July 10, 1945. F. W. SUHR ET AL 2,380,270

QUICK REVERSING SINGLE PHASE MOTOR

Filed Feb. 8, 1944

Fig. 1.

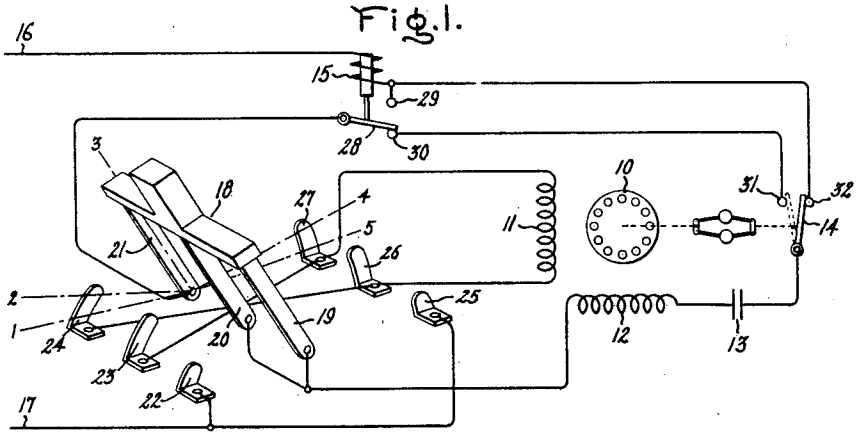


Fig. 2.

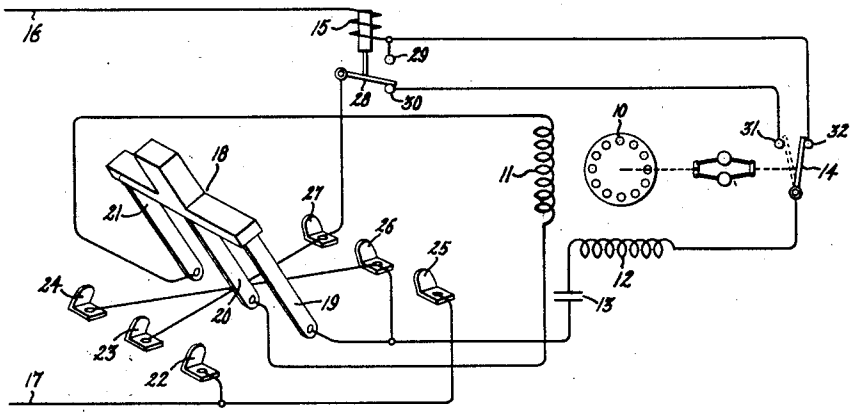
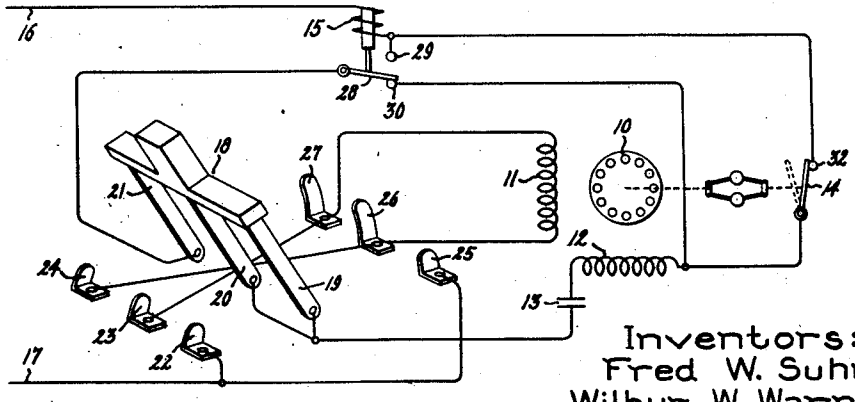


Fig. 3.



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QUICK REVERSING SINGLE PHASE MOTOR

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11 Claims. (Cl. 172—279)

Our invention relates to a quick reversing single phase electric motor employing regenerative braking and plugging in the reversing operation, with selection on the part of the operator as to the extent of the amount of regenerative braking and plugging or both which is employed in a stopping or reversing operation.

The features of our invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. For a better understanding of our invention, reference is made in the following description to the accompanying drawing showing in Fig. 1 a preferred embodiment of our invention, and Figs. 2 and 3 show modified forms of control switches.

In the drawing, 10 represents the squirrel-cage secondary rotor of a single phase, split phase induction motor having main and starting primary stator windings 11 and 12 having their winding axes displaced at a suitable angle approaching 90 degrees. In series with the starting winding are a phase modifying condenser 13, an automatic switch represented as the centrifugal type 14 for opening the starting winding circuit as the motor comes up to speed during a starting operation, and the coil 15 of a control relay. Sixteen (16) and 17 represent the line terminals. At 18 is a manual switch which serves as a line switch, a reversing switch, and for controlling the amount of regenerative braking and plugging employed in a reversing operation. The switch 18 is of the three pole, double throw variety having the movable blades or contacts 19, 20, and 21 and the stationary contacts 22, 23, and 24 on the left and 25, 26, and 27 on the right. Stationary contacts 22 and 25 are relatively short as compared to the remaining stationary contacts and are both connected to line terminal 17. The long stationary contacts 23 and 27, also 24 and 26, are cross-connected with each other and the cross-connections are connected to opposite ends of the main winding 11 and serve with their movable switch blades as a reversing switch for the main winding. Movable switch blades 19 and 20 are connected to each other and to one end of the starting winding circuit as shown. Switch blade 21 is connected to the movable contact 28 of the previously mentioned relay. When the relay is energized, its movable contact 28 makes contact at 29 with line 16 through relay coil 15 and when the relay is deenergized, the contactor 28 makes contact at 30 with a wire leading to a stationary running contact 31 of the automatic starting switch 14. This connection is used during regenerative braking. The stationary starting contact of the speed responsive switch 14 is designated 32. It is seen that the manual switch 18 has five different positions where different circuit conditions are possible. These positions are designated opposite switch blade 21 by the designations 1 to 5, the switch being shown in the open position 3 which extends over a considerable portion of the central range of switch movement.

In position 1 the motor is connected for operation in one direction of rotation which we will designate counterclockwise. The starting winding circuit may be traced as follows: From line 17, contact 22, switch blade 19, winding 12, condenser 13, switch 14 on starting contact 32, coil 15 to line 16. The main winding circuit is as follows: Line 17, contact 22, switch blade 19, switch blade 20, contact 23 through main winding 11, contact 24, switch blade 21, movable contact 28 and stationary contact 29 through coil 15 to line 16. The current through the starting winding during the starting operation assures that the relay will be energized and that its movable contact will be on contact 29. Somewhat below normal running speed the centrifugal switch 14 moves to the running contact 31 and opens the starting winding circuit. Relay coils 15, however, remains energized by the main winding current and retains its pulled-up position, and the motor now operates on the main winding only in the usual manner. When so operating, if power should fail, relay 15 will drop out and establish the regenerative braking circuit. The motor will quickly slow down and reestablish the starting winding circuit at contact 32, and the motor will restart as soon as power is resumed. When operating single phase the motor may be stopped without regenerative braking by quickly moving switch 18 to the open position 3. If, however, the switch 18 is moved to position 2 and left there, the motor will be disconnected from the line between contact 22 and switch blade 19, and a regenerative braking circuit will be established. When the line circuit is thus opened, relay 15 drops out and establishes connection 28, 30, 31 until the motor speed decreases to a point where the centrifugal switch moves to the starting contact 32. In the meantime the motor windings are connected in series through the condenser and regenerative braking occurs. This circuit may be traced as follows: From switch blade 20, starting winding 12, condenser 13, switch 14 on contact 31, contact 30, switch 28, blade 21, contact 24 through the main winding back to contact 23 with which blade 20 is in contact. Thus, regenerative braking occurs quickly to decrease the speed of the

motor to a point where the starting winding switch 14 moves to starting contact 32.

If, now, switch 18 is left in position 2, the motor comes to rest in a normal manner. If, however, switch 18 be moved to position 5 as soon as the centrifugal switch moves to its starting contact, the motor is connected to the line for the reverse direction of rotation and plugging action occurs to stop the motor and bring it up to speed in the opposite direction. The connections and manner of starting in the clockwise direction are the same as for counterclockwise starting except that the main winding 11 is reversed. Position 4 is for regenerative braking after clockwise operation, and is the same as for position 2 except that the main winding is reversed. It may be pointed out that regenerative braking will occur when the switch 14 is on contact 31, with switch 18 in either position 2 or 4 regardless of the direction of rotation, and regenerative braking from counterclockwise operation may be had by throwing switch 18 from position 1 to position 4 or to position 5, if desired.

From the above it is evident that the operator may start the motor in either direction of rotation; in stopping, he may use regenerative braking or not, as he chooses, and the extent thereof. For instance, if during regenerative braking, switch 18 be moved to position 3, regenerative braking will cease. Likewise, he may use plugging or not, as he chooses, and the extent thereof, and he may use plugging without regenerative braking. Regenerative action and plugging in reversing are obtained by throwing switch 18 quickly from one extreme position to the other. For example, when operating clockwise, switch 18 is quickly thrown from position 5 to position 1. Relay 15 drops out and establishes the regenerative braking circuit which persists until the centrifugal switch moves from contact 31 to contact 32. As soon as this happens, relay 15 will pull up and connect the motor for counterclockwise operation, and will then quickly stop and reverse and come up to speed in the counterclockwise direction. Thus, the operator has considerable choice in stopping or reversing the motor, as to whether it shall be done quickly or as slowly as the normal deceleration will allow.

In case he wants maximum speed in stopping without reversing, he may use both regenerative braking and plugging, and just as the motor comes to rest he may move the switch 18 to position 3. A little practice will enable the operator to accomplish the results desired within the possible limits of the apparatus. The three pole, double throw switch may take many forms and may be operated automatically as a limit reversing switch. It may be left in any position and moved quickly or slowly from any position to any other position without danger of injuring the motor or causing a short circuit. If all of the stationary contacts of the three pole, double throw switch be made alike, as shown in Fig. 2, much the same results may be accomplished except that the switch cannot be left in a position where only regenerative braking will result. With the switch of Fig. 2 one may, however, throw it from one extreme position to the other just as in Fig. 1 and obtain quick reversing where regenerative braking, plugging, and starting up in the opposite direction are obtained in sequence in the order named. If one desired to obtain only regenerative braking with the switch of Fig. 2, it would be necessary first to open the switch to let the relay 15 drop out, reclose the switch again in either direction, thereby obtaining regenerative braking, and then open the switch as soon as the speed switch moved to the starting contact.

It is not essential that both sets of stationary contacts connected to the starting winding in Fig. 1 be longer than the contacts 22 and 25, since all of the results obtained with the switch of Fig. 1 may be obtained if only one set of such long stationary contacts be used as shown in Fig. 3. With the switch of Fig. 3 the position corresponding to position 2 in Fig. 1 is eliminated but since regenerative braking will occur for both directions of rotation with the switch in either position 2 or 4 in Fig. 1, it is possible to eliminate one of such positions with no reduction in the results obtainable, except that the switch of Fig. 3 may not be quite so handy to use as the one of Fig. 1.

It will be noted that in Fig. 3 the regenerative braking connection between the contact 30 of the relay 15 and the starting winding circuit does not pass through the speed responsive switch, and the speed responsive switch is not provided with a running contact. While this arrangement is essentially similar to the arrangement of Fig. 1 in operation, it may have certain advantages under some circumstances as follows: When the motor is started, the main and starting windings are energized simultaneously without waiting for the relay 15 to pull up. Thus, the main winding circuit is energized through the relay coil, the starting switch in starting position, and the relay contacts 28 and 30. The main winding is thus energized exactly simultaneously with the starting winding. Energization of the main winding is however dependent on the speed responsive switch being in starting position During regenerative braking operation the regenerative braking, which starts as before upon deenergization of the motor, may continue even after the speed responsive switch moves from running to starting position, provided the motor is not reenergized, and even if energized, there is no interruption between the regenerative braking period and the plugging period as there is in Fig. 1 during the interval that the speed responsive switch is moving from contact 31 to 32.

In accordance with the provisions of the patent statues, we have described the principle of operation of our invention together with the apparatus which we now consider to represent the best embodiment thereof, but we desire to have its understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

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

1. A quick reversing single phase motor having axially displaced main and starting primary windings, a condenser in series with the starting winding, a speed responsive switch in the starting winding circuit having a movable contact and stationary start and running contacts, a relay having an energizing winding in series between a first line terminal and the starting contact of the speed responsive switch and a movable contactor which when the relay is energized establishes a connection from such contactor to the starting contact of the speed responsive switch and when the relay is deenergized establishes a connection from such contactor to the running contact of the speed responsive switch, and a double throw switch between a second line terminal and the motor providing connections from

such line terminal to one end of the main winding and that end of the starting winding circuit not connected to the speed responsive switch, and for connecting the other end of the main winding to said movable contactor when said double throw switch is closed and for disconnecting the motor from said second line terminal when said double throw switch is open, said switch reversing the said end connections to the main winding relative to the other connections when moved from one closed position to the other closed position.

2. A quick reversing single phase motor having axially displaced main and starting windings, a condenser and speed responsive switch in the starting winding circuit having a movable contact and a stationary starting contact serving to deenergize the starting winding as the motor comes up to speed during a starting operation, a relay having its energizing coil between one line terminal and the starting contact of the speed responsive switch and contacts for establishing an energizing connection from said line terminal through the relay coil for the main winding when the relay is energized, a double throw switch having connections to the other line terminal, to the motor windings and to a contact of said relay, said double throw switch having two fully closed positions for reversing the main winding, in which positions the motor winding circuits are energized in parallel from the line terminals when said relay is energized and the speed responsive switch is in a starting position, and a connection which is closed only when said relay is deenergized for connecting the motor windings and condenser in a series regenerative braking circuit through said double throw switch.

3. A single phase motor having main and starting axially displaced windings, a condenser and speed responsive switch in series with the starting winding, said switch serving to open the starting winding circuit when the motor comes up to speed, a relay having its energizing coil connected between one line terminal and the starting switch so as to be energized by the starting winding starting current, said relay having a movable contactor cooperating with stationary contacts in both the energized and deenergized conditions, a line switch for energizing the motor from the other line terminal, means cooperating with said line switch when closed for establishing a connection from the second line terminal to one end of both windings of the motor and a connection from the other end of the main winding to a contact of said relay, said relay when energized establishing an energizing circuit for the main motor winding to the first line terminal through the coil of the relay and when deenergized establishing a regenerative braking circuit with the main and start windings connected in series with the condenser through said line switch.

4. A quick reversing single phase motor having axially displaced main and start windings, a condenser and speed responsive switch in the starting winding circuit the latter serving to open the starting winding circuit during a starting operation, a relay having its energizing coil connected in the starting winding circuit in series to a first line terminal so as to be energized by the starting current of said winding and having a holding circuit in series with the main winding so as to remain energized by the main winding current after the speed responsive switch opens, a motor regenerative braking connection including contacts closed by said relay when deenergized, a double throw main switch having at least four positions and connections from said main switch to the motor windings, to a second line terminal and to the relay, one position connecting the motor for operating in one direction, another position connecting the motor for operation in the opposite direction of rotation, said connections to be effective requiring that said relay be energized to establish the main winding current relay holding circuit, a third position where the motor is disconnected from said second line terminals and the main and start windings are connected in series with said condenser to establish the regenerative braking circuit only when said relay is deenergized, and a fourth open position where both motor winding circuits are opened.

5. A quick reversing single phase motor having axially displaced main and starting windings, a condenser in the starting winding circuit, a speed responsive switch for opening and closing the starting winding energizing circuit as the motor accelerates to and decelerates from normal running speed respectively, relay means responsive to the flow of energizing current in the starting winding circuit for establishing an energizing for the main winding which circuit is also a holding circuit for said relay means, whereby said relay remains energized by the main winding energizing current after the speed responsive switch opens during a starting operation until the main winding energizing circuit is otherwise opened, a double throw switch and connections thereto for reversing the main winding and completing energizing circuits to both windings, and connections made in response to the deenergization of said relay means for establishing a regenerative braking circuit for the motor in which the motor windings are connected in series with the condenser, said double throw switch having two intermediate positions one where the energizing circuits to the motor windings are interrupted and the regenerative braking connection is closed thereby and one where all of said circuits are interrupted.

6. In a reversible single phase motor of the type having main and capacitor start windings and a speed responsive switch for opening and closing the starting winding circuit as the motor accelerates to and decelerates from normal running speed respectively, the method of quick reversing when the motor is running single phase in one direction on the main winding which consists in simultaneously deenergizing the motor, reversing the main winding and connecting the windings in series with the starting winding capacitance to establish a regenerative braking circuit to quickly reduce the speed to the point where the speed responsive switch closes, then reenergizing the motor in response to such speed responsive switch closing to cause, first, plugging of the motor to standstill and, second, starting the motor in the opposite direction of rotation.

7. A quick reversing single phase motor having axially displaced main and start windings, an automatic switch for opening the starting winding circuit when the motor comes up to speed during the starting operation, a double pole, double throw switch for connecting said motor to one line terminal and reversing the connections of the main winding for opposite directions of rotation and a relay connected to be energized by the current of the starting winding during starting, said relay having a movable contact connected to the double pole switch, a stationary holding contact engaged by the movable contact only when the relay is energized and a stationary contact for establishing connections to the starting winding

and engaged by the movable contact only when the relay is deenergized, said relay when energized completing a connection for the main winding to a second line terminal through the relay whereby the relay is held in energized position by the main winding current, said relay when deenergized establishing a regenerative braking circuit for the motor including both windings in series with the condenser and connections through said double pole, double throw switch in either of its closed positions whereby when running on the main winding, said motor may be deenergized, regeneratively braked, plugged and started in the opposite direction in the order named by throwing said double throw switch from one closed position to the other.

8. A quick reversing single phase motor having main and start axially displaced primary windings, a condenser in the starting winding circuit, an automatic switch for opening the starting winding circuit as the motor comes up to speed during a starting operation, first and second line terminals, a double throw main winding reversing switch having contacts for connecting and disconnecting both motor windings with respect to the first line terminal, a relay connected to have its energizing coil energized by the starting winding current during a motor starting operation for completing an energizing circuit for the main winding to the second line terminal through said double throw switch but only when said relay is energized, said last-mentioned circuit also comprising a holding circuit for said relay to maintain the circuit after the starting winding circuit is opened during a starting operation, and a regenerative braking circuit established by said relay only when deenergized which circuit includes the condenser, both motor windings and the double throw switch in series relation, said double throw switch having selective intermediate positions where said regenerative braking circuit may be opened or closed at will and where the motor is disconnected from the first line terminal.

9. The method of reversing a single phase condenser motor having main and start windings, which consists in deenergizing said motor while running single phase on the main winding in one direction of rotation, immediately reversing the main winding and connecting the motor windings in series with the condenser to establish a regenerative braking circuit while the motor is still running at high speed in the first-mentioned direction, to quickly reduce the speed, then energizing said windings in parallel with the condenser in series with the start winding to plug the motor to standstill and to start it up in the opposite direction of rotation and then opening the starting winding circuit when the motor has come up to speed in the opposite direction.

10. A quick reversing single phase motor having axially displaced main and starting windings, a condenser in the starting winding circuit, a speed responsive switch for opening and closing the starting winding energizing circuit as the motor accelerates to and decelerates from normal running speed respectively, relay means responsive to flow of energizing current in the starting winding circuit for establishing an energizing circuit for the main winding which circuit is also a holding circuit for said relay means, whereby said relay means remains energized after the speed responsive switch opens during a starting operation until said main winding energizing circuit is otherwise opened, a double throw switch and connections thereto for reversing the main winding and for completing the energizing circuits for both motor windings and connections made only when said relay means is deenergized for connecting the motor windings in series relation with the condenser for regenerative braking purposes.

11. A quick reversing motor according to the preceding claim in which said double throw switch has three intermediate positions where the energizing circuits to the motor windings are interrupted, one such position for completing the regenerative braking circuit with the main winding connected in one direction therein, another for completing the regenerative braking circuit with the main winding connected in the opposite direction therein, and another such position for interrupting the regenerative braking circuit.

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CERTIFICATE OF CORRECTION.

Patent No. 2,380,270. July 10, 1945.

FRED W. SUHR, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 38, after the word "position" insert a period; page 3, second column, line 24, after "energizing" insert --circuit--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of October, A. D. 1945.

Leslie Frazer

(Seal) First Assistant Commissioner of Patents.

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