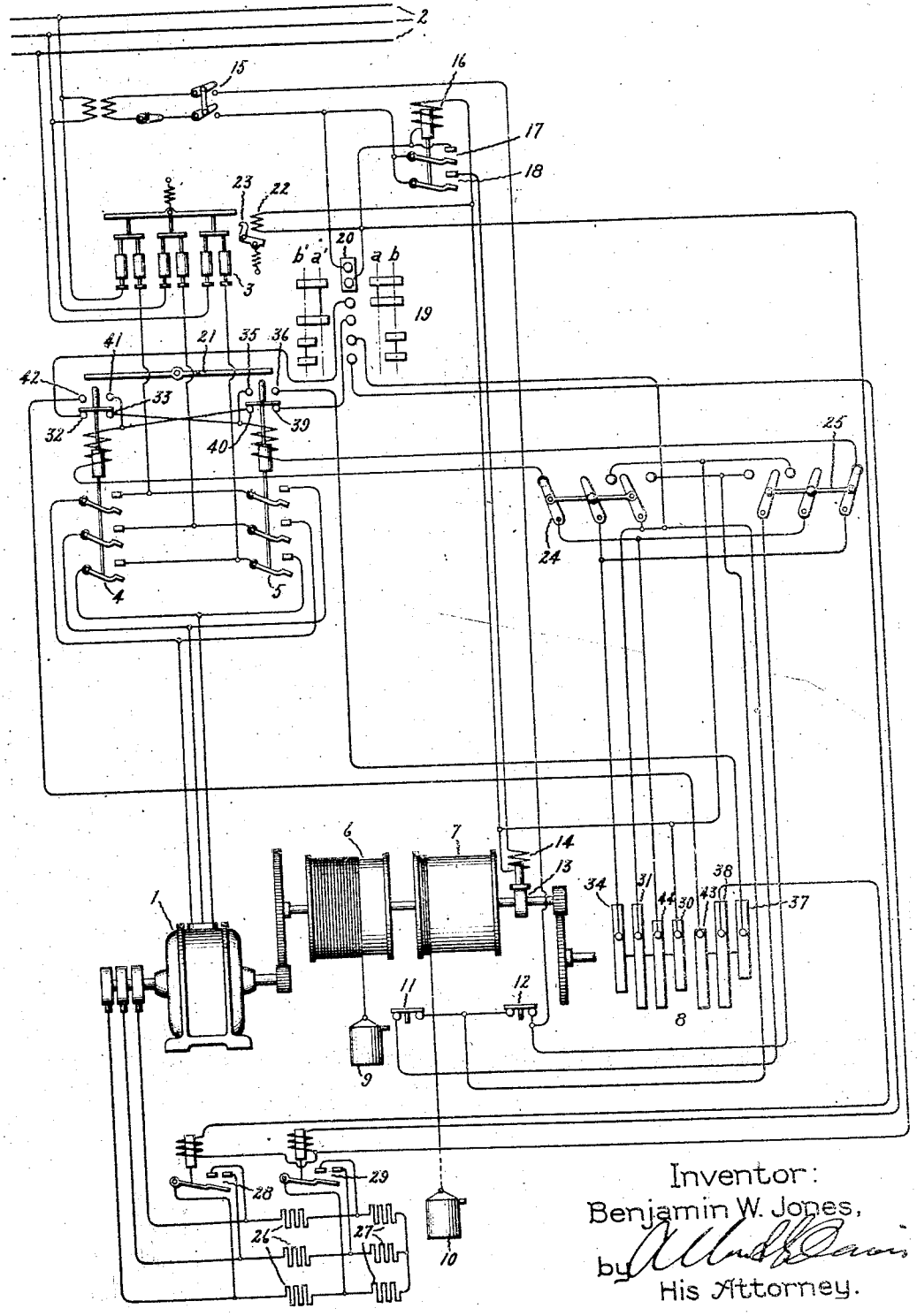
B. W. JONES.

SYSTEM OF CONTROL FOR ELECTRIC MOTORS.

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by
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UNITED STATES PATENT OFFICE.

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SYSTEM OF CONTROL FOR ELECTRIC MOTORS.

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To all whom it may concern:

Be it known that I, BENJAMIN W. JONES, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented a certain new and useful System of Control for Electric Motors, of which the following is a specification.

My invention relates to the control of hoists and the like, and has for its object the provision of means whereby the hoist may be started, stopped and generally controlled in a safe and effective manner.

My invention is particularly applicable to the control of an electric motor which drives a load, such as a hoist, in two directions, and it provides means for manually and automatically controlling the motor so that accidents due to over-travel may be avoided.

It is customary to provide some means such as limit switches which will automatically deënergize the electric driving motor and apply a brake to bring the hoist to rest when the hoist passes one of its predetermined limits of travel.

In the case of hoists and especially of the larger sizes it is customary to provide a circuit breaking switch which cuts off the motor from the line when either limit switch is operated. It is also desirable to slow down the hoist before it reaches a limit switch so as to reduce the over travel and make the point at which the hoist will stop more certain. One of the objects of my invention is to provide means whereby after the hoist has been slowed down, the limit switch cuts off the power from the motor and applies the brake to the hoist, thereby taking the control away from the controller. In order to regain control, the operator must operate a separate switch which permits the hoist to be returned but not moved forward. When the hoist has been returned past the point at which the limit switch operated, that is, when it is returned within the normal limits of travel, full control for both directions of travel is restored.

In one form of my invention, I employ two limiting devices, one a limit switch directly geared to the motor through the hoisting drums, hereinafter called a geared limit switch, and another set of limit switches in the path of travel of the hoisting buckets, hereinafter called track limit switches. Manually operated switches in the control circuit coöperate with the master controller, the motor reversing switches, the electro-magnetically actuated brake for the hoist, the geared limit switch and the track limit switches to protect the workmen and the hoist from dangers which would be present if full control of the motor by means of the controller could be had when the hoist was past either one of its limits. I also provide means for retarding the speed of the hoisting motor by automatically inserting a controlling resistance in the motor circuit before the limit of travel has been reached, with the further provision that the control of this resistance is restored to the master controller when it is desired to return the hoist to the safe limits of travel.

Referring to the drawing, the single figure of which shows one embodiment of my invention, the polyphase induction motor 1 is connected to the supply circuit 2, through the oil switch 3 and through either one of the electromagnetically actuated reversing switches 4 or 5 depending upon the direction of travel of the hoist desired. The motor 1 is directly geared to the hoisting drums 6 and 7 of a balanced hoist which I have shown for purpose of illustration, and directly geared to the hoisting drums is the geared limit switch 8. This geared limit switch has two sets of contact segments, the segments of each set being electrically connected together but the two sets insulated from each other. The hoisting drum 6 has connected to it by means of a cable a bucket 9, and the drum 7 has a hoisting bucket 10 connected to it in a similar manner; the arrangement being such that when the bucket 9 is being raised the bucket 10 is being simultaneously lowered, and vice versa.

In the path of travel of the bucket 9 is a track limit switch 11 and in the path of travel of the bucket 10 is a track limit switch 12, provided as additional protective devices in case the geared limit switch 8 should fail to operate. Associated with the hoisting drums is an electromagnetically actuated friction brake 13 which exerts a holding friction on the drum shaft when for any reason the electromagnet 14 is deënergized. The control circuit receives current through a potential transformer having its secondary

circuit controlled by a hand operated switch 15. The no-voltage relay 16 has two switch members 17 and 18 which open the circuit to all the controlling devices in case the current should fail or the hoist run past one of its limits of travel. The reversible master controller 19 has two operative positions for each direction of rotation and also has a contact segment 20 at its neutral or "off" position. Each of the reversing switches 4 and 5 has mechanically connected thereto an electrical interlock which is adapted to close a circuit through one set of contacts when its respective reversing switch is in the open position, and through another set of contacts when in the closed position. Associated with these reversing switches is a pivoted mechanical interlock 21 which mechanically prevents both switches being closed at the same time. The no-voltage release magnet 22 has in operative relation thereto a biased pivoted detent 23 which maintains the oil switch 3 in a closed position against its bias to the open position when the magnet 22 is energized. The triple pole double throw protective switches 24 and 25 are connected in the control circuits for a purpose to be hereinafter fully disclosed. The means for varying the speed of the motor comprise resistances 26 and 27 connected in the rotor circuit and controlled by electromagnetically actuated switches 28 and 29. The no-voltage relay 16, and no-voltage release magnet 22 are in multiple so that in case of failure of current or in case one of the supply circuits to these magnets is opened, the switches 17 and 18 are opened, the oil switch 3 is opened and the reversing switch 4 or 5 which had been closed is opened. The opening of the switch 18 deenergizes the brake coil 14 and the brake 13 exerts a braking pressure on the drum shaft to stop the hoist. The switch members 17 and 18, oil switch 3, reversing switch 4 or 5 and the resistance controlling switches 28 and 29 will all be automatically opened in case the hoist runs past one of its predetermined limits.

The operation of my device is as follows:—

As shown in the drawing, the control circuits and the motor are deënergized. Closing the switch 15 energizes the no-voltage relay magnet 16, the circuit being through the segment 20 of the master controller, the magnet coil 16, the segments 30 and 31 of the geared limit switch 8, through the track limit switches 11 and 12 to the other side of the control circuit. Since the no-voltage release magnet 22 is in multiple with the magnet coil 16, it is likewise energized through the same circuit. Energization of the magnet 16 causes switch members 17 and 18 to close, the switch member 17 closing a maintaining circuit for the magnet 16 and the no-voltage release magnet 22, so that the master controller 19 may be moved from the "off" position and these magnets remain energized. The switch 18 in closing put the brake coil 14 in multiple with the no-voltage relay 16 and the no-voltage release magnet 22, energizing the brake coil and releasing the brake 13. The oil switch 3 can now be closed as it will be maintained closed by the pivoted detent 23.

Assume that the operator now desires to lower the bucket 9 and raise the bucket 10. The switch 15, the switches 17 and 18, and the oil switch being closed, he would turn the master controller 19 to the first operative position *a*, making an energizing circuit for the coil of the reversing switch 5 through the switch 17, the master controller 19, the lower interlock contacts 32 and 33 of reversing switch 4, coil of reversing switch 5, through the right blade of switch 25, contacts 34 and 31 of the geared limit switch 8 and the track limit switches 11 and 12 to the other side of the control circuit. This will close the motor circuit through the resistances 26 and 27 and the motor would now run at a low speed due to the resistances in its rotor circuit. In order to cause the motor to run at full speed, the master controller is moved to its second operative position *b*, completing an energizing circuit for the coil of resistance controlling switch 28, through the switch 17, upper contacts of the master controller, upper interlock contacts 35 and 36 of reversing switch 5, segments 37 and 38 of geared limit switch 8, coil of switch 28, lower contacts of master controller, and the track limit switches 11 and 12 to the other side of the control circuit. The coil of switch 29 is also at the same time energized through the switch member 17, coil of switch 29, lower segments of master controller 19, through track limit switches 11 and 12 to the other side of the control circuit. Upon the closing of switches 28 and 29, the resistances 26 and 27 are short circuited and the motor runs at full speed.

If the operator should now desire to reverse the motor while the hoist is still within its predetermined limits of travel he would turn the master controller to the "off" position, deënergizing the reversing switch 5 and opening the motor circuit. By turning the master controller to the first position *a'* to the right he would energize the coil of the reversing switch 4 through the lower interlock contacts 39 and 40 of reversing switch 5, the coil of reversing switch 4, left blade of switch 24, segments 44 and 31, through the track limit switches 11 and 12 to the other side of the control circuit. The motor may then be brought to full speed by moving the controller to the second position *b'* energizing and closing the resistance short

circuiting switches 28 and 29. The circuit for the coil of switch 28 is through the switch 17, upper contacts of the master controller 19, lower interlock contacts 39 and 40 of reversing switch 5, upper interlock contacts 41 and 42 of reversing switch 4, segments 43 and 38 of the geared limit switch, lower contacts of the master controller and track limit switches 11 and 12 to the other side of the control circuit. The circuit for coil of switch 29 is the same as for the other direction of rotation, except for the changes caused by the movement of the master controller to the right.

If the operator should now continue operating the motor 1 to raise bucket 9 and lower the bucket 10, shortly before he reached the limit of travel the segment 43 would separate from its corresponding contact, deënergizing the coil of resistance controlling switch 28, inserting the resistance 26 in the rotor circuit of the motor, decreasing the motor speed. If the motor should continue to operate the hoist in this same direction, the bucket 9 will reach its upper limit of travel, deënergizing the control circuits at the track limit switch 11 and also at the segments 30 and 44 of the geared limit switch 8. This will deënergize no-voltage relay 16, the no-voltage release magnet 22, the coil of reversing switch 4, the coil 14 of the brake 13 and the coil of resistance controlling switch 29. The corresponding switches will open, deënergizing the motor and the control circuits, the brake will be applied to bring the hoist to rest and the resistance 27 will also be included in the rotor circuit of the motor.

Because of the inertia of the moving parts the hoist necessarily runs a certain distance beyond the limits determined by the limit switches and it is necessary to provide some means by which the operator may safely return the hoist to its proper limits of travel. If the master controller 19 is moved to the "off" position, the no-voltage relay 16 will not be energized as was the case when the hoist was operating within its proper limits of travel, since the circuit for this relay is open at the contact 30 of the geared limit switch and the track limit switch 11. Neither can the no-voltage release magnet 22 and the brake magnet 14 be energized because they are controlled by the switch members 17 and 18 of the no-voltage relay 16. The operator is in this way prevented from energizing the motor to run in either direction, and he can only energize the motor to return by throwing the switch 24 to the right. The no-voltage relay 16 may be energized if the master controller 19 is in the "off" position, the circuit being through the contact 20 of the master controller, the coil 16, the middle blade of the switch 24, segments 34 and 31 of the geared limit switch, the right blade of switch 24, track limit switch 12 to the other side of the control circuit. The switches 17 and 18 are thus caused to close energizing the no-voltage release magnet 22 and the brake coil 14, releasing the brake 13. From this it can be seen that by moving the switch 24 to the right position the track limit switch 11 has been short circuited and the geared limit switch 8 has been rendered ineffective to deënergize the motor when the bucket 9 is beyond its upper limit of travel, and the control of the motor is independent of the limit switch 11 and that part of the geared limit switch 8 which protects the hoist when raising the bucket 9. By moving the master controller 19 to the first position to the right the coil of reversing switch 5 may be energized, this time through the right blade of switch 25, segments 34 and 31 of the geared limit switch 8, the right blade of switch 24, the track limit switch 12 to the other side of the control circuit. The resistances 26 and 27 in the rotor circuit are short circuited when the master controller 29 is moved to the second position in the same manner as previously explained.

The operator may continue to lower the bucket 9, and raise the bucket 10, but he cannot reverse the motor for operation in the other direction by simply reversing the master controller 19 as he was able to do previously when he was operating the hoist within its proper limits of travel, because the circuit to the coil of reversing switch 4 has been opened by the movement of the switch 24 to the right position. If he has returned the hoist to within its proper limits of travel he may reverse the motor by first moving the controller to the "off" position and then throwing the switch 24 to the left position. He may then operate the hoist within the proper limits of travel in the same manner as heretofore explained. If, however, the operator should attempt to reverse the motor before the bucket 9 had returned past its predetermined upper limits of travel while the hoist is returning to its proper limits, he would be prevented from closing the circuit to the coil of reversing switch 4, as the circuit to this coil would have been opened by the movement of the switch 24 to the right. He could not complete the circuit for the coil of this reversing switch 4 by moving the switch 24 to its left hand position, because that would deënergize the no-voltage relay 16, the no-voltage release magnet 22, the brake magnet 14 and open the oil switch 3 and apply the brake 13, as the control circuit would be open at track limit switch 11 and segments 30 and 44 of the geared limit switch.

From this it can be seen that the operator can in no case render the limiting means ineffective so as to return the hoist to its predetermined limits of travel, and then,

before he has returned to some point within the limits, reverse the motor so as to operate the hoist farther beyond the limits with the limiting means rendered ineffective. It will also be seen that he can operate the motor so as to return to the predetermined limits of travel but after the hoist is within its proper limits of travel he is prevented from reversing until he has thrown the switch 24 to the left hand position, rendering the limiting means effective to protect the motor in case he should thereafter run the hoist beyond either one of its limits.

In case the operator should run the hoist beyond the other limit of travel, that is, when the bucket 10 had passed its upper limit, the geared limit switch at the contacts 30 and 34 and the track limit switch 12 will deënergize the control circuits and the motor and apply the brake. The operation of returning the hoist to its proper limits of travel is substantially the same as that when the bucket 9 had passed its upper limit except that in this case the switch 25 must be thrown to its left end position. The protective features above outlined are the same in this case as previously explained in connection with the protective features when the bucket 9 had passed its predetermined limit of travel, as will be readily understood.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

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

1. In combination with a hoist or the like, an electric motor for operating it in two directions and a reversing controller therefor, of a limit switch at each limit of travel, means for opening the motor circuit and rendering the controller inoperative to control the motor for operation in either direction upon the operation of either of said limit switches and means whereby control is restored to the controller to return the hoist beyond the point where the limit switch operated after which full control is restored to the controller.

2. In combination with a hoist or the like, an electric motor for operating it in two directions, and a reversing controller therefor, of a limit switch at each limit of travel, an electro-magnetically controlled main switch for opening the motor circuit upon the operation of either of said limit switches, connections whereby the operation of either of said limit switches renders the controller inoperative to control the motor for operation in either direction, and means whereby a control circuit for the main switch is established independently of the limit switches to return the hoist beyond the point where the limit switch was operated after which full control of the motor is restored to the controller.

3. In combination with a hoist or the like, an electric motor for operating it in two directions and a reversing controller therefor, of a limit switch at each limit of travel, an electro-magnetically controlled main switch for opening the motor circuit upon the operation of either of said limit switches, connections whereby the operation of either limit switch renders the controller inoperative to control the motor for operation in either direction, and means independent of the controller whereby a control circuit for the main switch is established through the controller to return the hoist beyond the point where the limit switch operated after which full control of the motor is restored to the controller.

4. The combination with a hoist or the like, an electric motor for operating it in two directions and a reversing controller therefor, of a switch operated to slow down the motor at a predetermined point in each direction of travel, a limit switch at each limit of travel, means for opening the motor circuit and rendering the controller inoperative to control the motor after it has slowed down and upon the operation of either of said limit switches and means whereby control is restored to the controller to return the hoist beyond the point where the limit switch operated after which full control is restored to the controller through the limit switches and slow down switch.

5. The combination with a hoist or the like, an electric motor for operating it in two directions and a reversing controller therefor, of a switch operated to slow down the motor at a predetermined point in each direction of travel, a limit switch at each limit of travel, means for opening the motor circuit and rendering the controller inoperative to control the motor after it has slowed down and upon the operation of either of said limit switches and means whereby control is restored to the controller to return the hoist at full speed beyond the point where the limit switch operated after which full control is restored to the controller through the limit switches and slow down switch.

6. The combination with a hoist or the like, an electric motor for operating it in two directions and a reversing controller therefor, of a switch operated to slow down the motor at a predetermined point in each direction of travel, a limit switch at each limit of travel, means for opening the motor circuit and rendering the controller inoperative to control the motor after it has slowed

down and upon the operation of either of said limit switches, and manually operated means independent of the controller for re-establishing a circuit through the controller independent of the limit switches and with the slow down switch ineffective whereby the hoist is returned beyond the point where the limit switch operated after which full control is restored to the controller through the limit switch and slow down switch.

In witness whereof, I have hereunto set my hand this 25th day of May, 1916.

BENJAMIN W. JONES.