

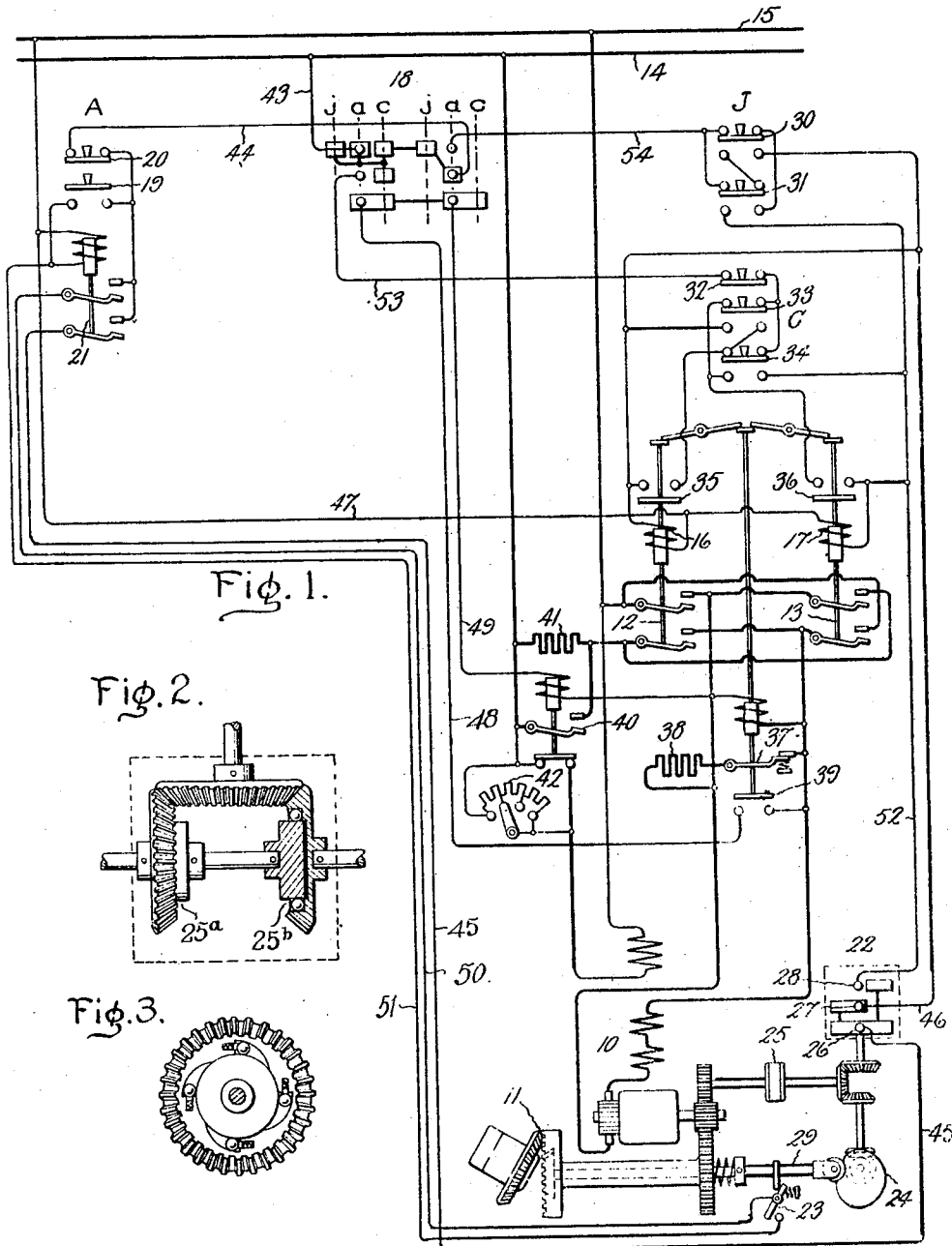
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MOTOR CONTROL SYSTEM AND APPARATUS

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MOTOR-CONTROL SYSTEM AND APPARATUS.

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My invention relates to improvements in motor control systems and apparatus, and more particularly to control systems and apparatus for a reversible motor which either automatically effects a predetermined number of alternate unequal rotations of the motor in opposite directions or selectively jogs or operates the motor continuously at full speed in either direction.

One of the objects of my invention is to provide a control system for a reversible electric motor in which reversing switch mechanism is automatically actuated to successively reverse the motor after a predetermined number of revolutions in one direction and a different predetermined number of revolutions in the opposite direction.

Another object of the invention is to provide such an automatic reversing motor control system with limit switch mechanism for stopping the motor after a predetermined total number of revolutions of the motor in opposite directions.

A further object of the invention is to provide a control system for a reversible electric motor in which electromagnetically actuated switches for connecting the motor to a source of supply for operation in either direction are controlled by a plurality of control elements, one of which automatically effects a predetermined number of unequal rotations of the motor in opposite directions and then stops the motor, another effects continuous operation of the motor in either direction, and another effects jogging operation of the motor in either direction.

Although not limited thereto, my invention is of particular utility when applied to control the driving motor of certain types of industrial machinery, such as for example, hot metal rolling mills, hot gear rolling machines and the like. In operating such machinery it is often necessary to repeatedly reverse the machine during the rolling operation in order to shape the hot metal blank into the desired form, as well as to jog the machine at slow speed in either direction in setting up the rolling dies, and to operate the rolls continuously in either direction for the finishing operation. With a full manually controlled driving motor, the skill of the operator in effecting the reversals of the rolls during the rolling operation so as to properly distribute the cooling effect thereof evenly over the work determines, in a large degree,

the quality and uniformity of the product. Due to this requirement the ordinary automatic motor control system for reversible machines such as reciprocating planers and the like are unsatisfactory when applied to control the rolling operation of hot metal rolling machines for the reason that the automatic reversals of the driving motor are produced only after equal movements of the rolls in opposite directions and hence the cooling effect is localized at certain portions of the hot metal blank.

My invention, however, provides a motor control system which when applied to drive a hot metal rolling machine overcomes the difficulty of localized cooling during the rolling operation by automatically effecting the reversal of the rolls after alternate unequal movements in opposite directions, and also automatically stops the rolls upon completion of this operation, as well as permits jogging or continuous operation of the rolls at the will of the operator.

For a better understanding of my invention, reference is had to the accompanying drawing in which Fig. 1 diagrammatically illustrates a preferred embodiment of my invention in a motor control system for a hot gear rolling machine, and Figs. 2 and 3 show one form of automatic operating mechanism which may be employed in a control system for effecting automatic reversal of the motor. The novel features, which I believe to be characteristic of my invention are set forth with particularity in the appended claims.

Referring to the drawing, a reversible electric motor 10 is shown connected through suitable gearing to drive the hot gear rolling machine 11. The electric motor 10 may be of any desired type although I have illustrated a shunt wound direct current motor having commutating field windings. The hot gear rolling machine 11 may be of the type described in Anderson Patent 1,240,917 and since it is shown only as representative of a machine which is to be repeatedly reversed after unequal movements of the driving motor in opposite directions, as well as jogged or operated continuously in either direction further description of the structure of the gear rolling machine is deemed unnecessary.

A pair of electromagnetically actuated switches 12 and 13 are provided for connecting the motor 10 to current supply lines

14 and 15 for operation in either direction. The several control elements indicated as A, J, and C, are provided for controlling the energization of the operating windings 16 and 17 of the reversing switches 12 and 13 to effect respectively a predetermined number of automatic successive reversals of the motor 10 after unequal rotations thereof in opposite directions, jogging operation in either direction, and continuous operation in either direction. In order to prevent more than one of the control elements A, J, and C from simultaneously controlling the energization of the reversing switches, the interlocking or control transfer switch 18 is arranged to give the control of motor 10 to the individual control elements A, J, and C, when manually operated to the positions indicated as *a*, *j*, and *c*, respectively.

The automatic control element A, in the preferred form shown, comprises the manually operated start and stop control buttons 19 and 20 which are biased to the positions shown, the double pole electromagnetic switch 21, the drum switch 22, the limit switch 23 the cam 24, and the motion rectifying mechanism 25, which may be of the form shown in Figs. 2 and 3. In the motion rectifying mechanism illustrated a pair of oppositely acting clutches 25^a and 25^b of suitable design such, for example, as a pair of ordinary bicycle coaster brake mechanisms are arranged to grip in opposite directions so as to rotate the drum switch 22 and the cam 24 through suitable gearing, as shown, in a fixed direction regardless of the direction of rotation of the motor 10.

The drum switch 22 is illustrated as a developed cylinder and consists essentially of a plurality of cooperating contacts and segments 26, 27, and 28. The segments 27 and 28 are of unequal lengths and are each permanently connected to the segment 26. The several contacts and segments are arranged in a spaced relation such that as the drum switch 22 is moved in a fixed direction by the alternate rotations of the motor in opposite directions, the cooperating contacts and segments 27 and 28 are brought into successive sliding engagement.

The limit switch 23 is biased to the closed position by a suitable compression spring and is moved from the closed position to the open position in which it is shown in the drawing by the roller arm 29 which cooperates with the cam 24. Cam 24 is so mechanically connected to the hot gear rolling machine 11 through the motion rectifying mechanism 25 that it will complete one revolution during the predetermined number of reverse operations of motor 10 required to roll the teeth on a hot gear blank, and is so designed that after the initial movement of motor 10, the arm 29 will move to the left and permit switch 23 to close according to its bias.

The control element J, includes the manually operated forward and reverse control buttons 30 and 31 which are biased to the positions shown and electrically interlocked to prevent interference in case both buttons should be simultaneously operated. This control element J cooperates with transfer switch 18 to effect jogging operation of motor 10 at slow speed in either direction.

The continuous control element C, consists primarily of the stop, forward, and reverse manually operated control buttons 32, 33, and 34, which are biased to the positions shown. Control buttons 33 and 34 cooperate with the transfer switch 18 and with the auxiliary contacts 35 and 36 carried respectively by the reversing switches 12 and 13 to effect continuous operation of the motor 10 in either direction.

The reversing switches 12 and 13 are shown as mechanically interlocked in a well known manner with electromagnetic switch 37 which controls a dynamic braking resistance 38 for the motor 10 and also the auxiliary contact 39 in the energizing circuit of electromagnetic switch 40, which latter controls the motor starting resistance 41. The switch 40 may be provided with an auxiliary contact for controlling the variable regulating resistance 42 which is connected in the field circuit of motor 10, if desired.

With the parts as thus constructed and arranged and in their respective positions shown in the drawing, the operation of my improved control system is as follows.

Automatic operation.

The interlocking or transfer switch 18 is shown in the mid position *a*, in which the conductor 43 is connected to the conductor 44 to give the control of the motor 10 to the automatic control element A. The reversing switches 12 and 13 for the motor 10 are thus placed under the control of element A and closure of start button 19 will initiate the automatic operation of the motor to repeatedly reverse the hot gear rolling machine 11 after unequal movements in opposite directions in the following manner. An energizing circuit for the operating winding of switch 21 is completed by closure of start button 19 from line 14 through conductor 43, control transfer switch 18, conductor 44, stop button 20, start button 19, and the winding of switch 21 to the other line 15.

The resulting closure of switch 21 completes an energizing circuit for the operating winding of reversing switch 12 as follows: from line 14, through conductor 43 transfer switch 18, conductor 44, stop button 20, the lower blade of switch 21, conductor 45 contacts 26 and 27 of drum switch 22, and conductor 46, the operating winding 16 of switch 12, and conductor 47 to the other supply line 15. Thereupon, after opening

the dynamic braking switch 37 by means of the mechanical interlocking arrangement, switch 12 closes and connects the motor 10 through the starting resistance 41 to the supply lines 14 and 15 for operation in the forward direction.

It will be noted that upon the opening of dynamic braking switch 37 the auxiliary contact 39 closes and connects the winding of accelerating switch 40 through the conductor 48, the lower contacts of transfer switch 18, and the conductor 49 across the armature of motor 10. After the counter voltage of the motor 10 has reached the value required to operate switch 40 the starting resistance 41 is short circuited and the field regulating resistance 42 is automatically inserted to bring the motor up to full operating speed.

It will also be observed that after the initial movement of the motor 10, the limit switch 23 will be permitted to close according to its bias by the rotation of the cam 24 in a counterclockwise direction and the resulting movement of roller arm 29 to the left. This will establish a holding circuit in shunt to the start button 19 extending from the conductor 44 through the stop button 20, the upper contact of switch 21, conductor 50, limit switch 23, and conductor 51, which serves to maintain the winding of switch 21 energized until either the stop button 20 is operated, the transfer switch 18 is moved to position *j*, or *c*, or the cam 24 is rotated through a complete revolution back into the position in which it is shown. As the motor 10 rotates the gear rolling machine 11 to form the hot gear blank which has been placed in the machine, drum switch 22 and the cam 24 are driven in a fixed direction through the motion rectifying mechanism 25. The cooperating contacts 27 of drum switch 22 are in a spaced relation such that after a predetermined number of rotations of the motor in the forward direction they are disengaged and the connection between the conductor 45 and the conductor 46 is broken. This deenergizes the winding of reversing switch 12 and disconnects the motor 10 from the supply lines 14 and 15. The dynamic braking switch 37 then closes and the accelerating switch 40 opens so that the motor is quickly slowed down under full field dynamic braking action.

During this slowing down of motor 10, the drum switch 22 is further rotated to bring the cooperating contacts 28 into engagement and effect the connection of conductor 45 to conductor 52. This energizes the operating winding 17 of reversing switch 13, through the following circuit; from conductor 45 which remains connected to supply line 14, as previously described, through contacts 26 and 28 of drum switch 22 to conductor 52, the operating winding 17 of reversing

switch 13, and conductor 47 to supply line 15. When the motor dynamic braking voltage decreases sufficiently to permit switch 37 to be opened by reversing switch 13 acting through the mechanical interlock mechanism, the latter switch closes and connects the motor 10 to supply line 14 and 15 for operation in the opposite or reverse direction with the starting resistance 41 in circuit and under full field. Switch 40 again operates when the generated voltage of the motor reaches the proper value to short circuit resistance 41 and insert resistance 42 in the field circuit to bring the motor 10 up to full operating speed.

After the motor has completed a different predetermined number of revolutions in the reverse direction, the drum switch 22 is rotated sufficiently to first break the connection between conductor 45 and conductor 52 and then subsequently reestablish the connection between conductor 45 and conductor 46 as the motor again slows down under dynamic braking. It will be evident that this will deenergize reversing switch 13 and then energize reversing switch 12 to reverse the motor in a similar manner to that previously described. The motor 10 thus continues to rotate drum switch 22 in a fixed direction to move its contacts 27 and 28 into successive sliding engagements and alternately shift the connection of conductor 45 between conductors 46 and 52 to effect the successive reversals of the motor after alternate unequal rotations thereof in opposite directions.

As the motor is thus successively reversed during the gear rolling operation of machine 11 the cam 24 is continuously being rotated in a fixed direction and, as has been pointed out, returns to the position in which it is shown upon completion of the predetermined number of reverse operations of motor 10 required for machine 11 to fully form the hot gear blank into a gear. This results in roller arm 29 opening the limit switch 23 and the consequent deenergization and opening of electromagnetic switch 21. The opening of the lower blade of switch 21 interrupts the energizing circuit of both windings 16 and 17 of the reversing switches 12 and 13 and the motor 10 is thus automatically stopped under dynamic braking.

Continuous operation.

Should it be necessary to run the completed gear continuously in either direction during the cooling period in order to properly finish the gear teeth, the control transfer switch 18 is manually operated to position *c* to disconnect the conductor 43 from the conductor 44, thus preventing further operation by control element A, and to connect the conductor 43 to conductor 53, thus

giving the control of motor 10 to control element C.

Operation of forward control button 33 energizes the winding 16 of switch 12 through a circuit extending from supply line 14, through conductor 43, transfer switch 18, conductor 53, control buttons 32, 34, and 33, in series, winding 16, conductor 47, to the other supply line 15. Upon response of switch 12, the motor 10 is connected to the current supply lines 14 and 15 for operation in the forward direction and accelerated by the automatic action of switch 39 as previously described. As switch 12 closes, a holding circuit in shunt to the control button 33 is closed by auxiliary contact 35. The motor then operates continuously in the forward direction until stopped by operation of control button 32 or the movement of transfer switch 18 to a different position.

It will be evident that the operation of control button 34 serves to energize the winding 17 of switch 13 and connect the motor 10 for continuous operation in the reverse direction in a similar manner.

Jogging operation.

If it is desired to jog the motor 10 at slow speed in either direction, the transfer switch 18 is shifted to position *j*, in which the conductor 43 is connected to the conductor 54 and the circuit of accelerating switch 40 is opened at the lower contacts of transfer switch 18. Operation of control button 30 will complete an energizing circuit for winding 16 of switch 12 from supply line 14, through conductor 43, transfer switch 18, conductor 54, control buttons 30 and 31 in series winding 16, conductor 47, to the supply line 15. Switch 12 closes and the motor 10 is operated in the forward direction at slow speed as long as the control button 30 is held in the operative position.

Operation of control button 31 effects jogging operation of motor 10 in the reverse direction by energizing the operating winding 17 of switch 13 in a similar manner.

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. An electric drive for a hot metal rolling machine or the like comprising a reversible electric motor arranged for positive driving connection with the machine for each direction of rotation, switch mechanism

for reversing the motor, and automatic means actuated responsively to rotation of the motor for operating the said switch mechanism upon a predetermined number or revolutions of the motor in one direction and a different predetermined number of revolutions of the motor in the opposite direction to thereby progressively vary the point of reversal of the motor.

2. An electric drive for a hot metal rolling machine or the like comprising a reversible electric motor arranged for positive driving connection with the machine for each direction of rotation, electromagnetically actuated switch mechanism for connecting the motor to a source of supply for operation in each direction, a plurality of contacts actuated into successive engagements responsively to alternate unequal movements of the motor in opposite directions, and electrical connections controlled by the said contacts for automatically controlling the energization of the said switch mechanism to successively reverse the motor for alternate unequal rotation thereof in opposite directions.

3. An electric drive for a hot metal rolling machine or the like comprising a reversible electric motor arranged for positive driving connection with the machine for each direction of rotation, electromagnetically actuated switch mechanism for connecting the motor to a source of supply for operation in each direction, a plurality of cooperating sliding contacts of unequal lengths disposed in spaced relation, means actuated responsively to rotation of the motor for moving the said contacts into successive sliding engagements, and electrical connections whereby the said contacts control the energization of the said reversing switches to successively reverse the motor after alternate unequal rotation thereof in opposite directions.

4. An electric drive for hot metal rolling machines and the like comprising a reversible electric motor arranged for positive driving connection with the machine for each direction of rotation, electromagnetically actuated reversing switches for the motor, a rotatable switch having spaced contacts of unequal length for successively controlling the energization of said reversing switches to reverse the motor, and motion rectifying mechanism actuated by the alternate rotation of the motor in opposite directions for continuously rotating said rotatable switch in a single direction to effect successive reversals of the motor after alternate unequal rotation thereof in opposite directions.

5. A control system for a reversible electric motor, comprising switch mechanism actuated responsively to a predetermined number of revolutions of the motor in each

direction for successively connecting the motor to a source of supply for operation in the other direction, and limit switch mechanism actuated responsively to a predetermined total number of said revolutions for stopping the motor.

6. A control system for a reversible electric motor, comprising electrically operated reversing switches, for the motor, and automatic means for controlling the operation of said reversing switches including switch mechanism actuated responsively to a different predetermined number of revolutions of the motor in each direction, limit switch mechanism actuated responsively to a predetermined total number of revolutions of the motor, and electrical connections jointly controlled by said switch mechanisms for energizing the said reversing switches to effect a predetermined number of alternate unequal rotations of the motor in opposite directions and thereupon deenergizing the said reversing switches to stop the motor.

7. A control system for a reversible electric motor, comprising a pair of electromagnetically actuated switches for connecting the motor to a source of supply for rotation in either directions, a rotatable switch provided with spaced contacts of unequal lengths cooperating with fixed contacts for controlling the alternate energization of

said electromagnetic switches, a limit switch for interrupting the energization of said electromagnetic switches, a rotatable mechanism for operating said limit-switch, and motion rectifying mechanism actuated by the alternate rotations of the motor in opposite directions for rotating the said rotatable switch and the said mechanism to effect a predetermined number of alternate rotations of the motor in opposite directions and thereupon stop the motor.

8. A control system for a reversible electric motor, comprising electromagnetically actuated switches for connecting the motor to a source of supply for operation in either direction, a plurality of control elements for controlling the energization of the said switches, one to automatically effect a predetermined number of alternate unequal rotations of the motor in opposite directions and then stop the motor, another to effect continuous operation in either direction, and another to effect jogging operation in either direction, and an electrical interlocking transfer switch for preventing more than one of said elements from simultaneously controlling the energization of said switches.

In witness whereof, I have hereunto set my hand this 21st day of March, 1924.

FRANK H. PENNEY.

Certificate of Correction.

It is hereby certified that in Letters Patent No. 1,584,703, granted May 11, 1926, upon the application of Frank H. Penney, of Scotia, New York, for an improvement in "Motor-Control Systems and Apparatus," errors appear in the printed specification requiring correction as follows: Page 4, line 70, claim 1, for the word "or" read *of*; same page, line 90, claim 2, for the word "for" read *after*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of June, A. D. 1926.

[SEAL.]

M. J. MOORE,
Acting Commissioner of Patents.