UNITED STATES PATENT OFFICE.

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MOTOR-CONTROL SYSTEM.


To all whom it may concern:

Be it known that I, HENRY D. JAMES, a citizen of the United States, and a resident of Edgewood Park, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Motor-Control Systems, of which the following is a specification.

My invention relates to motor-control systems and it has particular relation to motors employed to operate skip hoists, especially those that are subjected to variable loads.

One of the objects of my invention is to provide an automatic device which will prevent a skip of a hoist from traveling below a predetermined speed, especially near the end of its journey.

In actual practice, for satisfactory operation it is necessary to operate the skip at a fixed speed near the top and bottom of the hoist in such manner that the track limit switches will stop the skip at the proper point. It is difficult to adjust resistors to compensate for different loads such, for example, as coke, limestone, and iron ore. In order to maintain the motor at a certain speed, when the skip is near the top or bottom of a hoist, with variable loads, an automatic device must be employed to compensate for the loads of different weights.

By means of my invention, it will be possible for the track limit switches to bring the controller to the position for effecting relatively slow operation of a motor, when the skip is near the end of its travel, and, if the speed of the skip falls below a predetermined value, an automatic device will cause the motor to increase its speed.

Briefly speaking, my invention consists in so controlling a contactor for shunting a resistor that is connected in series with the field-magnet winding of a motor, that the contactor will be automatically opened by my device when the speed of the motor falls below a predetermined value and closed upon the speed of the motor becoming greater than this value.

For a better understanding of my invention, reference should be made to the accompanying drawing.

Figure 1 of which is a diagrammatic view of a motor-control system embodying my invention;

Fig. 2 is a schematic view of the motor-control system shown in Fig. 1;

Fig. 3 is a sequence chart of well-known form for the contactors shown in Figs. 1 and 2;

Fig. 4 is a view, partly in elevation and partly in section, of apparatus employed in Fig. 1, and

Fig. 5 is a schematic view of a modified form of control system embodying my invention.

Referring particularly to Figs. 1 and 2, a motor 1, having an armature 2 and a shunt field magnet winding 3 is energized through a circuit comprising knife-blade switch 4 and a circuit-breaker 5. A shunt resistor 6, which is also employed for dynamic breaking, may be electrically connected in parallel relation to the armature 2 of the motor 1 by a contactor 7.

A resistor 9 is connected in series relation with the shunt field-magnet winding 3. A starting resistor 10 is connected in series relation with the armature 2 of the motor 1, and portions of the resistor may be shunted by accelerating contactors 11 and 12.

A master controller 15 governs the operation of the contactors 7, 11 and 12 and of the circuit breaker 5. A speed-control device 16 is mechanically connected to the armature 2 of the motor 1 by a shaft 17 that is provided with a pulley 18 and a belt 19 that is mounted thereon. The device 16 is constructed in accordance with the invention of Stephen A. Staeger, as set forth in a copending application, Serial No. 297,927, filed May 15, 1919, and assigned to the Westinghouse Electric & Manufacturing Company.

The master controller 15 has an “off” position and three operating positions, a, b, and c. The controller 15 may be any well-known type, such as a drum controller.

The device 16 (see Figs. 1 and 4) is operated by a small auxiliary motor 21, which may be energized from any suitable source of energy. The motor 21 drives a shaft 22 on which is mounted a pinion 30. The pin-
ion 23 actuates a bevel-gear member 24, which is rotatably mounted upon the shaft 25. The belt 19 actuates a bevel gear member 26 which is also rotatably mounted upon the shaft 25.

Between the gear members 25 and 26 is a disk member 27, which is likewise rotatably mounted upon the shaft 25. The member 27 has a plurality of pins 28 rotatably mounted thereon by means of pins 29. The pins 28 are engaged and rotated by the bevel-gear members 24 and 26. A metal band or strip 31 surrounds the central member 27 and is maintained in frictional engagement therewith by means of a bolt 32 on which is mounted a resilient member, such as a helical spring 33, a washer 34, and a nut 35. The bolt 32 is slidably mounted in a stationary slotted member or bar 36.

A contact member 37 is rigidly mounted upon the bolt 32 and may be brought into engagement with the stationary contact terminal 38. The belt 19 moves in the direction shown by the arrows when the armature 2 of the motor 1 is operating to raise the skip. This causes the bevel-gear member 26 to rotate in a counter-clockwise direction. The bevel-gear member 24 is actuated in a clockwise direction by the pinion 23 of the motor 21. The speed and direction of the central rotatable member 27 is then determined by the difference in speed of the bevel-gear members 24 and 26.

When the motor is operating above a predetermined speed, the movable contact member 37 engages a stationary contact terminal 38, but if the speed of the armature 2 so decreases that the belt 19 drives the bevel-gear member 26 below the speed of the bevel-gear member 24, the central rotatable member 27 will turn in a clockwise direction until the contact terminal 38 is no longer engaged by the movable contact member 37.

The operation of the motor 1 is begun by closing the knife-blade switch 4 and actuating the controller 15 from its off position to the initial hoist position a. When the master controller 15 occupies position a, a circuit is established from supply conductor 39 through knife-blade switch 4, conductors 40 and 41, track-limit switch 41, contact terminal 42, contact segment 43 of the master controller 15, contact terminals 46, conductor 47, actuating coil 48, conductors 49 and 50, and knife-blade switch 4, to supply conductor 51. When this circuit is established, the actuating coil 48 is energized, thereby closing the circuit-breaker 5.

The actuating coil 48 of the circuit-breaker 5, being thus energized, causes the circuit-breaker 5 to assume its closed position, thereby establishing a circuit from conductor 40 through circuit-breaker 5, armature 2 of the motor 1, and starting resistor 10 to negative conductor 50. A shunt circuit is also established around the armature 2 by a circuit comprising shunt resistor 6 and contactor 7.

When the master controller 15 is actuated to its second position b, a circuit is established from contact segment 43 through contact terminal 53, conductor 54, actuating coil 55 of the contactor 7 and conductors 56 to return conductor 50. The actuating coil 55, being thus energized, causes the contactor 7 to assume its open position.

In addition, when the master controller 15 is in its second position b, contact segment 43 engages contact terminal 60, thereby establishing a circuit comprising the actuating coil of the contactor 11. The actuating coil of the contactor 11, being connected across the armature 2, will be energized in accordance with the counter-electromotive force of the motor 1. When the counter-electromotive force is sufficient to close the contactor 11, a portion of the starting resistor 10 is thereby shunted.

When the master controller 15 is actuated to its third position c, contact segment 43 engages contact terminal 64, thereby establishing the circuit comprising the actuating coil of the accelerating contactor 12. The contactor 12 is subsequently closed by the counter-electromotive force of the motor 1, thereby shunting the entire starting resistor 10. If the master controller 15 has only a single position, such as c, for forward operation, the accelerating contactors 11 and 12 may be adjusted to close in proper sequence, in accordance with a well-known practice.

The motor 1 will now operate at its maximum speed for the load that it is carrying. The skip will ascend at the corresponding speed until it arrives at a point where it operates the track limit switch 41*, which will stop the motor 1 by opening contactors 5, 11 and 12 and closing contactor 7. A dynamic braking circuit is thus formed through the shunt resistor 6 and contactor 7.

It is, of course, apparent to those skilled in the art, that, if the resistor 6 is adjusted to reduce the speed of the motor 1 to a relatively low value with a light load, such, for example, as coke, the motor 1 may come to a stop with a maximum load, such, for example, as iron ore; for a greater portion of the current will then flow through the shunt resistor 6.

If there is no compensating means provided, the skip will stop prematurely, when it is filled with iron ore, or, at least it will travel below a safe and desirable speed. It is to avoid such occurrences that I have devised the present control system.

When the armature 2 travels above a predetermined speed, the contact member 37 engages contact terminal 38, thereby establishing a circuit from conductor 40 through con-
tact terminal 37, contact member 38, resistor 67, actuating coil 68 of the contactor 69, and conductor 70 to conductor 50. When this circuit is established, the actuating coil 68 of contactor 69 is energized, thereby closing the contactor 69 and shunting the field-circuit resistor 9. The speed of the motor 1 will be reduced, since the energization of the field-magnet winding 3 is thus increased.

10 If the armature 2 of the motor 1 travels below a predetermined speed, the bevel-gear member 20 will rotate at a slower speed than the speed of the bevel-gear member 24, thereby causing the central rotatable member 27 to rotate in a clockwise direction and thus separating the contact member 37 from the contact terminal 38. Under this condition, the actuating coil 68 of the contactor 69 is de-energized, thereby allowing the contactor 69 to open.

When the contactor 69 is open, the field-circuit resistor 9 is connected in series relation with the shunt field magnet winding 3, thereby lessening the excitation thereof and thus causing the motor 1 to increase its speed.

In the modification shown in Fig. 5, a contactor 71, corresponding somewhat to the contactor 69, normally shunts a portion of the shunt or dynamic braking resistor 6. When the speed of the motor 1 falls below a predetermined value the contactor 71 opens, thereby inserting more resistance in the shunt circuit around the armature 2 of the motor 1, thus causing a greater current to traverse the armature 2. The motor speed is thereby increased to the desired value.

Directional or reversing contactors for the motor 1 have been purposely omitted because they are well-known in the art. Track limit switches to prevent over-travel of the skip have not been shown in detail for the same reason.

By the employment of my invention, it is possible to operate a skip hoist with greater efficiency than in the past, for the weights of the various loads carried by the skips will not change the speed of the motor. The skip speed will not vary greatly from a predetermined value consistent with safety, until the track limit switches and the automatic brakes (not shown) operate to stop the skip.

While I have shown my invention in a preferred form it is apparent that modifications may be made in the apparatus employed and arrangements of circuits without departing from the spirit thereof. I desire, therefore, to be limited only by the scope of the appended claims.

I claim as my invention:

1. In a motor-control system, the combination with a motor and means for controlling the speed of said motor, and means for effecting dynamic braking of said motor, of automatic means for restoring the speed of said motor upon the speed thereof departing from a predetermined value during electrical braking.

2. In a motor-control system, the combination with a motor and means for normally controlling the speed of said motor, of means for effecting dynamic braking of said motor, and automatic means comprising an auxiliary motor and a differential gear mechanism driven by said auxiliary motor for accelerating said main motor upon the speed of said main motor falling below a predetermined value during dynamic braking of said motor, and for decreasing the motor speed when it increases above a fixed value.

3. In a motor-control system, the combination with a main motor and means for normally controlling the speed of said main motor, of means for effecting electrical braking of said motor, and automatic means comprising an auxiliary motor and a differential gear mechanism driven by said auxiliary motor for accelerating said main motor upon the speed of said main motor falling below a predetermined value during electrical braking.

4. In a motor-control system, the combination with a motor and means for controlling the energization of said motor, of automatic means for effecting electrical braking of said motor, and automatic means for restoring the speed of said motor upon said controlling means being so operated that the speed of said motor departs from a predetermined value during electrical braking.

5. In a motor-control system, the combination with a motor, having an armature and a field magnet winding, and means for controlling the current flow through said armature, of automatic means for effecting dynamic braking of said motor, and automatic means for diminishing the excitation of said field-magnet winding upon the speed of said motor decreasing below a predetermined value during dynamic braking.

6. In a motor-control system, the combination with a main motor having an armature and a field-magnet winding, and means for controlling the current flow through said armature, of means for effecting electrical braking of said motor, an auxiliary motor, a differential gear having the end members thereof, respectively, rotated by said main and said auxiliary motor, and means controlled by said differential gear for, varying the voltage across said field magnet winding upon the speed of said motor changing more than a predetermined value during electrical braking.

7. In a motor-control system, the combination with a main motor having an armature and a field-magnet winding, and a resistor, of a contactor for connecting said resistor in parallel relation to the armature of
said motor, a controller for operating said contactor, a field resistor in series relation with said field-magnet winding, a contactor for shunting said field resistor, an auxiliary motor, a differential gear having the end members thereof, respectively, rotated by said main motor and said auxiliary motor, and means controlled by said differential gear for controlling the operation of said shunting contactor.

8. The combination with a motor, and means comprising a controller having a plurality of positions for normally operating and controlling the speed of said motor, of automatic means adapted to partially compensate for an excessive variation in speed of said motor upon said controller being actuated to an inoperative position.

9. The combination with a motor subject to variable loads, and a controller having an "off" position and an operative position, of an automatic device for maintaining the speed of said motor at a substantially constant value for a period of time after said controller has been actuated to its "off" position, regardless of the variation in weight of said loads.

10. The combination with a motor subject to variable loads during electrical braking, of an automatic device controlled by the speed of said motor for operating said motor at substantially constant speed during electrical braking.

11. The combination with a motor subjected to variable loads and means for effecting dynamic braking of said motor, of an automatic device for increasing the speed of said motor upon said speed falling below a predetermined value during dynamic braking, said means reducing the speed of said motor upon said speed becoming greater than a predetermined value.

12. The combination with a motor subject to variable loads, said motor having a field-magnet winding, of means for varying the excitation of said winding during dynamic braking, and an automatic device comprising a member controlled by the speed of said motor for operating said means to raise or lower the speed of said motor upon said motor varying its speed below or above a predetermined value during dynamic braking.

In testimony whereof, I have hereunto subscribed my name this 22nd day of October 1920.

HENRY D. JAMES.