

J. F. SCHNABEL.
 CONTROL SYSTEM FOR ELECTRIC MOTORS.
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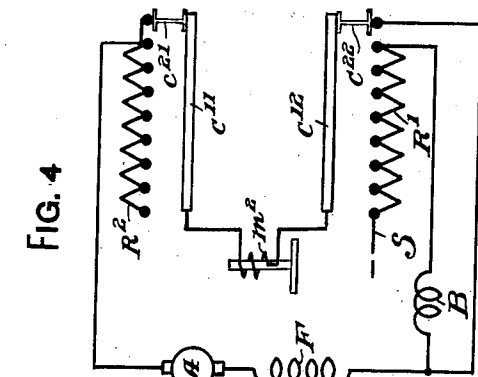


FIG. 4

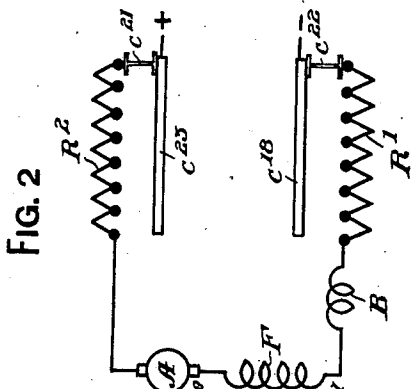


FIG. 2

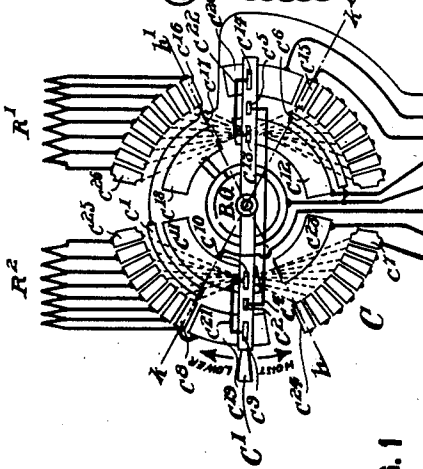


FIG. 1

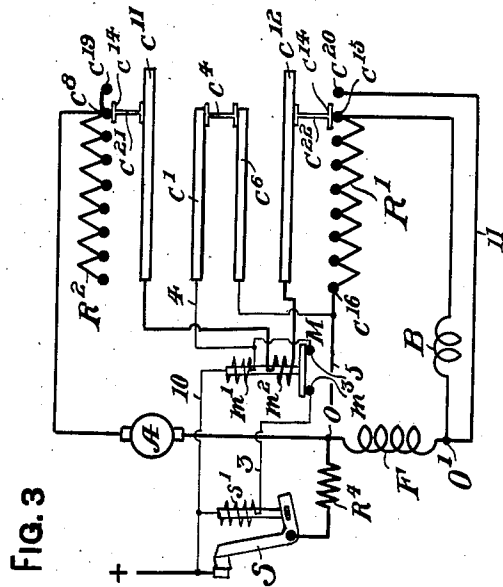


FIG. 3

WITNESSES

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UNITED STATES PATENT OFFICE.

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CONTROL SYSTEM FOR ELECTRIC MOTORS.

1,008,495.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, JAMES F. SCHNABEL, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga, State of Ohio, have invented or discovered new and useful Improvements in Control Systems for Electric Motors, of which the following is a specification.

My invention relates to controlling apparatus for electric motors; and though I have shown it in connection with a series wound motor, it is applicable to all motors having series field windings.

It is the object of my invention to provide an improved system which permits the load to be lowered without the use of the so-called mechanical brake and which is so arranged as to operate satisfactorily in lowering operations whether the loads are greater or less than required to overhaul the hoisting mechanism.

More specifically, the objects of my invention are to provide a safety device near the motor in order to effect a safe lowering of the load upon failure of the current supply; to obtain more than a single point of power-lowering without materially increasing the current through the series field, minimum speed being obtained on the first point and maximum speed on the last point, whatever the load; to obtain power-lowering with selective dynamic braking on any condition of load; and to maintain the dynamic braking circuit when the controller is brought to the off-position, and at the same time allow the magnetic friction-brake to set, so that both systems of braking will act together to stop the lowering of the load.

Other minor objects will appear herein-after.

Referring to the accompanying drawings, Figure 1 is a diagram showing the preferred form of my invention with the parts as they are when the master-switch is in the off-position; Fig. 2, a simplified diagram showing the motor circuit as it is with the master-switch on the first hoisting position; Fig. 3, a simplified diagram showing the motor and control circuits as they exist when the master-switch is on its first lowering position; and Fig. 4, a diagram of the motor circuits when the master-switch is in the off-position.

On the drawings, C is the master-switch provided with contacts and fingers which

operate in connection with the banks of resistances R' and R^2 and the circuit wires leading therefrom in a manner which will be clearly understood from the description of the operation of the system.

Supposing the master-switch arm C' to be moved to the first hoisting position, that is, to the line $h h'$, the fingers c^9 and c^{10} connect the contacts c^{23} and c^{24} , and the fingers c^{13} and c^{14} connect the contacts c^{16} and c^{18} , the motor circuit being as follows: from the positive through the contact c^{23} , the finger c^{10} , the connection c^{21} , the finger c^9 , the contact c^{24} , the cross connection to the contact c^{25} , the resistance R^2 , the contact c^8 , the cross-connection to the contact c^7 , the wire 6, the armature A, the field F, the winding B of the brake B' , the wire 9, the contact c^{15} , the cross-connection to the contact c^{26} , the resistance R' , the contact c^{16} , the finger c^{14} , the connection c^{22} , the finger c^{13} , the contact c^{18} , the blow-out coil B. O., and the wire 5 to the negative. This circuit leads the current in such a direction, it will be assumed, as to rotate the armature in the hoisting direction. Fig. 2 shows in simplified form the master circuit just traced. As the arm C' is moved farther in the hoisting direction, the resistances R' and R^2 are gradually removed from the motor circuit until, at the final hoisting position, the armature and field are directly across the line in series with the brake-coil B, the connections c^{21} and c^{22} then being at the left hand end of the resistances R^2 and R' on Fig. 2. If the arm C' be placed on the first lowering position, that is, on the line $k k'$, the circuits will be as shown on Fig. 3, in which the switch S is shown closed. This switch is closed by reason of the following circuit: from the positive through the wires 1 and 2, the winding s' of the switch S, the wire 3, the contacts m^3 of the switch M, the wire 4, the contact c' , the finger c^2 , the connection c^4 , the finger c^5 , the contact c^6 , and the wire 5 to the negative. The current in this circuit energizes the winding s' , which causes the switch S to close. The closing of the switch S completes the motor circuits which are as follows: from the positive through the wire 1, the switch S, the variable resistance R^4 to the point O, where the circuit divides, one path leading through the armature A, the wire 6, the contacts c^7 and c^8 , the finger c^9 , the connection c^{21} , the finger c^{10} , 110

the contact c^{11} , the wire 7, the winding m^2 of the switch M, the wire 8, the contact c^{12} , the finger c^{13} , the connection c^{22} , the finger c^{14} , and the contact c^{15} ; the other path from the point O being through the field F, the brake winding B, and the wire 9 to the contact c^{15} , where it joins the circuit through the armature, the current from both paths continuing through the contact c^{26} , the resistance R', the contact c^{16} , the wire c^{17} , the contact c^{18} , the blow-out B. O., and the wire 5 to the negative. At the time the motor circuit closes, the shunt winding m' of the relay M is energized through current from the circuit through the wires 1 and 10, the winding m' , the wire 4, the contact c' , the fingers c^2 and c^5 , the contact c^6 , and the wire 5 to the negative. The strength of this shunt winding is such that it alone cannot lift the plunger of the relay M. The currents through the windings m' and m^2 are such that the said windings oppose each other.

With the circuits as shown on Fig. 3, the brake winding is energized so as to cause the release of the brake B' and the motor has a tendency to move very slowly because its armature is shunted. As soon as the brake has been released and the motor has been started by current through the circuits described in connection with Fig. 3, the back E. M. F. of the motor will be increased, if the load overhauls the motor, and the current through the armature will be reversed. This reversed current will cause the current in the relay winding m^2 to be reversed, whereupon the effects of the windings m' and m^2 on the plunger of the relay M become additive. When the current in the winding m^2 has risen to a certain point, dependent on the adjustment of the relay, the plunger of the relay M will be lifted, thereby opening the contacts m^3 and the circuit through the winding s' of the switch S, causing the latter to open and cut off the current supplied from the line to the motor circuit. The motor is not at this time left in open circuit, the load still operating to drive the motor as a dynamo generating a dynamic braking current which is traced as follows: from one terminal of the armature A through the field F in the same direction as when electric power was applied to drive the motor, the brake winding B, the wire 9, the contact c^{15} , the fingers c^{14} and c^{13} , the contact c^{12} , the wire 8, the coil m^2 , the wire 7, the contact c^{11} , the fingers c^{10} and c^9 , the contact c^8 , the cross-connection to the contact c^7 , and the wire 6 to the remaining terminal of the armature A. This circuit having no resistance except the windings of the armature, the field, and the brake, is practically a short circuit for the motor, which makes the speed of the motor very slow. If the switch arm C' be further moved in the

lowering direction, the resistances R' and R² will be gradually inserted in the armature circuit, which will allow the load to run the motor at a faster speed. If at any time the speed should be so slow as not to generate enough back E. M. F. to maintain the relay M open, the closing of the latter at the contacts m^3 will again close the circuit through the winding s' , which will cause the switch S to close and permit current to be supplied from the line to drive the load down.

If the load be very light, it might not be sufficient to overhaul the motor, when the master-switch is on the line k k' , but power would be applied through the switch S to drive the motor in the down direction. If the arm C' is advanced farther in the lowering direction, the resistance R' would be diminished and the resistance R² would be inserted in the armature branch of the motor circuit. By proper proportioning of the resistances R' and R², the speed of the motor will be increased as the arm C' is moved in the lowering direction. The resistance R² prevents a heavy surge of current in the armature when the master-switch arm C' is moved quickly in the lowering direction. In order to increase the speed of the motor in driving a light load down by electric power, the resistance R² should be smaller in ohmic value than the resistance R'. If the load is not sufficient at any time to overhaul the motor fast enough to produce a sufficiently strong reversed current through the winding m^2 to open the contacts m^3 , the load will continue to be driven down by the motor. When the load is such as to cause the relay M to open, the transfer from power lowering to dynamic lowering is caused to take place automatically by the relay, and this transfer cannot be controlled by the operator. The relay windings should be adjusted to the desired relation which will cause the transfer on any predetermined current in the armature. When the arm C' is brought nearly to the off-position the circuits through the windings of the switch S and of the relay M are broken and the circuit through the field F passes through the wire 11 to the contact c^{20} and the finger c^{14} , and also through the brake winding B to the contact c^{15} and the finger c^{14} , which is wide enough to contact with both the contacts c^{15} and c^{20} . The finger c^9 bridges the contacts c^8 and c^{19} when the finger c^{14} bridges the contacts c^{15} and c^{20} . Thus, the brake coil is short circuited. A further movement of the arm C' toward the off-position will cause the finger c^{14} to leave the contact c^{15} , when the brake winding will be entirely cut out of circuit. This allows the brake to be set and assists in stopping and holding the load. The dynamic braking circuit still exists and has in it a low resistance, which

assists in stopping the motor during the operation of the magnetic brake B'. The motor circuits for this position are shown on Fig. 4. The contacts c' and c^6 are preferably made so long that the fingers c^2 and c^5 engage therewith before the fingers c^9 and c^{14} leave the contacts c^{19} and c^{20} , thus causing the switch S to close and all the current through both the armature and the field to pass through the brake winding B. This current is traced thus: from the positive through the wire 1, the switch S, the resistance R⁴, the armature A, the wire 6, the contacts c^7 , c^8 , and c^{19} , the fingers c^9 and c^{10} , the contact c^{11} , the wire 7, the winding m^2 , the wire 8, the contact c^{12} , the fingers c^{13} and c^{14} , the contact c^{20} , and the wire 11 to the point O' between the field and brake windings, when it joins the current from the field F, the united current passing through the brake-winding B, the wire 9, the contact c^{15} , the resistance R', the contact c^{16} , the wire c^{17} , the contact c^{18} , and the wire 5 to the negative. This circuit provides sufficient current through the winding B to insure the release of the brake B' even though, on account of poor design, it takes a large current to operate it. It will be noticed that with the switch S closed the current through the field F must always pass through the whole of the resistance R', regardless of the position of the master switch, which keeps the current in the field at a safe value. As the resistance in the armature circuit is varied, the back E. M. F. tends to keep the current in this circuit also to a safe value.

I do not limit my invention to series wound motors or brakes, nor to any definite type of controller, nor to other details and combinations thereof unless required by the prior art or by language in the claims which permits of no other construction.

I claim—

1. In an electric control system, an electric motor, means for connecting the armature and the field winding in parallel paths, a brake winding in the field branch of the parallel paths, a resistance in series with the said parallel paths, and means for removing the said resistance gradually and inserting the same gradually in the path containing the field winding.

2. In an electric control system, an electric motor, means connecting one terminal of the armature to one terminal of the field, a brake winding in the field branch of the parallel paths, means connecting the remaining field terminal to a source of supply, a resistance permanently in series with the field, and means adjustably connecting the remaining armature terminal to the said resistance.

3. In an electric control system, an electric motor, means connecting one field terminal to one armature terminal and to one side of

a source of current supply, means connecting the remaining field terminal to the remaining side of said current supply, a brake winding in the field branch of the parallel paths, a resistance in series with the field, and means connecting the remaining armature terminal to various points on the said resistance.

4. In an electric control system, an electric motor, means connecting one side of the source of supply to a point between the armature and the field, means connecting the remaining terminal of the field in series with a resistance to the other side of the source of supply, means adjustably connecting the other terminal of the armature to the said resistance, and a brake winding in series with the field between the said point and the said other side of the source of supply.

5. In an electric control system, an electric motor, means connecting the field to one terminal of the armature, a resistance connected to the other field terminal, means for connecting the other terminal of the armature to various points on said resistance, another resistance, and means for inserting the latter resistance gradually into the armature circuit.

6. In an electric control system, an electric motor, a resistance adapted to be connected in series with one terminal of the field, means adjustably connecting one armature terminal to the said resistance, means connecting the remaining terminals of the armature and field in parallel branches to a source of current supply, and a brake winding in the field branch.

7. In an electric control system, an electric motor, a resistance adapted to be connected in series with the field, means adjustably connecting one armature terminal to the said resistance, a resistance in the said connecting means, and means for varying the latter resistance.

8. In an electric control system, an electric motor, two variable resistances, means for inserting one resistance in series with the armature and removing the other resistance therefrom in different degrees, one resistance having a different value from the other.

9. In an electric control system, an electric motor, means connecting the armature and field in parallel branches, a switch to connect the parallel branches to a source of supply, and means to automatically open said switch when the armature current reverses.

10. In an electric control system, an electric motor, means connecting the armature and field in parallel branches, a relay having a winding connected in the armature branch, and means governed by said relay to disconnect the parallel branches from the

source of supply when the armature current reaches a certain value on reversal of the armature current.

11. In an electric control system, an electric motor, means connecting the armature to the source of supply to cause the current to flow in a certain direction, and means responsive to the current in the armature for causing the first mentioned means to disconnect the armature from the source of supply when the current in the armature flows in a reverse direction.

12. In a control system for electric hoists, an electric motor, a relay having a shunt winding connected to the source of current supply and a winding connected in series with the armature circuit, the two windings acting differentially when, in lowering a load, the motor takes current from the said source, and cumulatively when the load drives the motor, returning the current to the said source, and means governed by the relay to disconnect the motor from the source of supply when the armature current flows in a direction to return current to the said source.

13. In an electric control system, an electric motor, an operator's switch, a friction brake winding in the motor circuit, means for connecting the motor in a dynamic braking circuit including the brake winding, and means for deenergizing the brake winding without interrupting the continuity of the dynamic braking circuit.

14. In an electric control system, an electric motor, a friction brake winding, an operator's switch, means connecting the motor in a dynamic braking circuit including

the brake winding, and means for short-circuiting the brake winding when the operator's switch is moved to the off-position.

15. In an electric control system, an electric motor, a master controlling switch, means connecting the motor in a dynamic braking circuit, a friction brake winding, and means controlled by the master controlling switch for short circuiting the brake winding.

16. In an electric control system, an electric motor, means connecting the motor in a dynamic braking circuit, a friction brake, and means for first short circuiting the brake winding and then open circuiting the same, still maintaining the motor connected in a dynamic braking circuit.

17. In an electric control system, an electric motor, means connecting the armature and field of the motor in parallel branches, a friction brake winding normally connected in series with one of said branches, and means for causing the current in both of said branches to pass through the brake winding.

18. In an electric control system, an electric motor, means connecting the armature and field in parallel paths, a brake winding in the field branch of the parallel paths, and a resistance adjustably connected to the armature path and fixedly connected to the field path.

Signed at Cleveland, O., this 9th day of March, 1910.

JAMES F. SCHNABEL.

Witnesses:

J. H. HALL,
W. M. DIEMER.