518 ELECTRICITY, MOTIVE POWER SYSTEMS

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H. E. WHITE.

MOTOR CONTROL SYSTEM.

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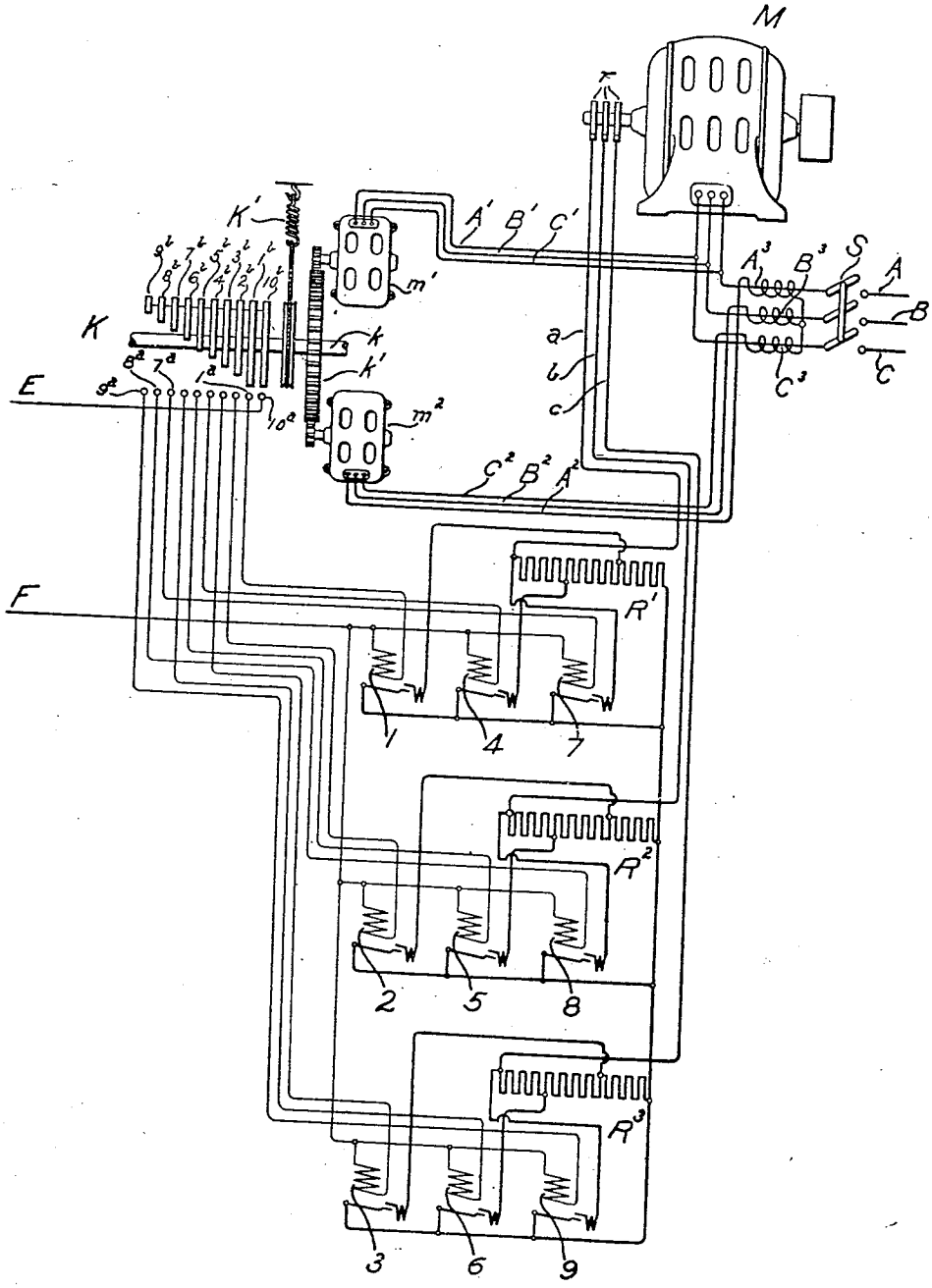

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MOTOR-CONTROL SYSTEM.

No. 839,687. Specification of Letters Patent. Patented Dec. 25, 1906.

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To all whom it may concern:

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

My invention relates to the control of induction-motors; and its object is to provide automatic means for controlling the motor at starting and during operation under varying loads in such manner that the current taken by the motor is at all times limited to a predetermined amount.

In starting induction-motors it has been customary heretofore to connect the resistance in the rotor-circuit in order to limit the starting-current and gradually to cut out this resistance as the motor comes up to speed. In the case of large motors it is desirable that the control should be automatic in order that the cutting out of the resistance may always be at the proper rate and not left to the discretion of the operator, since if the resistance is removed too rapidly an excessive current will flow through the motor, overheating it and ordinarily producing a drop of voltage in the supply-circuit. Furthermore, it is frequently desirable in the case of a motor operating on variable load that if at any time the motor-current exceeds a certain amount the resistance or a portion of it should again be cut into the rotor-circuit. For instance, in the case of a varying load a fly-wheel is sometimes provided to take up a portion of the variation, and so to prevent large fluctuations of current in the driving-motor. In order that the full benefit of the fly-wheel effect may be obtained, it is necessary that the speed shall be somewhat lowered upon an increase in load, so as to permit the fly-wheel to give up a portion of its stored energy. Since an efficient induction-motor is very nearly a constant-speed machine, it opposes the tendency of the fly-wheel to slow down and tries to keep it up to speed. In this way much of the beneficial effect of the fly-wheel is lost and large currents flow to the motor. On the other hand, if with increase of motor-current a portion of the rotor resistance is again inserted in circuit the speed of the motor will fall, so as to allow the fly-wheel to deliver its stored energy to take care of load fluctuations. With such an arrangement the motor may operate with substantially constant current, varying its speed to adjust itself to variations in the load.

The object of my invention is to provide simple and efficient means for automatically controlling the resistance in the motor-circuit at starting, so as to limit the current to a predetermined amount, and also for reinserting a portion of the resistance in the rotor-circuit if the motor-current in operation exceeds a predetermined amount.

My invention consists of the combination, with an induction-motor and a resistance connected in the rotor-circuit, of means for cutting out the resistances when the motor-circuit is closed at starting and means for retarding the cutting out of the resistance and for reinserting it in the rotor-circuit whenever the motor-current rises above a predetermined amount.

More specifically stated, my invention consists of the combination, with an induction-motor and a resistance connected in the rotor-circuit, of electroresponsive means operative upon closing the motor-circuit and tending to cut said resistance out of circuit and opposing means energized with current proportional in amount to the motor-current and tending to cut the resistance into circuit.

My invention will best be understood by reference to the accompanying drawings, which show diagrammatically controlling means for an induction-motor arranged in accordance with my invention.

In the drawings, M represents a three-phase induction-motor supplied from the three-phase mains A, B, and C through the switch S. The rotor is provided with collector-rings *r*, which are connected to the resistances R′, R², and R³. These resistances are controlled by magnetic circuit-closers or contactors, of which nine are shown, (indicated by the reference characters 1 to 9.) The circuits of the operating-coils of these circuit-closers are controlled by a switch K, which is arranged to connect these operating-coils successively to a suitable source of current, indicated by the line-wires E F. The controlling-switch K is rotatably mounted on a shaft *k* and is normally held in off position by a spring K′. The shaft *k* carries a gear-wheel *k′*, which is engaged by

pinions on the rotor-shafts of two small motors m' and m^2. The motor m' is connected by the leads A', B', and C' in shunt with the main motor M, while the motor m^2 is connected by the leads A^2, B^2, and C^2 to the series transformers A^3, B^3, and C^3. The two auxiliary motors m' and m^2 are connected to exert opposing torques upon the gear-wheel k'. The torque of the motor m' depends upon the voltage supplied to the motor M and is consequently substantially constant. The torque of the motor m^2, on the other hand, depends upon the amount of current-flow to the motor M. The two motors m' and m^2 are so proportioned that with normal current flowing to the motor M the motor m' has a greater torque than that of the motor m^2 and spring K' combined.

The operation is then as follows: With the switch S open the circuits of the main motor M and the two auxiliary motors are broken and the controlling-switch K is held in the off position, as shown by the spring K'. All the circuit-closers 1 to 9 are open, and all the resistances R', R^2, and R^3 are included in the motor-circuit of the motor M. When the circuit of the motor M is closed by switch S, the motor starts with all the resistances in the rotor-circuit. Simultaneously the auxiliary motors m' and m^2 are energized, and the motor m', being the stronger, begins to drive the controller K, so as to close successively the circuits of the several circuit-closers, and consequently to cut out step-by-step resistances R', R^2, and R^3. If at any time these resistances are cut out too fast, so as to increase the current flowing to the motor M beyond a predetermined amount, the motor m^2 will become strong enough to overpower the motor m' and prevent further cutting out of resistances or even to cut resistances back into circuit. Unless such an excess of current flows the resistances are entirely cut out and the motor M operates in the usual manner with a short-circuited rotor; but if at any time during operation the motor-current increases beyond a predetermined amount the motor m^2 immediately begins to cut resistance back into the rotor-circuit. This results in decreasing both the speed and current of main motor M, allowing it to take advantage of the inertia of the load and to meet variations in the load torque without drawing excess of current from the supply-current, as has been heretofore explained.

The arrangement shown possesses the additional advantage that if at any time a sudden increase of load should slow the main motor M down beyond the point of maximum torque, so as to bring it to rest, the resistances would immediately be cut back into the motor-circuit, so as to prevent the motor from being damaged by excess of current-flow and also to enable it to start up again immediately under normal load as soon as the excessive load is removed.

While I have shown an arrangement of controlling-switches and operating means therefor which I believe to be particularly advantageous for use with motors of large size, it is obvious that very many modifications may be made in the arrangement. Thus, for instance, the magnetic circuit-closers may be omitted entirely and the resistances controlled directly by the controlling-switch. Other similar changes may be made without departing from the spirit of my invention. Accordingly I do not desire to limit myself to the particular construction and arrangement of parts here shown, but aim in the appended claims to cover all modifications which are within the scope of my invention.

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

1. In combination, an induction-motor, a resistance connected in circuit with the secondary, means for automatically cutting said resistance gradually out of circuit when the primary circuit of said motor is closed, and means for automatically retarding the cutting out of said resistance and reinserting it in the rotor-circuit when the primary current of said motor exceeds a predetermined amount.

2. In combination, an induction-motor, a resistance connected with the secondary winding, a switch adapted by its movement gradually to cut said resistance out of circuit, means for automatically moving said switch when the primary circuit of said motor is closed, and means for automatically retarding said movement and for moving said switch in the opposite direction when the primary current of said motor exceeds a predetermined amount.

3. In combination, an induction-motor, a resistance connected in circuit with the secondary winding, an electroresponsive device supplied with substantially constant current and adapted to cut said resistance out of circuit, and a second electroresponsive device supplied with a current varying in amount with the motor-current and opposing the first device.

4. In combination, an induction-motor, a resistance connected in the secondary circuit of the motor, a controlling-switch adapted by its movement gradually to cut said resistance out of circuit, means for automatically moving said device when the motor-circuit is closed, and an electroresponsive device supplied with current varying in amount with the motor-current and arranged to oppose said movement.

5. In combination, an induction-motor, a resistance connected in the secondary circuit of said motor, a switch adapted to cut said resistance out of circuit, a device connected in shunt with said motor and adapted to

move said switch to cut said resistance out of circuit when the motor-circuit is closed, and an opposing device connected in series with said motor and adapted to move said switch in the opposite direction upon a flow of motor-current in excess of a predetermined amount.

6. In combination, an induction-motor, a resistance connected in the secondary circuit of said motor, a switch adapted to cut said resistance out of circuit, and two opposing devices controlling said switch and connected in shunt and in series respectively with said motor.

7. In combination, a main induction-motor, a resistance connected in the secondary circuit of said motor, a switch adapted to cut said resistance gradually out of circuit, means for holding said switch normally in off position, and two auxiliary controlling-motors mechanically connected to said switch to exert opposing torques thereon and electrically connected in shunt and in series respectively with said main motor.

8. In combination, an induction-motor, a resistance connected in the secondary circuit of said motor, a switch controlling said resistance, and two opposing devices operatively connected to said switch and depending for their operation respectively on the voltage and current supplied to said motor.

9. In combination, an induction-motor, a resistance connected in the secondary of said motor, and a controlling device adapted to cut said resistance out of and into circuit and energized differentially by currents proportional respectively to the voltage and current supplied to said motor.

10. In combination, an induction-motor, a resistance connected in the secondary circuit of said motor, a switch controlling said resistance, and an operating means for said switch energized differentially by currents proportional respectively to the voltage and current supplied in said motor.

In witness whereof I have hereunto set my hand this 6th day of April, 1905.

HAROLD E. WHITE.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.