interposing a time period between the closures thereof, and means for causing each circuit-changing switch, except the one last closed, to open before the next main switch is closed.

48. In a system of control, the combination with one or more translating devices, a source of electrical energy, a transformer winding supplied therefrom, leads connected to different points in said winding, a set of switches having corresponding terminals connected to the respective leads and the alternate switches of the set having their other corresponding terminals connected together, automatic means for effecting successive closure of said switches, a resistance connected between the terminals of successive switches of the set, and circuit-changing switches having corresponding terminals connected to said resistance and having their other corresponding terminals connected together and to said translating device or devices.

49. In a system of control, the combination with one or more translating devices, a source of electrical energy, a transformer winding supplied therefrom, leads connected to different points in said winding, a set of switches having terminals connected to said leads and alternate switches of said set having terminals connected together, automatic means for effecting successive closure of said switches, means for preventing simultaneous closure of alternate switches of said set, a resistance connected between terminals of successive switches of the set, and circuit-changing switches having terminals connected to said resistance and having other terminals connected together and to said translating device or devices.

50. In a system of control, the combination with one or more translating devices, a source of electrical energy, a transformer winding supplied therefrom, leads connected to different points in said winding, a set of switches having terminals connected to said leads and alternate switches of the set having terminals connected together, a resistance connected between the terminals of successive switches of the set, circuit-changing switches having terminals connected to said resistance and having other terminals connected together and to said translating devices, and automatic means for effecting successive closure of the circuit-changing switches.

51. In a system of control, the combination with one or more translating devices, a source of electrical energy, a transformer winding supplied therefrom, leads connected to different points in said winding, a set of switches having terminals connected to said leads and alternate switches of the set having terminals connected together, a resistance connected between the terminals of successive switches of the set, circuit-changing switches having terminals connected to said resistance and having other terminals connected together and to said translating devices, automatic means for effecting successive closure of the circuit-changing switches, and automatic means for interposing a time period between the closures thereof.

52. In a system of control, the combination with one or more translating devices, a source of electrical energy, a transformer winding supplied therefrom, leads connected to different points in said winding, a set of switches having terminals connected to said leads and alternate switches of the set having terminals connected together, a resistance connected between the terminals of successive switches of the set, circuit-changing switches having terminals connected to said resistance and having other terminals connected together and to said translating devices, automatic means for effecting successive closure of the circuit-changing switches intermediate the closure of each two successive main switches, automatic means for interposing a time period between the closures of said circuit-changing switches, and means for causing each of the circuit-changing switches, except the one last closed, to open before the next main switch is closed.

53. In an electrical circuit, means for delaying the flow of current in that circuit, comprising a magnetizable core and means for utilizing the residual magnetism of the core for increasing the delay in the flow of current.

54. In an electrical circuit, means for delaying the flow of current in that circuit, comprising a magnetizable core and means for alternately reversing the direction of the magnetic flux in said core, whereby the residual magnetism may be utilized for increasing the delay in the flow of current.

55. In a system of control, the combination of main circuit switches, interlocking switches operated thereby, relay switches, a reversing switch, an interlocking switch operated thereby which prevents the operation of said relay switches until the reversing switch is thrown to its forward or to its reverse position and a master switch.

56. In a system of control, the combination of main circuit switches, circuit-changing switches, operating magnet windings

therefor, interlocking switches operated by said switches, time-period adjusting devices having windings, relay switches which effect closure of certain of the main circuit switches and control circuits to certain of the windings of the time-period adjusting devices and to operating magnet windings of circuit-changing switches, and other relay switches which effect the opening of certain of the main switches, control circuits to the remaining windings of the time-period adjusting devices and to operating magnet windings of circuit-changing switches and control circuits to the circuit-changing switches, the operations of the relay switches being interdependent and dependent upon the operations of the interlocking switches.

In testimony whereof, I have hereunto subscribed my name this 18th day of October, 1904.

RAY P. JACKSON.

Witnesses:

OTTO S. SCHAIRER,

BIRNEY HINES.