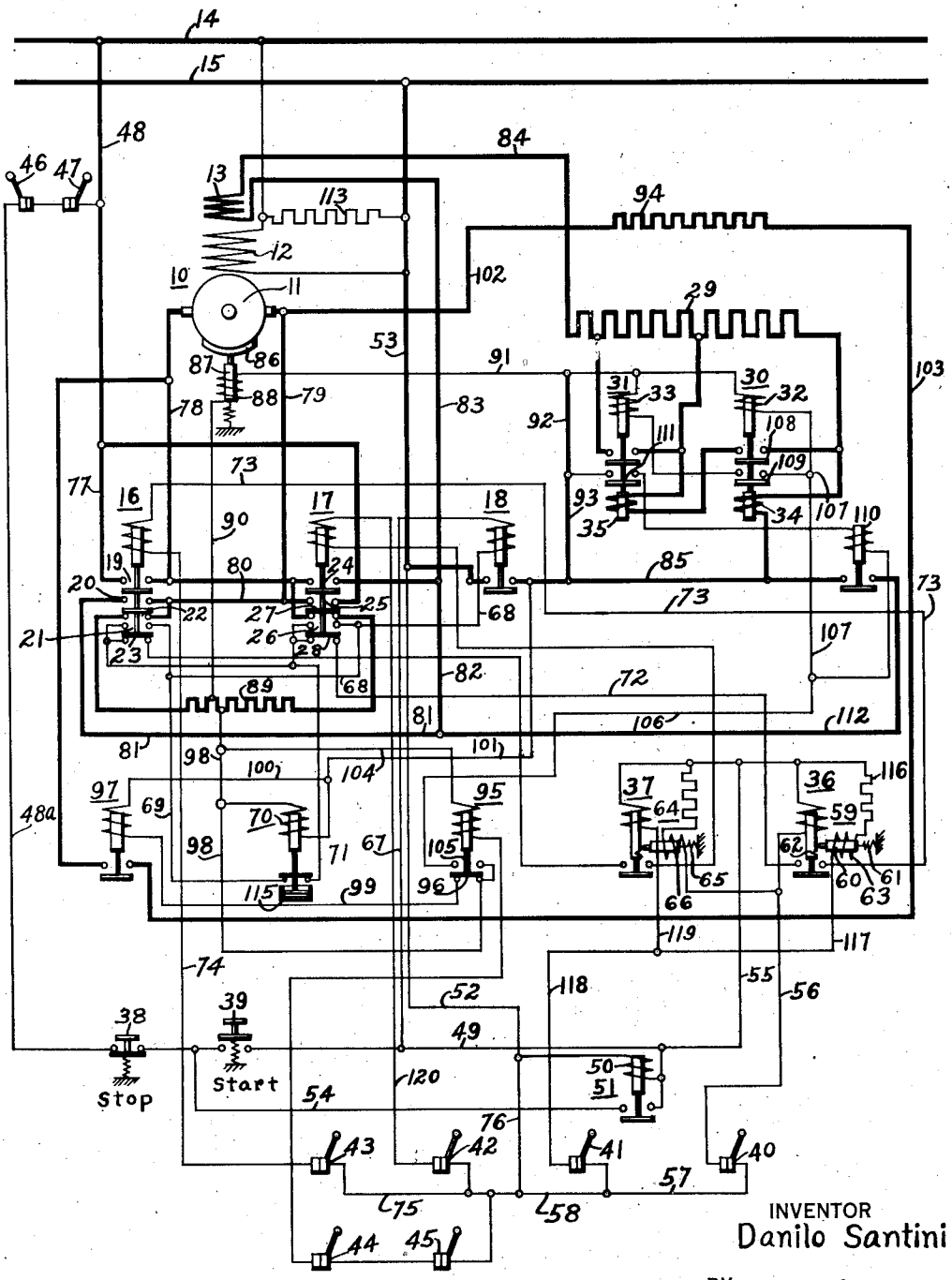
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CONTROL SYSTEM

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INVENTOR
Danilo Santini

BY
ATTORNEY

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DANILO SANTINI, OF EAST PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

CONTROL SYSTEM

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The invention relates generally to control systems and more particularly to control systems for electric motors which may be utilized for operating hoisting apparatus or devices having similar characteristics.

The object of the invention, generally stated, is to provide a control system for hoisting motors which shall be simple and efficient in operation and economical to manufacture and install.

A more specific object of the invention is to provide for controlling the operation of a hoist motor to insure a predetermined movement of the hoist in a selected direction, irrespective of interruptions in power supply or the stopping of the motor.

Other objects will become evident from the following description, taken in conjunction with the accompanying drawing, in which the single figure is a diagrammatic view of a control system embodying the invention.

Referring to the drawing, 10 designates, generally, an electric motor suitable for operating a hoist of the particular kind known as a skip hoist which is not illustrated, since hoists and the means for driving them by motors are well known in the art. In this particular instance, a direct-current motor, having an armature 11, shunt field winding 12, and a series field winding 13, is utilized.

The motor 10 may be operated from any suitable source of direct-current power which may, in this instance, be illustrated by line conductors 14 and 15.

In order to control the direction of operation of the motor 10, a pair of reversing switches 16 and 17 and a line switch 18 are provided. As shown, the reversing switch 16 is provided with a plurality of main contact members 19, 20 and 21 and "back" contact members 22 and 23. Likewise, the other reversing switch 17 is provided with main contact members 24, 25 and 26 and "back" contact members 27 and 28.

The starting current of the motor 10 is controlled, in a well known manner, by means of a series resistor 29 which may be shunted in any desired manner, to increase the motor speed. In this instance, accelerating switches 30 and 31 are provided for this purpose. The accelerating switches 30 and 31 are provided with operating coils 32 and 33, respectively, and also with restraining coils 34 and 35, and are arranged to provide for "current limit" acceleration. Since accelerating systems of this type are well known, it is deemed sufficient to say that the motor current is led through the restraining coils which hold the accelerating switches in their open positions until the motor current decreases to a predetermined value, whereupon the operating coils, being energized, effect the closure of the switches.

It will be readily understood that, in operating hoists of this character, it is desirable to definitely establish and maintain the direction in which the hoist is to operate until a complete cycle has been completed. In apparatus of this character, it is common practice to provide a carriage or skip, for lifting material from one level to another. Generally, in operating hoists, the load is carried only when the carriage is moved upwardly, and no great expenditure of power is required to control it when it is moved downwardly.

If a loaded hoisting carriage or skip is stopped while it is being moved upwardly, as a result of failure of power, then upon the re-establishment of the power supply, it is desirable to be able to effect starting and operation of the motor in the proper direction to continue the upward movement of the carriage; otherwise, the carriage may begin to descend and, if the lifting apparatus is not designed for the lowering of heavy loads, the hoist may be damaged.

Accordingly, in order to accomplish this function, relays controlled in accordance with the position of the skip may be utilized to establish and maintain the proper switch-operating circuits, even though a power failure occurs, and thereby insure that the same motor-control switch will again close with the re-establishment of the power supply.

In this particular embodiment of the invention, relays 36 and 37 are provided for controlling the operating circuits of the reversing switches 16 and 17, respectively, in a manner which will be described in detail

hereinafter. Since the relay 36 controls the operating circuit for the up-reversing switch 16, and the relay 37 controls the operating circuit for the down-reversing switch 17, they will be referred to hereinafter as the "up" relay 36 and "down" relay 37.

The operation of the system may be manually controlled by push-button switches 38 and 39, which will be referred to as "stop" and "start" push buttons, respectively. However, after the system is once set in operation, it is desirable to control the movements of the hoist automatically, which, in this instance, is effected by a plurality of limit switches 40 to 45, inclusive, which are disposed to control the energization of the various switch-operating circuits in response to predetermined movements of the hoist or skip.

The limit switches are shown schematically in the drawing as simple trip-type switches which are well known and which are usually installed along the path of the hoist carriage so that they are actuated when the hoist carriage passes predetermined points. A drum-type limit switch may be used instead of trip-type switches and operated through reduction gearing or a chain drive from the motor, if desired.

The limit switches 40 and 41 are disposed to control the operating circuits for the "up" relay 36 and the "down" relay 37, switch 40 being closed and switch 41 being open when the skip is in the down or loading position. The limit switches 42 and 43 are disposed to control the operation of the reversing switches 16 and 17 and the line switch 18 in response to movements of the skip, switch 43 being closed and switch 42 open when the skip is in the down or loading position. The limit switches 44 and 45 are disposed to control the operation of the motor-accelerating switches 30 and 31, the switch 45 being open and switch 44 being closed, when the skip is in the down position.

In describing the system and its operation, it will be assumed that the skip is in its lowermost position. The circuits established and the switches operated in order to manipulate the skip will be explained in the proper sequence. When the limit switches 40, 43 and 44 are closed, the hoist motor 10 may be set in operation to move the skip upwardly by actuating the "start" push-button switch 39 to its closed position. Current then flows from the line conductor 14 through conductor 48, limit switches 46 and 47, conductor 48*a*, "stop" push-button switch 38, "start" push-button switch 39, conductor 49, operating coil 50 of the switch 51 and conductors 52 and 53 to the line conductor 15.

Upon the closure of the switch 51, a holding circuit is established comprising conductors 54, contact members of the switch 51 and coil 50 which bridges the start push-button switch 39 and maintains the switch 51 in its closed position. Upon the closure of switch 51, an operating circuit for the "up" relay 36 is established which extends from the energized conductor 48*a*, through "stop" push-button switch 38, conductor 54, contact members of the relay 51, conductor 55, operating coil of the "up" relay 36, conductor 56, limit switch 40 and conductors 57, 58, 76, 52 and 53 to the line conductor 15.

It will be observed that the "up" relay 36 is provided with a latching device 59 comprising a plunger 60 and an actuating spring 61 which is disposed to actuate the plunger 60 into a latching position which, as shown, engages in the slot 62 in the armature of the relay 36, when in its closed position. The latching device 59 is also provided with a releasing coil 63 which, when energized, unlatches the plunger of the switch 36 permitting it to drop to the open position, when its operating coil is deenergized. Likewise, the "down" relay 37 is provided with a latching device 64 having an actuating spring 65 and releasing coil 66.

It will be observed that, when the operating coil of the "up" relay 36 was energized, an energizing circuit for the releasing coil 66 of the latching device 64 was established which caused the releasing of the armature member of the down relay 37, permitting it to fall to the open position. Therefore, it will be readily understood that, since the relay 36 controls the operating circuit of the "up" reversing switch 16 and is securely latched in the closed position when the hoist is being moved upwardly, then the operating circuit will not be interrupted upon the failure of power until the skip reaches its uppermost position where the proper limit switches are operated to effect the downward movement of the skip.

Upon the closure of the "up" relay 36, an operating circuit for the "up" reversing switch 16 and line switch 18 is established, which may be traced from the energized conductor 48*a*, through push-button switch 38, conductor 54, the contact members of the relay 51, conductors 49 and 67, the operating coil of the line switch 18, conductors 68 and 69, contacts of relay 70, conductor 71, back contact member 28 of the reversing switch 17, conductor 72, the contact members of the "up" relay 36, conductor 73, the operating coil of the "up" reversing switch 16, conductor 74, limit switch 43, which is closed, conductors 75, 76, 52 and 53 to the line conductor 15.

Upon the closure of the "up" reversing switch 16 and the line switch 18, an energizing circuit for the hoist motor 10 is established which may be traced from the line conductor 14 through conductors 48 and 77, contact members 19 of the switch 16, conductor 78, armature 11, conductors 79 and 80, con-

tact members 20 of switch 16, conductors 81, 82 and 83, series field winding 13, conductor 84, starting resistor 29, restraining coil 34 of the accelerating switch 30, conductor 85, contact members of the line switch 18 and conductor 53 to the line conductor 15.

In accordance with common practice in installations of this kind, a spring-pressed brake shoe 86 is utilized to stop the motor when the motor circuit is open. For the purpose of illustration, the brake shoe 86 is shown engaging the armature 11 of the motor 10 although it is to be understood that, actually, a separate brake wheel is provided on the motor shaft for this purpose. In order to withdraw the brake shoe 86 from the engaging or braking position when the motor is started, an electromagnet, disposed to be energized upon the closure of the motor circuit, is provided.

As shown, the electromagnet comprises an iron core 87 connected to the brake shoe 86 and disposed to be actuated by a coil 88.

In this particular embodiment of the invention, the motor is provided with a dynamic-braking resistor 89 which is shunted directly across the armature 11 when the reversing switches 16 and 17 are both in their "open" positions, the dynamic-braking circuit being established through the back-contact members 22 and 27 of the reversing switches 16 and 17, respectively.

It will be readily understood that, as only one of the reversing switches is closed at any one time, energizing current may be obtained for the brake-actuating coil 88 by connecting it to the dynamic-braking resistor 89. When the reversing switch 17 is in the open position, current flows from the line conductor 14 through conductors 48 and 77, the contact members 19 of the "up" reversing switch 16, the back contact members 27 of the "down" reversing switch 17, dynamic-braking resistor 89, conductor 90, brake-actuating coil 88, conductors 91, 92 and 93, line switch 18 and conductor 53 to the line conductor 15. Therefore, when the motor circuit is closed by means of the "up" reversing switch 16, the coil 88 is energized and the brake shoe 86 is withdrawn. Likewise, when the "down" reversing switch 17 is closed, a brake-actuating circuit is established through the back contact members 22 of the "up" reversing switch 16.

In order to provide for reducing the speed of the motor before dynamic braking begins, a slow-down resistor 94 is provided which is also connected in shunt relation to the armature 11 during the acceleration or deceleration of the motor.

In order to control the connection of the slow-down resistor 94, a transfer switch 95 is provided. As shown, the actuating coil of the transfer switch 95 is connected in series with the limit switches 44 and 45 and, as described hereinbefore, the limit switch 44 is closed and limit switch 45 is open when the skip is in the down position. Therefore, the transfer switch 95 is deenergized and the lower contact members 96 are bridged, thereby establishing an actuating circuit for the slow-down switch 97 which may be traced from the dynamic-braking resistor 89 which is connected to the line conductor 14, through the back contact members 27 of the switch 17, conductor 98, contact member 96 of the transfer switch 95, conductor 99, operating coil of the slow-down switch 97, conductors 100 and 101, line switch 18, and conductor 53, to the line conductor 15. The closure of the switch 97 connects the slow-down resistor 94 in shunt relation to the motor armature 11, through a circuit extending from one side of the armature 11, conductor 102, resistor 94, conductor 103, contact members of the switch 97 to the other armature terminal.

The motor 10, therefore, operates to move the skip upwardly and, since it is desirable to accelerate the motor to full speed as quickly as possible, the limit switch 45 is disposed to be closed after the skip has been raised a predetermined distance in the upward direction. Upon the closure of the limit switch 45, an energizing circuit for the transfer switch 95 is established, which may be traced from the energized dynamic-braking resistor 89, conductor 104, the operating coil of the transfer switch 95, limit switches 44 and 45 and conductors 76, 52 and 53, to the line conductor 15. The transfer switch 95, is accordingly, actuated to its "up" position to bridge contact members 105 and thereby interrupt the energizing circuit for the slow-down switch 97 which opens its contact members to disconnect the slow-down resistor 94 from the motor armature.

Simultaneously with the operation of the slow-down switch 97, an energizing circuit for the accelerating switch 30 is established by the bridging of the contact members 105 of the transfer switch 95. This circuit may be traced from the energized dynamic-braking resistor 89, through conductor 98, contact members 105, conductors 106 and 107, the actuating coil 32 of the accelerating switch 30, conductors 92 and 93 and line switch 18, to the line conductor 15.

Since the starting current of the motor is flowing through the restraining coil 34 of the accelerating switch 30, it is maintained in the open position until such time as the motor current decreases to a predetermined value. Upon the closure of the accelerating switch 30, the first section of the resistor 29 is shunted through a circuit comprising contact members 108 of the accelerating switch 30 and the restraining coil 35 of the accelerating switch 31. Simultaneously, an energizing circuit for the actuating coil 33 of the accelerating coil 31 is established from the

conductor 107, through contact members 109 of the accelerating switch 30, coil 33, conductors 92 and 93 and the line switch 18, to the line conductor 15. After the motor current again decreases to a predetermined minimum value, the second section of the resistor 29 is shunted by the closure of the accelerating switch 31.

In order to operate the motor 10 at a maximum rate of speed, provision is made for shunting the series field winding 13, in which event, the motor operates as a shunt motor. In order to provide for shunting the series field winding 13, a switch 110 is provided. As shown, the accelerating switch 31 is provided with contact members 111 which, upon the closure of the switch 31, establishes an energizing circuit for the switch 110. Upon the closure of the switch 110, a shunting circuit is established around the series field winding 13 which may be traced from the junction point of the line conductors 81 and 82, through conductor 112, the contact members of the switch 110 and conductor 85, directly to the line switch 18. As will be observed, this shunt circuit also completely shunts the starting resistor 29. The speed of the motor 10 is, therefore, entirely dependent upon the strength of the shunt field winding 12 which, as shown, is connected, directly across the line conductors 14 and 15, in shunt relation to a resistor 113 which may be utilized to control the excitation current flowing in the field winding.

Since it is desirable to reduce the speed of the skip as it nears the limits of its upward travel, the limit switch 44, which is now closed, is disposed to open at approximately the same distance from the upper limit of the travel of the skip as the limit switch 45 was closed from the beginning of its travel.

In this instance, the transfer switch 95 is deenergized, which, as described hereinbefore, establishes an energizing circuit for the slow-down switch 97, and the slow-down resistor 94 is again connected in shunt relation to the armature 11 which reduces the speed of the motor prior to the establishment of the dynamic-braking circuit. When the skip reaches the limit of its upward travel, the limit switch 43 is opened, thereby deenergizing the operating circuit for the "up" reversing switch 16 and the line switch 18. Upon the opening of the contact members 19 of the reversing switch 16, the operating circuit for the brake coil 88 is interrupted, which permits the brake to close. Simultaneously with the brake-closing operation, dynamic braking of the motor 10 is effected since the back contact member 22 of the reversing switch 16 is now closed, to establish the dynamic-braking circuit hereinbefore described.

In operating hoists of this character, it is necessary to provide sufficient time delay after the skip reaches the limit of its upward travel to provide sufficient time for an unloading operation.

When the skip is in its uppermost position, the limit switch 42 is closed and the limit switch 43 is opened. The closure of the limit switch 42 establishes an energizing circuit for the down-reversing switch 17 and line switch 18 which depends, for its complete establishment, upon the down relay 37 and the switch 70, which are in their closed positions.

In this instance, the switch 70 is provided with a dash pot 115 in order to ensure a time delay in its closing operation and, therefore, the switch 70 is utilized to control the energizing circuit for the reversing switch 17 and the line switch 18 after the down relay 37 has been actuated to its closed position.

Since the limit switch 40 was maintained in a closed position until the skip reached its uppermost position, the "up" relay 36 is held in its closed position both magnetically and mechanically. The limit switch 41, being open until the skip reaches its uppermost position, the operating coil 63 of the latching device 59 is deenergized, which causes the latching device 59 to securely hold the "up" relay 36 closed, even though a power failure occurred which would deenergize its actuating coil. The limit switch 40, being opened at this time, deenergizes the operating coil of the "up" relay 36 which cannot open until the latching device 59 has been actuated. The closing of the limit switch 41, which starts the skip in a downward direction, energizes the actuating coil 63 of the locking device 59 through a circuit extending from the energized conductor 48, through push-button switch 38, conductor 54, switch 51, conductor 55, resistor 116, coil 63, conductors 117 and 118, limit switch 41, conductors 58, 76, 52 and 53, to the line conductor 15. An energizing circuit for the "down" relay 37 is also established to extend from the energized conductor 118, through conductor 119, operating coil of the relay 37, to the energized conductor 55.

As described hereinbefore, the relay 70 was in its closed position when the starting push-button switch was actuated. However, upon the closure of the reversing switch 16 and the line switch 18, the operating coil of the relay 70 was energized through a circuit extending from the line conductor 14, through conductors 48 and 77, contact member 19, back contact members 27, resistor 89, conductor 98, operating coil of the switch 70, conductor 101, line switch 18 and conductor 53, to the line conductor 15. The switch 70 is, therefore, actuated to its open position and, since the contact members 21 of the reversing switch 16 are bridged, the energizing circuit for the reversing switch 16 and the line switch 18 is maintained which would otherwise have been interrupted by the opening of the switch 70.

It will be readily understood that, so long as the motor is energized, the switch 70 will be maintained in its open position and, since its initial closure is necessary in order to establish an energizing circuit for either of the reversing switches 16 and 17, the energizing circuit for the reversing switch 17 which connects the motor 10 to operate in a direction to lower the skip cannot be established until the time-delay switch 70 closes after it has been deenergized by the opening of the reversing switch 16. Since the dash pot 115 may be regulated to give any desired time element, the final establishment of the energizing circuit for the "down" reversing switch 17 and line switch 18 may be delayed to provide sufficient time for unloading the skip.

With the "down" relay 37 in the closed position and securely locked by the locking mechanism 64, the closure of the time-delay relay 70 establishes an energizing circuit for the reversing switch 17 and the line switch 18 which may be traced from the line conductor 15, through conductors 53, 52 and 76, limit switch 42, conductor 120, operating coil of the switch 17, contact members of the "down" relay 37, the back contact members 23 of the switch 16, contact members of the time-delay switch 70, conductors 69 and 68, the operating coil of the line switch 18, conductors 67 and 49, switch 51, conductor 54 and push-button switch 38, to the energized conductor 48.

Since the skip stands in its uppermost position, the limit switch 44 is open and, consequently, the transfer switch 95 is in the down position, bridging contact members 96 and thereby establishing an operating circuit for the slow-down switch 97 which, as described hereinbefore, connects the slow-down resistor 94 in shunt relation to the armature 11. After a predetermined movement of the skip downwardly, limit switch 44 closes to energize the operating coil of the transfer switch 95, which, upon its operation, initiates the acceleration of the motor, as described hereinbefore in detail.

It will be readily understood that the skip continues to move in the downward direction until it reaches its lowermost position, in which event, the limit switches 41 and 42, which are now closed, are actuated to their open positions, and the limit switches 40 and 43, which are now open, are actuated to their closed positions, and their simultaneous operation effects the slowing down and stopping of the skip and the starting of it in the upward direction again, which movement is initiated only upon the operation of the time-delay relay 70.

As has been pointed out hereinbefore, a dominant feature of this control system is the provision of means for maintaining the initially established control circuits to insure that the initially closed switches, which may be opened because of power failure, will automatically be closed in response to the return of the power. It will be apparent that this important function is performed by the utilization of the up relay 36 and down relay 37, the operation of which, in connection with the directional controlling switches, has been described in detail in the preceding paragraphs.

Since certain changes may be made in the above construction, and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that all the matter contained in the above description and shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In a control system for hoists, in combination, a hoist motor, electro-magnetically-operated switches for establishing motor circuits to operate the motor in either direction, limit switches for reversing the motor, and means for locking the electro-magnetically-operated switches, said locking means being disposed to be operated only in response to the operation of a limit switch.

2. In a control system, in combination, an electric motor, means for establishing motor circuits to operate the motor in either direction, limit switches for effecting the reversing of the motor connections to reverse the operation of the motor, means for delaying the completion of the reversing connections for a predetermined period after the operation of the limit switch, and means for re-establishing a selected motor circuit if the motor is stopped before the next reversing limit switch is operated.

3. In a control system for hoists, in combination, a hoist motor, a plurality of electromagnetic switches for establishing circuits to operate the motor in either direction, a plurality of limit switches and auxiliary switches provided with electrically-controlled latching devices for controlling the operation of the electromagnetic-motor-circuit switches, and other limit switches for effecting the operation of the auxiliary switches and their respective latching devices to insure the re-establishing of a selected motor circuit in case the motor is stopped before a reversing limit switch is operated.

4. In a motor-control system, in combination, a motor for operating a skip hoist, reversing switches for the motor, limit switches disposed to be operated in accordance with the movements of the skip for controlling the operation of said reversing switches, auxiliary switches disposed to co-operate in the control of the reversing switches, electrically-controlled locking-means for said auxiliary switches, and means for controlling the locking means in accordance with the position of the skip, thereby to maintain the prop-

er auxiliary switch effective, regardless of power failure, until the skip is actuated to predetermined positions.

5. In a motor-control system, in combination, a motor for actuating a skip hoist, a source of power, reversing switches and a line switch for connecting the motor to the power source, circuits for controlling said switches, limit switches disposed to be actuated in accordance with the position of the skip for controlling the switch-actuating circuits, a directional-controlling switch for each switch-actuating circuit, spring-biased-locking devices for each directional-controlling switch, said devices being provided with releasing coils, and limit switches for controlling the energization of said directional-controlling switches and the releasing coils of the locking devices, thereby to prevent the release of either locking device until its respective limit switch has been actuated by the movement of the skip to predetermined positions.

6. In a control system for a skip hoist, in combination, a motor for actuating a skip hoist, a source of power for the motor, reversing switches for connecting the motor to the power source, manual control means for stopping and starting the motor when the skip is in any position, limit switches for controlling the operation of the reversing switches, a directional switch cooperative with each limit switch for further controlling the operation of the reversing switches, spring-biased latching means disposed to hold the directional switches in the closed position, said latching means being provided with releasing coils, and other limit switches for controlling the operation of the directional switches and the latching means, said other limit switches being disposed to alternately close and release the directional switches at the end of the skip travel in either direction.

7. In a control system for hoist motors, in combination, a motor for actuating a skip hoist, a source of power, reversing switches for connecting the motor to the power source, starting and slow-down resistors for the motor, bridging switches for the starting resistor, a switch disposed to connect the slow-down resistor across the motor armature, a transfer switch for controlling said bridging switches and the switch for connecting the slow-down resistor, limit switches for controlling the operation of the reversing switches, other limit switches for controlling the operation of the transfer switch to alternately disconnect the slow-down resistor and bridge the starting resistor, and means disposed to cooperate with said limit switches for controlling the reversing switches to cause said switches to reestablish a preselected motor circuit if the motor circuit is interrupted prior to the operation of any limit switch.

8. In a control system for hoists, in combination, a motor for actuating the hoist, a source of power for the motor, reversing switches for connecting the motor to the power source to cause the hoist to be actuated in upward and downward directions, a plurality of limit switches disposed to be operated by the movements of the hoist, certain of said limit switches being disposed to control the operation of the reversing switches, and means responsive only to other of said limit switches disposed to cooperate with said first limit switches in controlling the reversing switches, said means being effective to cause the initially-operated reversing switch to reclose in the event that the motor has been disconnected from the power source before the hoist has completed its travel in either direction.

9. In a control system for hoists, in combination, a hoist motor, reversing switches for establishing motor circuits to operate the motor in either direction, limit switches for controlling the energization of the reversing switches to effect a reversal of the motor at the end of the hoist travel in either direction, and means disposed to cooperate with said limit switches in controlling the energization of the reversing switches to insure the reclosure of the initially closed reversing switch in the event that the initially-established energizing circuit for the hoist motor is interrupted before the hoist has completed its downward or upward travel.

In testimony whereof, I have hereunto subscribed my name this first day of May, 1928.

DANILO SANTINI.