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H. E. WHITE & H. C. PEASE.

SYSTEM OF CONTROL.

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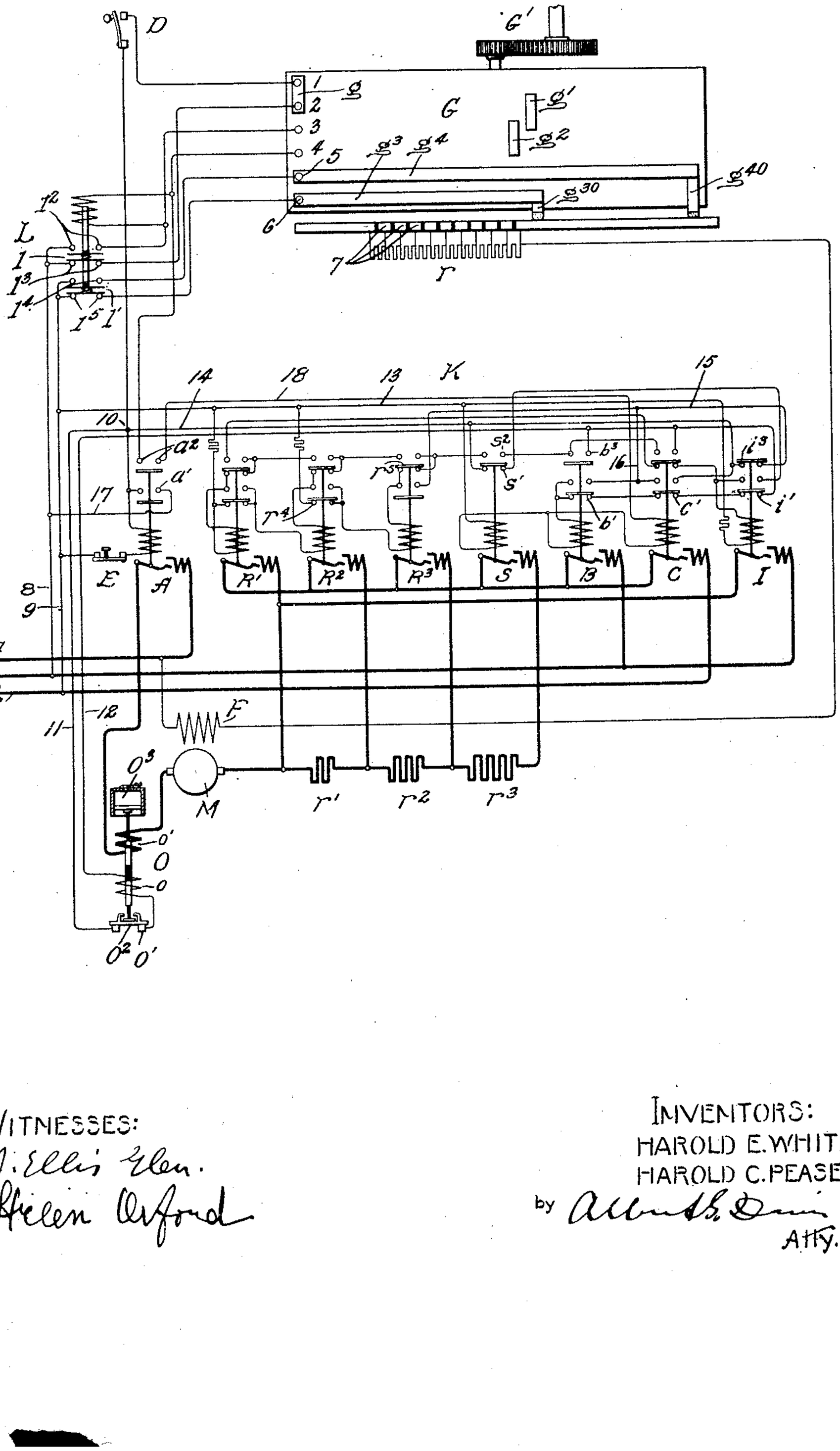

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UNITED STATES PATENT OFFICE.

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SYSTEM OF CONTROL.

No. 845,023. Specification of Letters Patent. Patented Feb. 19, 1907.

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To all whom it may concern:

Be it known that we, HAROLD E. WHITE and HAROLD C. PEASE, citizens of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Systems of Control, of which the following is a specification.

The present invention relates to apparatus for controlling the operation of an electric motor or motors.

The arcing produced at the controller-contacts in the process of controlling motors has led to the practice of employing a motor-controller adapted for heavy currents and the attendant arcing, together with a master-controller or switch for governing the action of the motor-controller, the arrangement being such that no heavy currents are broken by the master-controller. In apparatus for many purposes the arcing caused by the breaking of small currents in the master-controller is of no moment, although the controller must be made larger and heavier than would otherwise be necessary. In some cases, however, any arcing in the master-controller is of considerable disadvantage. For example, in control systems for variable-speed motors driving automatic machinery in which the master-controller is automatically driven speed changes are produced upon small movements of parts of the machinery, such as the tool-feed. It is obvious that if the speed changes are numerous and if live circuits are interrupted in the master-controller it must be made large to afford sufficient space between the contacts to enable the arcs to be broken. Not only is a large and unwieldy master-controller undesirable, but even though the controller be large the arcs formed between coöperating contacts will bridge them during a material movement of the controller, giving perhaps different speed conditions for the same position of the master-controller, depending upon the direction in which the controller is being moved.

In one of its aspects the present invention consists in a construction and arrangement of parts constituting a system of control whereby the master-controller is permitted to operate without the formation of arcs at its contacts. It is sometimes desirable to operate variable-speed motors at different line-potentials, current being supplied from the low-potential circuit until a certain speed is reached and the motor being then connected to the circuit of high potential for operation at increased speeds.

In another of its aspects the present invention may be regarded as comprising means for connecting a motor or group of motors to a source of current-supply, automatically accelerating the motor, and then automatically connecting it to another source of supply and again accelerating it.

The present invention will be more fully understood in the above and other aspects from the following description thereof.

The accompanying drawing illustrates a preferred form of the present invention.

The particular embodiment of our invention illustrated consists in control apparatus for a shunt-wound motor adapted to be supplied successively with current from two different circuits. Upon starting the motor-armature is connected to the low-potential circuit in series with a starting resistance and is brought up to speed through the automatic elimination of the resistance. The speed of the motor may then be increased by cutting resistance into the shunt field-circuit until the maximum speed for that voltage is attained. The armature is then automatically disconnected from the low-potential circuit and connected to the high-potential circuit, again in series with the starting resistance. At the same time the field is strengthened by cutting out the field resistance. The starting resistance is cut out automatically, as before, and the speed increased by gradually cutting the field resistance in again. When the master-controller is in its "off" position, the motor may be started by pressing a "starting-button," and it may at all times be stopped upon pressing a "stopping-button." The master-controller for the main motor-controller serves also to control the field resistance, and the circuits are all so arranged that in the operation of the master-controller no live circuits are broken, the actual breaking of the active circuits taking place at the contacts of a relay adapted for that purpose. By this arrangement all danger of arcing in the master-controller is eliminated.

Reference being had to the drawings, M indicates a motor-armature, and F a shunt field-winding.

a, *b*, and *c* are the supply-conductors.

r', r^2, and r^3 are resistance-sections comprising a starting resistance for the motor.

K is a motor-controller, preferably of the separately-actuated type, adapted to connect the motor-armature successively across conductors *a b* and *a c* and automatically control the starting resistance.

O is a combined throttle and time-interval relay governing the rate of progression of the resistance-switches of the controller.

G is a master-controller.

D and E are starting and stopping switches or buttons, respectively.

r is a field-rheostat, and L is a relay arranged to shift the field-circuit and the active control-circuits in response to the movements of the master-controller.

The motor-controller comprises a switch A for connecting one terminal of the motor-armature to supply-conductor *a*, switches B and C, which coöperate with switch S to connect the opposite terminal of the armature to conductors *b* and *c*, respectively, resistance-controlling switches R', R^2, and R^3, and a switch I, which automatically closes and places a shunt or bridge about the resistance-switches and switch B after the latter switches have operated. The master-controller comprises the fixed contacts 1–4 and the movable contacts *g*, *g'*, and g^2 for governing the controller K and additional fixed contacts 5, 6, and 7 and movable segmental contacts g^3 and g^4 for regulating the field resistance *r*. The movable contacts of the master-controller are illustrated as mounted upon a developed cylinder arranged to be revolved through gearing G'. The relay L consists of an electromagnet to the core of which are attached two contact members *l* and *l'*. When the relay-coil is deënergized, these contacts engage, respectively, with the fixed contacts l^3 and l^5, and when the coil is energized then engagement is made with contacts l^2 and l^4.

In the drawings the parts of the apparatus are illustrated as occupying their off or inoperative positions, contact *g* in the master-controller bridging contacts 1 and 2. When it is desired to start the motor, switch D is momentarily closed. Current thereupon flows from line *b* through wire 8, contacts l^2 and *l* of the relay L, contacts 2, *g*, and *l* of the master-controller, switch D, actuating-coil of switch A, switch E, wire 9 to line *c*. Switch A is thereupon closed, connecting one terminal of the motor-armature to line *a*. A branch circuit passes from point 10 through wire 11, contacts O' O^2, and coil *o* of relay O, wire 12, auxiliary contacts *i'*, *c'*, and *b'*, associated with switches I, C, and B, actuating-coils of switches B and S, wire 13, and thence through wire 9 to line *c*. This closes switches B and S and connects the remaining terminal of the motor-armature to line *b*.

When switch B closes, it breaks its own actuating-circuit and establishes a maintaining-circuit from point 10, through wire 14, auxiliary contacts i^3, wire 15, wire 16. When switch A closes, it establishes a maintaining-circuit by connecting its coil directly to wire 8 through wire 17 and auxiliary contacts *a'*, which are bridged when the main switch closes. Current also flows to point 10 and to the actuating-coils of switches B and S, so that the switches A, B, and S are now maintained closed independently of the relay L and the master-controller. Consequently the master-controller may be moved to disengage contact *g* from contacts 1 and 2 without interrupting an active circuit. The motor-armature is now connected across the low-voltage circuit *a b* in series with the resistance r', r^2, and r^3.

The passage of the current through the coil *o* of relay O causes the core to be lifted and contact O^2 to be disengaged from contacts O', thus breaking the actuating-circuits. A lost motion is provided between the core of the relay and movable contact O^2, so that switches B and S have time to close before the actuating-circuit is broken. After the relay O has operated it closes slowly under the influence of the dash-pot O^3, again completing the controlling-circuit at contacts O' and O^2. Current now flows from wire 12 through auxiliary contacts b^3 and s^2, associated, respectively, with switches B and S, thence through auxiliary contact r^5, associated with switch R^3, through the actuating-coil of the switch R^3, through the auxiliary contacts r^4, associated with the switch R^3, and thence to wire 13. Switch R^3 is now closed, cutting out resistance-sections r^3 in the armature-circuit. The closing of switch R^3 closes auxiliary contact r^6 associated therewith and establishes a maintaining-circuit from wire 15 through these latter auxiliary contacts, and thence to wire 13, as before. Switches R^2, R', and I are then closed in automatic progression, cutting out the remaining resistance from the armature-circuit and connecting the armature directly across *a* and *b* through switches A and I. It is noted that upon the operation of each of the switches B, R^3, and R^2 the actuating-circuit is broken by the relay O, and if the motor-current increases too rapidly the throttle-coil *o'* serves to keep the core of the relay raised and prevents the closing of resistance-switches R^3, R^2, and R', respectively, until the motor-current has fallen within safe limits.

The actuating-circuit for the switches B and S and the maintaining-circuits for the switches B and S and the resistance-switches pass through the auxiliary contacts *i' i³*, associated with switch I, so that when switch I closes the actuating-coils of the switches B S and the resistance-switches are de-

energized, and these latter switches all drop open. This system of automatically-progressing contacts forms in itself no part of the present invention, being illustrated simply as a desirable form of motor-controller for use in carrying out the present invention. For a more complete understanding of this form of motor-controller and of the construction of time-interval and throttle relay and main and auxiliary contacts or switches reference may be had to Patent No. 798,342, granted August 29, 1905, on the application filed by George H. Hill.

The field F of the motor is connected at one terminal to line *a* and at its other terminal to one terminal of the resistance *r*. When the master-controller is moved from its off position, the brush g^{30}, which is in electrical connection with the contact-segment g^3, engages with the contacts 7, so that current is free to flow from line *a*, through the field-coil, through one of the contacts 7, through the brush g^{30}, segment g^3, contact 6, contact l^5 l' of the relay L, wire 9 to line *c*. As the master-controller is moved toward the left the amount of resistance *r* which is in the field-circuit is increased until finally the entire resistance has been cut into the field-circuit and the maximum speed for the low voltage attained. In the next position of the master-controller the contact g' bridges the fixed contacts 2 and 3 and current flows from wire 8, through contact l^3 and l of the relay L, contacts 2, g', and 3 of the master-controller, through the actuating-coil of the relay L, through the auxiliary contacts a^2, associated with the switch A, through wire 18, actuating-coil of switch C, actuating-coil of switch S, wire 13, wire 9 to line-wire *c*. Switches C and S are thereupon closed, and the motor-armature is connected across line *a c* in series with the entire starting resistance. The closing of the switch S breaks the maintaining-circuit of the switch I at the auxiliary contacts s', whereby the switch I is made to open immediately upon the closing of the switches C and S. The switches R^3, R^2, and R' are again closed in automatic progression in exactly the same manner as before, the operation finally leaving the motor-armature connected across lines *a c*, with no resistance in circuit.

It will be seen that as soon as the actuating-coil of the relay L has been energized the core is lifted and the current instead of passing through contacts l^3, through the master-controller, and thence through the coil of the relay now passes through the contact l^2 of the relay and thence directly through coil of the relay and the wire 18, as before, shunting the controller-contacts 2 and 3, so that when these contacts are disengaged from segment g' upon a further movement of the master-controller no sparking occurs, because no current is flowing through the contacts. Another effect of the operation of the relay L is to break the connection between wire 9 and the contact 6 of the master-controller and to complete a connection between said wire and contact 5. Segments g^3 and brush g^{30} are now rendered idle, and the field-circuit passes through brush g^{40} and segment g^4. The relation of the brushes g^{30} and g^{40} is such that when the brush g^{30} is in engagement with the left-hand terminal of resistance *r* the brush g^{40} is in engagement with the opposite terminal. Consequently at the point at which the brush g^{30} is cut out the brush g^{40} is ready to traverse the contacts 7 and cut resistance into the field-circuit. Upon returning the master-controller toward its off position the segment g^2 bridges contacts 3 and 4, thereby short-circuiting the actuating-coil of the relay L and causing it to be deënergized. The core of the relay falls, cutting out brush g^{40} and again bringing into play brush g^{30} and interrupting the maintaining-circuit for all the switches, except the switch A. Since, however, the switch A remains closed, the switches B S R^3 R^2 R' I may close in automatic succession and bring the motor into operation again on the low-potential circuit. When it is desired to stop the motor, the switch or push button E is operated, breaking the controlling-circuit and preventing the further operation of the controller until the master-controller is again moved to its off position. If the motor is being used to drive a lathe or boring-mill, for instance, the master-controller may be geared to the cross-feed of the tool, and so cause the motor to gradually increase its speed as the diameter of the cutting-surface decreases. In this way a definite cutting speed may be maintained irrespective of the diameter of the work. While the use of a starting-button is advantageous in cases where the master-controller is power-operated, this button is not an essential feature, since the master-controller may readily be arranged to perform the function thereof.

While the system described is one well adapted for service in connection with machine-tools or other machines, the present invention is not limited to control apparatus used in such situations nor to apparatus in which the master-controller is automatically driven. Furthermore, different types of motors than the particular type illustrated may be effectively controlled in accordance with the present invention, and the details and arrangement of parts of the control apparatus may be greatly varied without departing from the spirit of the present invention.

What we claim as new, and desire to secure by Letters Patent of the United States, is—

1. In combination, a controller, a governing-relay for said controller, a controlling-circuit for said relay, a master controlling device having contacts arranged in said circuit,

and means for placing a shunt about said contacts upon the operation of the relay.

2. In combination, a controller, a governing-relay for said controller, a controlling-circuit for said relay, a master controlling device having contacts in said circuit, and means for automatically shunting said circuit past said contacts.

3. In combination, a controller, electromagnetic controlling means therefor, an electromagnetic relay, a master controlling device having contacts for completing a circuit through said electromagnetic controlling means and through the actuating-coil of said relay, and contacts on said relay for shunting said circuit past the contacts of the master devices upon the operation of the relay.

4. In combination, a controller, electromagnetic actuating means therefor, a relay for controlling said actuating means, a master controlling device arranged to energize said relay, and means associated with said relay for rendering said master device inoperative upon the operation of the relay.

5. In combination, a controller, electromagnetic controlling means therefor, an electromagnetic relay, a master controlling device having contacts for completing a circuit through said electromagnetic controlling means and through the actuating-coil of said relay, contacts on the relay for shunting said circuit past said contacts upon the operation of the relay, and additional contacts on said master controlling device arranged to short-circuit the actuating-coil of said relay.

6. In combination, a motor, a plurality of supply-circuits, a controller adapted to connect said motor successively to different circuits, electromagnetic actuating means for said controller, a relay controlling the circuit of said actuating means, a master controlling device for energizing said relay, and means associated with said relay for placing a shunt about the master controlling device upon the operation of the relay.

7. In combination, a motor having a shunt-field, a controller, a resistance in said shunt-field, electromagnetic actuating means for said controller, an electromagnetic relay, a master controlling device having contacts for completing a circuit through said actuating means and through said relay, means associated with said relay for shunting said circuit past the said contacts upon the operation of the relay, and means controlled by the master controlling device for varying the resistance in the shunt-field.

8. In combination, a motor having a shunt-field, a controller, electromagnetic actuating means for said controller, a resistance in said shunt-field, a relay, a series of contacts associated with said resistance, a switch having a plurality of contacts arranged to traverse said series of contacts successively, means controlled by the relay for either of said switch-contacts to one terminal of said resistance, and contacts on said switch device for controlling said relay.

9. In combination, a plurality of supply-circuits, a motor having a shunt-field, an armature resistance, a field resistance, a controller arranged to connect the motor-armature successively to said supply-circuits and to vary the amount of resistance in series with the armature, means for operating said controller, a master-controller for governing said means and for varying the amount of resistance in the field-circuit.

10. In combination, a plurality of supply-circuits, a motor-controller constructed and arranged to disconnect the motor from one circuit and connect it to another, electromagnetic actuating means for said controller, a master controlling device adapted to complete a circuit through said actuating means, and means for automatically shunting said latter circuit around the master controlling device.

11. In combination, a plurality of supply-circuits, a motor, a resistance, an electromagnetically-actuated motor-controller arranged to connect the motor to the supply-circuits in succession and to automatically vary the amount of the resistance in the motor-circuit, a master controlling device arranged to control the circuit of the actuating means for said motor-controller, and means for automatically shunting said latter circuit around the master controlling device.

12. In combination, a plurality of supply-circuits, a motor, a motor-controller, electromagnetic actuating means for said controller, a relay, a master controlling device adapted to energize said relay and to cause said controller to operate to disconnect the motor from one circuit and to connect it to another circuit, and means associated with said relay for placing a shunt around said master controlling device upon the operation of the relay.

13. In combination, a plurality of supply-circuits, a motor, a resistance, an electromagnetically-actuated controller arranged to connect the motor to the supply-circuits in succession and to automatically vary the amount of the resistance in the motor-circuit, an electromagnetic relay, a master controlling device having contacts adapted to complete a circuit through the actuating-coil of said relay and through the actuating means for said controller, and means associated with said relay for shunting said latter circuit around said contacts upon the operation of the relay.

14. In combination, a plurality of supply-circuits, a motor, a resistance, an electromagnetically-actuated controller arranged to connect the motor to the supply-circuits in succession, a controlling-circuit, an electromagnetic relay having contacts in said con-

trolling-circuit, a master controlling device, and connections arranged to connect the actuating-coil of said contacts on the relay arranged to place a shunt about said controlling device upon the operation of the relay.

15. In combination, a resistance, a series of contacts connected therewith, a controller having a plurality of brushes arranged to traverse said contacts in succession, a supply-conductor, a relay arranged to connect either of said brushes to said supply-conductor, and contacts on said controller for controlling said relay.

16. In combination, a resistance, a series of contacts connected thereto, a controller having a plurality of brushes arranged to traverse the contacts in succession, a supply-conductor, a relay arranged to connect either of said brushes to said supply-conductor, contacts on said controller for energizing said relay, and means associated with said relay for placing a shunt around said controller-contacts upon the operation of the relay.

17. In combination, a resistance, a series of contacts connected thereto, a controller having a plurality of brushes arranged to traverse the contacts in succession, a supply-conductor, a relay arranged to connect either of said brushes to said supply-conductor, contacts on said controller for energizing said relay, means associated with said relay for placing a shunt around said controller-contacts upon the operation of the relay, and additional contacts in said controller for short-circuiting said relay.

18. In combination, a pair of supply-conductors, a motor having one field-terminal connected to one of said conductors and the other field-terminal with one terminal of a resistance, a controller having a plurality of brushes, a relay for connecting either of said brushes to the remaining supply-conductors, contacts in electrical connection with said resistance arranged to coöperate with said brushes, and contacts on said controller for controlling said relay.

19. In combination, a plurality of supply-circuits, a motor, a starting resistance, a motor-controller arranged to successively connect said motor to the supply-circuits in series with the starting resistance and to automatically cut out said resistance, a master-controller for governing the operation of said motor-controller, a field resistance, and means associated with the master-controller for regulating said field resistance intermediate the positions of the master-controller wherein the motor connections are caused to be shifted from one supply-circuit to another.

In witness whereof we have hereunto set our hands this 24th day of June, 1905.

HAROLD E. WHITE.
HAROLD C. PEASE.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.