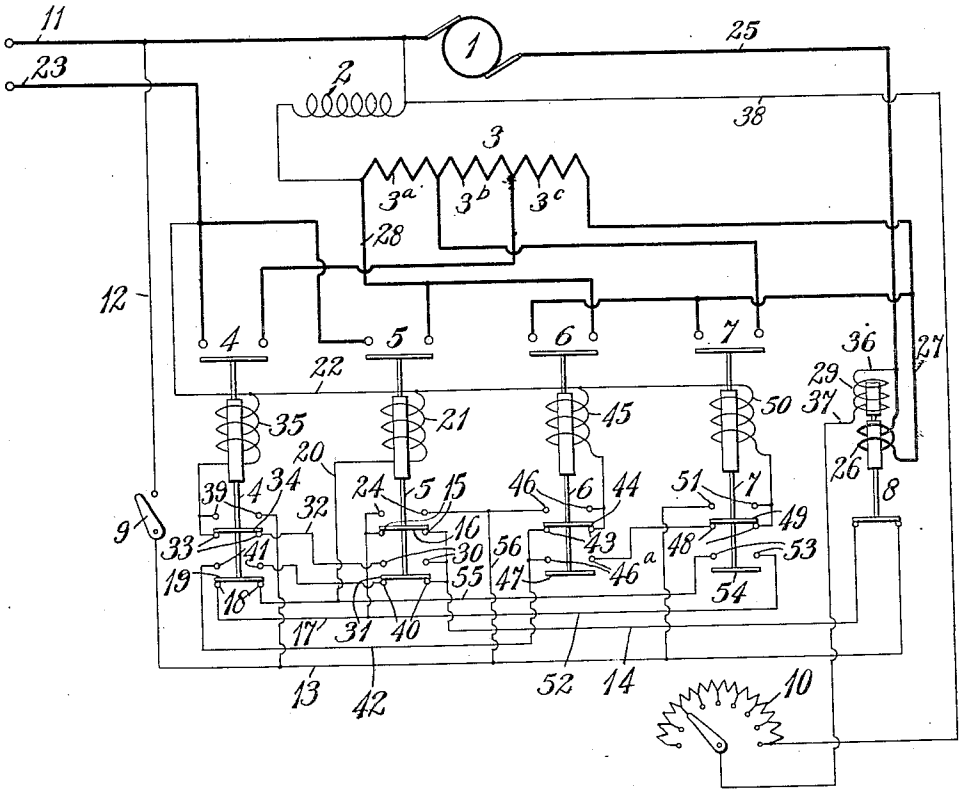
W. COOPER.

SYSTEM OF ELECTRIC MOTOR CONTROL.

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1,126,163. Patented Jan. 26, 1915.



WITNESSES:

Fred H. Miller

R. J. Barbour

INVENTOR

William Cooper

BY

Insley & Carr

ATTORNEY

UNITED STATES PATENT OFFICE.

WILLIAM COOPER, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

SYSTEM OF ELECTRIC-MOTOR CONTROL.

1,126,163. Specification of Letters Patent. **Patented Jan. 26, 1915.**

Application filed December 21, 1910. Serial No. 598,518.

To all whom it may concern:

Be it known that I, WILLIAM COOPER, a citizen of the United States, and a resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Systems of Electric-Motor Control, of which the following is a specification.

My invention relates to controllers for electric motors and particularly to such controllers as comprise a plurality of independently operated switches for governing the circuit connections of the motor and its starting resistance.

The object of my invention is to provide simple and inexpensive means, in a system of the class above indicated, for delaying the action of the resistance-control switches until the current traversing the motor circuit falls below a predetermined value, the current value being automatically varied for each of the accelerating switches.

Series relay switches for delaying the successive action of independently operated control switches are in very general use and are well understood. When a single relay switch of this character is employed, the same current value in the motor circuit determines the action of each of the switches. In some cases it is particularly desirable to delay the action of the switches located near the end of the series until the motor current has fallen to a lower value than is desirable or necessary in connection with the first switches of the series and, in order to determine independently the closure of each switch, a relay switch has, in some cases, been provided for each of the control switches. According to my present invention, I accomplish substantially the same result with the use of a single relay switch by equipping the relay switch with a shunt winding in addition to the usual series winding and connecting the shunt winding across the terminals of the motor armature. By this means, the actual relay switch is not only dependent upon the current traversing the motor circuit, but also upon the counter-electromotive force generated at the armature terminals which is, of course, dependent upon the speed of the motor. By so conecting the two windings of the relay switch as to assist each other, the relay switch will obviously remain closed until the current in the motor circuit has reached a lower value, when the motor has attained a considerable speed than will permit the same action when the motor has just been started and is operating at low speed.

The single figure of the accompanying drawing is a diagrammatic view of a control system embodying my invention.

Referring to the drawing, the control system here shown comprises an electric motor having an armature 1 and a field magnet winding 2, a motor-starting resistor 3, a plurality of independently operated control switches 4, 5, 6 and 7, a relay switch 8, a master switch 9 and a regulating resistor 10.

Assuming that the master switch 9 is closed, energy is supplied from any suitable source through line conductor 11, conductor 12, master switch 9, conductor 13, relay switch 8, conductor 14, contact terminals 15, contact member 16 (the switch 5 being open) conductor 17, contact terminals 18, contact member 19 (the switch 4 being open), conductor 20, actuating magnet winding 21 of the switch 5 and conductor 22 to line conductor 23. When magnet winding 21 is energized, the switch 5 is closed, a holding circuit being established from conductor 13 through contact terminals 24 which are now bridged by contact member 16, conductor 17, etc., as before. The motor circuit is now established from conductor 11, through armature 1, conductor 25, series magnet winding 26 of relay switch 8, conductor 27, resistor sections 3^c, 3^b and 3^a, conductor 28 and switch 5 to line conductor 23. By reason of the connections just described, the motor is started and sufficient current traverses the winding 26 to temporarily open relay switch 8. As soon as the motor is so far accelerated and the motor current is so much reduced as to permit the relay switch 8 to close, in spite of the increased counter-electromotive force of the motor armature 1, a control circuit is established from conductor 13, through the relay switch, conductor 14, contact terminals 30, contact member 31 (the switch 5 being closed) conductor 32, contact terminals 33, contact member 34 (the switch 4 being open) magnet winding 35 of the switch 4 and conductor 22 to conductor 23.

When magnet winding 35 is energized, switch 4 is closed and contact member 19 is separated from contact terminals 18, thereby interrupting the circuit of magnet winding 21 to permit the switch 5 to open. The

resistance in the armature circuit is thus decreased, only the section 3^c of the resistor 3 being now included.

The relay switch 8 is provided with a shunt winding 29, one terminal 36 of which is connected, through conductor 25, to one terminal of the armature and the other terminal 37 of which is connected, through more or less of the variable resistor 10 and the conductor 38, to the opposite armature terminal. As the speed of the motor increases, the pull exerted by the winding 29 is obviously increased. Consequently, if the windings 26 and 29 assist each other, the delay between steps in the acceleration of the motor which is occasioned by the relay switch will be greater as the speed of rotation and the counter-electromotive force of the motor armature increase. It may be found desirable to make the delay just referred to shorter as the speed of the motor increases, in which case the winding 29 of the relay switch will be arranged to oppose the series winding 26.

The switch 4 is held closed because contact member 34 engaged contact terminals 39 and a control circuit is completed from conductor 13, through said contact member and terminals and the winding 35 to conductors 22 and 23. The reduction of resistance in the armature circuit will usually cause the relay switch 8 to open temporarily and, as soon as the relay switch is again closed, a control circuit is established from conductor 13 through the relay switch, conductor 14, contact terminals 40, contact member 31 (the switch 5 being open) contact terminals 41, contact member 19 (the switch 4 being closed) conductor 42, contact terminals 43, contact member 44 (the switch 6 being open) magnet winding 45 of switch 6, and conductor 22 to line conductor 23.

When magnet winding 45 is energized, switch 6 is closed and contact member 44 engages contact terminals 46 to complete a holding circuit directly from the conductor 13 through said magnet winding to conductor 22. Since switches 4 and 6 are both closed, the resistor sections 3^a and 3^b are connected in multiple circuit with the section 3^c and again the motor current is increased. As soon as the relay switch is again closed, a control circuit is established from conductor 13, through conductor 14, contact terminals 40 of switch 5, contact terminals 41 of switch 4, conductors 42, contact terminals 46^a, contact member 47, (the switch 6 being closed) contact terminals 48, contact 49, (the switch 7 being open) magnet winding 50 of switch 7 and conductor 22 to line conductor 23.

As soon as switch 7 is closed, its magnet winding 50 is connected in a direct holding circuit which is established through contact terminals 51 and contact member 49. The switch 7 short circuits the resistor section 3^a and, consequently, the resistor sections 3^b and 3^c are connected in multiple circuit. The motor speed now approaches its normal running value and, consequently, the counter-electromotive force generated in the motor armature is considerable. It is, therefore, necessary for the current traversing the motor circuit to be materially reduced before the relay switch can open, and the last step in the sequence of control taken.

As soon as the relay switch has closed after the switch 7 is closed, control circuit connections are established from conductor 13 to the relay switch, through conductor 14, contact terminals 15 and contact member 16 of switch 5, conductor 52, contact terminals 53 and contact member 54 of switch 7, conductor 55, conductor 20 and magnet winding 21 of switch 5 to conductors 22 and 23. The switch 5 is thus finally closed and its holding circuit is established from conductor 13, through conductor 56, contact terminals 24, contact member 16, conductor 52, contact terminals 53, contact member 54, conductor 55, etc., as before. A motor circuit is then established directly from conductor 27, through switches 6 and 5, the resistor sections being excluded from the circuit. The action of the shunt magnet coil 29 of the relay switch 8 may be adjusted by means of the variable resistor 10 until the acceleration of the motor is accomplished in the most economical and satisfactory manner possible.

The total amount of resistance and the number of independently operated switches are relatively small by reason of the fact that the resistor sections are connected first in a series and then in a multiple circuit relation.

The circuit connections of the system may be varied within the spirit and scope of my invention, and I desire that no limitations shall be imposed which are not specified in the appended claims.

I claim as my invention:

1. In a control system, the combination with an electric motor, and a plurality of independently operated accelerating switches, of a relay switch for delaying the operation of the several switches, said relay switch having a compound winding, a part of which is responsive to the counter-electromotive force of the motor armature.

2. In a control system, the combination with an electric motor, and a plurality of independently operated accelerating switches, of a relay switch for delaying the operation of the several switches, said relay switch having two magnet windings acting in the same direction, only one of which is responsive to the counter-electromotive force of the motor armature.

3. In a control system, the combination

with an electric motor, and a plurality of independently operated accelerating switches, of a relay switch for delaying the operation of the several switches, said relay switch having magnet windings, one of which is responsive to the counter-electromotive force of the motor armature and the other of which is responsive to the current in the motor circuit.

4. In a control system, the combination with an electric motor, and a plurality of independently operated accelerating switches, of a relay switch for delaying the operation of the several switches, said relay switch having a winding connected in series with the motor circuit and a second winding connected across the terminals of the motor armature.

5. In a control system, the combination with an electric motor, and a starting resistor therefor comprising connected sections, of means for connecting said resistor sections in series relation and subsequently in parallel relation, said means comprising a series of progressively actuated switches, and a relay switch for delaying the action of several switches, said relay switch having a compound winding, a part of which is responsive to the counter-electromotive force of the motor armature.

In testimony whereof, I have hereunto subscribed my name this 9th day of Dec. 1910.

WILLIAM COOPER.

Witnesses:
HOWARD L. BEACH,
B. B. HINES.