United States Patent

[11] **3,551,749**

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Bath, England

[32] Priority **Dec. 15, 1966**
[33] **Great Britain**
[31] **No. 56165/66**

[54] **VALVE ACTUATING MECHANISMS**
6 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **317/48,** 307/127; 318/207
[51] **Int. Cl.** **H02h 3/26**
[50] **Field of Search** 318/207; 317/47, 48; 307/127

[56] **References Cited**

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Primary Examiner—Oris L. Rader
Assistant Examiner—K. L. Crosson
Attorney—Stevens, Davis, Miller & Mosher

ABSTRACT: This invention relates to a polyphase electric motor operated actuator which has a reversing starter circuit forming an integral part of the actuator assembly and which is selectively operable for changing the phase rotation of the motor supply to reverse the direction of rotation of the motor. The actuator includes a star-connected control circuit which is sensitive to the phase sequence of the electrical supply. The circuit comprises a voltage sensing relay, a resistor and a capacitor. The relay is operative to prevent energization of the starter circuit unless the actuator supply is properly phase connected.

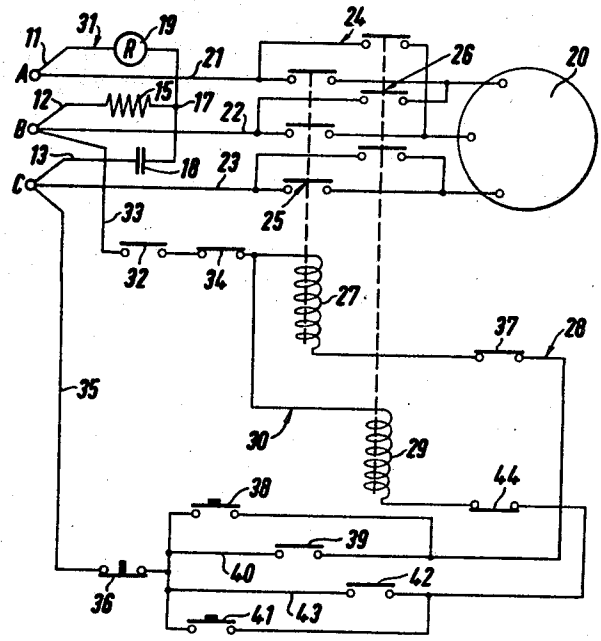

FIG. 1a.

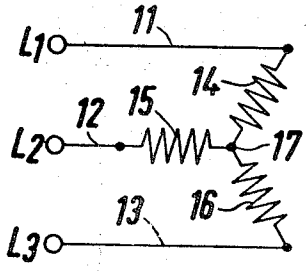

FIG. 1b.

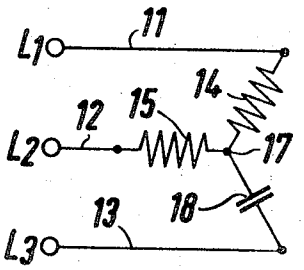

FIG. 1c.

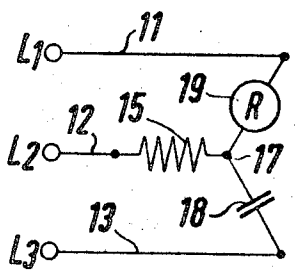

FIG. 2.

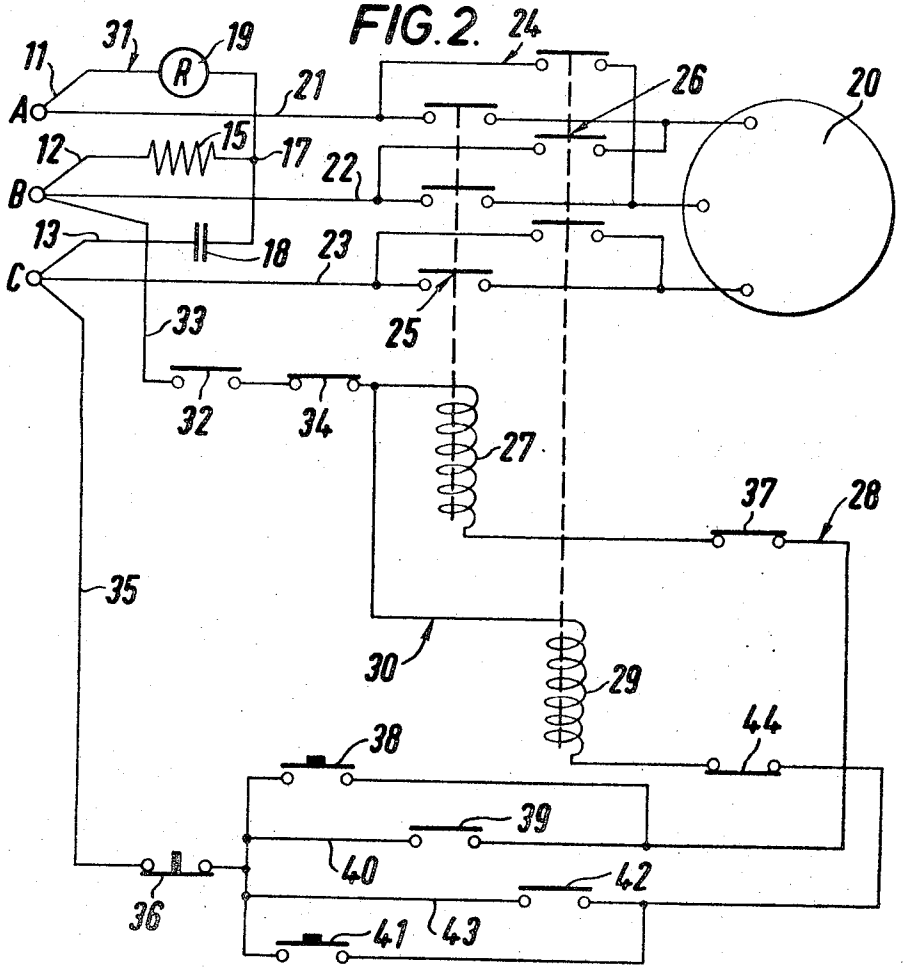

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FIG. 3.

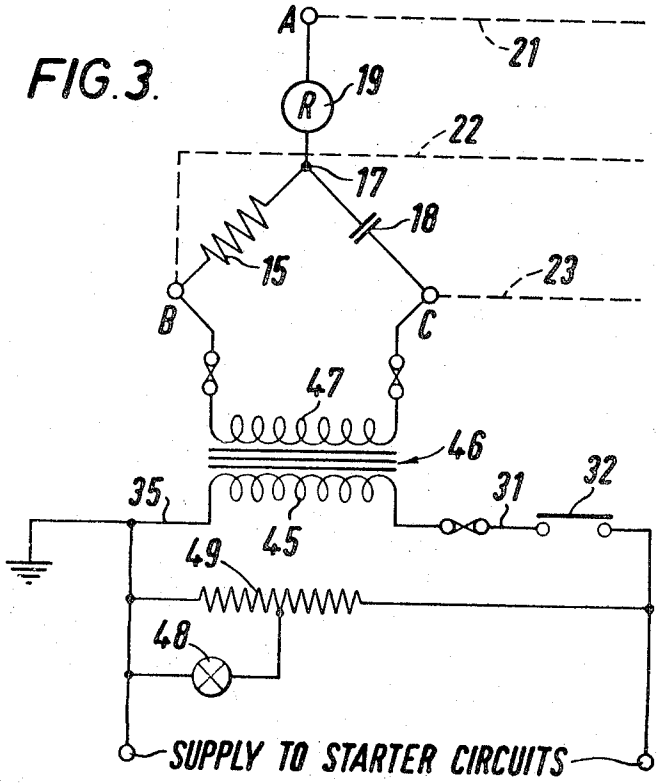
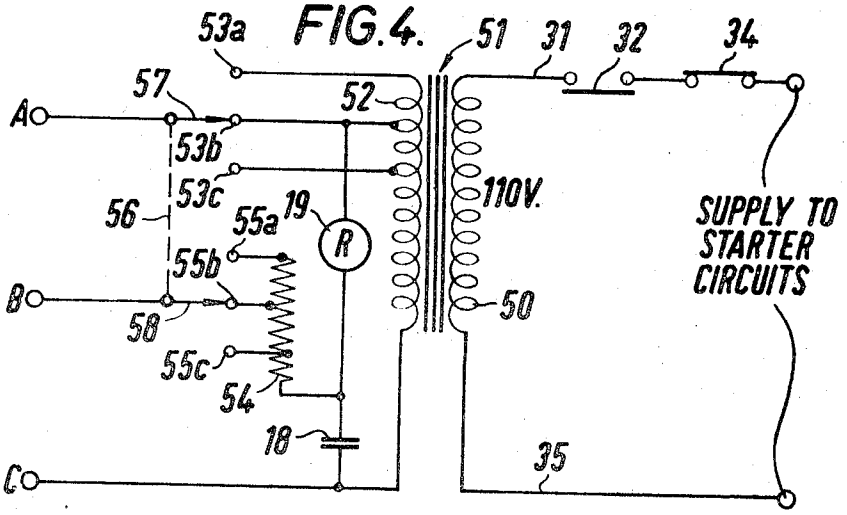


FIG. 4.



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VALVE ACTUATING MECHANISMS

This invention relates to motor operated valve actuating mechanisms of the kind in which the opening and closing movements of the valve are initiated by a pushbutton operation and stopped automatically by suitable limit, e.g., position, and/or torque switches in the motor circuits. In particular, the invention is concerned with electric motor actuating mechanisms, which may be of the kind described and claimed in U.S. Pat. Nos. 3,198,033; 3,209,090; and 3,267,741, all issued to J. J. Fry and assigned to the present assignee, and which includes a reversing starter located within the housing of the actuator so as to form an integral art of the mechanism.

The present invention has for its object to provide a control device for preventing such actuators from moving in the wrong direction when the pushbutton is pressed to open or close the valve, and in particular when the valve is initially set up with its actuating mechanism. An incorrect movement may occur with an electric polyphase induction reversing motor operated actuator if the phase rotation of the electrical supply is incorrectly connected and if the movement is not stopped immediately serious damage may be caused as the motor will drive the valve away from the limit switch which will trip the contactor thus causing a jammed valve and a stalled motor.

The present invention provides a control device which is sensitive to the phase rotation of the polyphase supply to the motor and which prevents operation of the motor by the pushbuttons in either direction unless the direction of phase rotation of the electrical supply is correct for the motor and starter circuits.

The invention is also concerned with the provision of a control device which prevents starting of the motor under single-phase conditions.

In its broadest aspect the invention is concerned with a three-phase or other polyphase operated electric motor valve actuator having integral reversing contactors or equivalent static switching components. According to the invention the actuator is provided with a control device which includes a circuit sensitive to the phase sequence of the electrical supply when connected to the actuator and which is operative to prevent energization of the starting circuit or circuits of the actuator if the phase sequence is incorrect.

In a preferred embodiment of the invention the phase sequence sensitive circuit is intended for use with a three-phase supply and comprises three elements connected respectively across the three phases of the motor supply lines to form a star point, the elements comprising a voltage sensing relay, a resistor or other suitable impedance, and capacitor. In such an arrangement the voltage across the relay will be greater or less than that across the resistor or other impedance depending on the direction of rotation of the three-phase supply. The relay is therefore arranged for operation when a predetermined voltage level is reached corresponding to one particular direction of rotation of the three-phase supply and the operation of the relay is utilized to connect or disconnect the starting circuit or circuits of the actuator as determined by tests to ascertain the correct phase rotation of the actuator motor.

In one embodiment the starting circuits of the actuator (i.e., the "open" and the "close" circuits) may be connected through a common contact with two phases of the electrical supply. The common contact may be normally open, but may be closed so as to permit energization of the actuator by one or other of the starter circuit pushbuttons when the relay picks up due to the connection of the electrical supply in the correct phase sequence.

If the electrical supply for the starter circuits is taken from the two phases to which the relay is not directly connected the circuit may also be used to prevent starting under single-phase conditions, provided the impedances of the elements in the phase sensitive circuit are high compared with that of the contactor coils in the starter circuits.

A visual indicator, such as a lamp, can also be included connected across the same supply as the contactor coils and which will therefore be out if the phase rotation is incorrect (even if all three phases are alive) or if any one phase is dead.

The invention will now be described by way of example with reference to the accompanying drawings in which:

FIGS. 1*a*, 1*b* and 1*c* illustrate the theory involved in the phase sequence sensitive circuits as used in accordance with the present invention;

FIG. 2 is a diagrammatic illustration of a typical actuator circuit provided with a phase sequence sensitive circuit in accordance with the invention;

FIG. 3 is a diagrammatic illustration of a modified control circuit utilizing an indicator lamp; and

FIG. 4 is a diagrammatic illustration of a further modified control circuit which allows for three-phase voltage tappings so as to give a wide voltage range with a minimum change of components.

As previously mentioned, FIG. 1 illustrates the theory involved in the fitting of a phase sensitive circuit to a three-phase electric motor operated actuator of the kind having integral reversing starter circuits.

In FIG. 1*a* a conventional three-phase star connected electrical circuit is illustrated. The conductors for each of the phases L_1, L_2 and L_3 of the supply are shown by the references **11**, **12** and **13** respectively, and they are connected to one end of the impedances **14**, **15** and **16**, the other ends of which are connected together in star at the common point **17** across the supply conductors. In the drawing the impedances **14**, **15** and **16** are shown as resistors, but the theory involved applies also for impedances of an inductive or capacitive nature.

In the arrangement of FIG. 1*a* with three similar elements, the voltages across the three impedances will be equal.

If, however, one phase element is made to have a different phase angle, e.g., by making one element capacitive, the voltages across the elements will no longer be equal. The arrangement is shown in FIG. 1*b* where the resistor **16** has been replaced by a capacitance **18** in the phase supply L_3. If the remaining two resistors **14** and **15** are similar, the voltage across one resistor will be greater or less than that across the other resistor depending upon the direction of rotation of the three-phase supply.

This phenomenon is utilized in the present invention to provide a phase sensitive circuit, one arrangement of which is illustrated in FIG. 1*c*. In this arrangement one of the remaining resistors, for example resistor **14**, is replaced by a voltage sensitive relay **19** which is responsive to a preselected voltage whereby the relay contacts may be arranged to be open for one direction of phase rotation of the supply and to be closed for the other direction of phase rotation.

The circuit as shown in FIG. 1*c* is therefore responsive to the phase sequence of the three-phase supply and according to the invention this characteristic is used for controlling the operation of the starter circuits of an actuator so that the actuator will remain inoperative until the supply has been properly connected.

A typical starter circuit for controlling the operation of a valve actuator is shown in FIG. 2 of the drawings. The actuator may be of the kind described and claimed in the above-mentioned U.S. Pat. No. 3,198,033 having an electrical control unit in accordance with the above-mentioned U.S. Pat. No. 3,209,090. The control panel assembly may be in accordance with the above-mentioned U.S. Pat. No. 3,267,741 whereby the actuator is provided with a reversing starter which is located within the housing of the actuator and thereby forms an integral part of the mechanism.

The actuator includes a three-phase electric induction reversing motor **20** and after the assembly of the mechanism it is possible to determine the correct phase rotation for the motor to suit the starter control circuits by tests. The motor is provided with three supply lines **21**, **22** and **23** connected with the input connections A, B and C of the actuator. The supply lines **21**, **22** and **23** are controlled by a reversing contactor starter **24** having two sets of contacts **25** and **26**. The set of contacts **25** is under the control of an open contactor coil **27** in the open starter control circuit **28**, while the other set of contacts **26** is under the control of a close contactor coil **29** in the close starter control circuit **30**. In accordance with con-

ventional practice energization of one or other of the contactor coils 27, 29 in the starter control circuits 28, 30 closes the corresponding set of contacts 25 or 26 to change the phase rotation of the supply by connecting the motor 20 to the appropriate input connections so that the motor is rotated in the corresponding direction.

The present invention utilizes the phase sequence sensitive circuit of FIG. 1*c* as part of the actuator starter circuit so as to ensure that energization of the motor 20 is completely prevented until the external electrical supply has been properly phase connected to the connections A, B and C of the actuator.

The phase sequence sensitive circuit is shown generally by the reference 31 and, by way of example, the relay 19 is connected with input connection A, the resistor 15 or other impedance is connected with the input connection B, and the capacitance 18 is connected with the input connection C. The relay 19 is a voltage sensing relay which may be of any suitable electromagnetic, thermal, thermionic or semiconductor type.

The relay 19 controls a contact 32 which is located in a supply line 33 common to both the starter control circuits 28 and 30. In the embodiment shown the contact 32 is normally open, thus preventing operation of either of the starter control circuits until the contact is closed by the relay 19 which only occurs when a predetermined voltage level is reached as a result of a correct phase rotation resulting from the correct connection of the three-phase supply to the input connections A, B and C.

If desired the relay 19 can be arranged to open a normally closed contact 32.

The starter circuits 28, 30 are preferably energized from the two phases of the supply not directly connected with the relay 19. In the drawing the supply line 33 extends from input connection B and is connected with the open and close starter circuits 28 and 30 through the relay contact 32 and a normally closed motor overload switch 34. The starter circuits 28 and 30 are connected in parallel with a supply line 35 which extends to input connection C and which includes a normally closed stop button 36.

The open starter circuit 28 includes the open contactor coil 27, one or more limit switches 37 which may be position and/or torque switches, and a press-button starter switch 38. In order to move the valve to its open position the open pushbutton 38 is depressed and this will energize the open contactor coil 27 so long as the contact 32 is in its closed position under the control of its relay 19 in the phase sequence sensitive circuit 31. Energization of the coil 27 closes the set of contacts 25 to rotate motor 20 and closes contact 39 in a holding circuit 40 in parallel with pushbutton 38. The motor 20 thereby continues to rotate to move the valve to its open position until one or other of the position switches 37 are tripped to deenergize the starter circuit.

The operation in the reverse direction to close the valve is similar, the close starter circuit 30 being controlled by the press-button 41 which energizes close contactor coil 29 to close the set of contacts 26 thus reversing the phase rotation of the supply to motor 20. At the same time the coil 29 closes the contact 42 in the holding circuit 43 in parallel with pushbutton 41. The close starter circuit 30 includes one or more limit switches 44 which may be position and/or torque switches.

The starter control circuits described above are illustrated only by way of example and many changes can be made in the nature and disposition of the various components of the circuits. For example, the contactor coils could be replaced by static switching components of the semiconductor type.

The supply for the starter control circuits 28 and 30 is preferably taken from the input connections (i.e., phases) to which the relay 19 is not directly connected as the arrangement permits the circuit to operate also to prevent starting of the motor 20 under single-phase conditions, providing the impedance of the elements 15, 18 and 19 in the phase sequence sensitive circuit 31 is high compared with that of the contactor coils. In most cases, if one phase of the supply is dead the motor will fail to start and just heat up, but if it does manage to start there is no certainty as to which way it will run. The present invention avoids this difficulty as absence of voltage at input connection B or C will prevent energization of the contactor coils 27, 29, while absence of voltage at input connection A will prevent relay 19 from picking up to close contact 32. In each case the starter control circuits will remain dead.

In FIG. 3 a modified starter control circuit is shown having an indication for showing visually if the phase rotation of the supply is incorrect or if any one phase is dead.

The input lines 31, 35 of the control circuits are connected across the secondary winding 45 of a transformer 46, the primary winding 47 of which is connected across the input connections B and C. A low voltage lamp 48 is connected across supply lines 31, 35 via an impedance shown as resistor 49 so that the lamp will be out if the phase rotation is incorrect (relay 19 inoperative) even if all three phases are live, or if any one phase is dead.

In FIG. 4 a further modified control circuit is shown which provides an actuator capable of operating over a wide voltage range with minimum change of components.

The supply lines 31, 35 for the starter control circuits are connected as in FIG. 3 with the secondary winding 50 of a transformer 51 to provide a 110-volt supply. The primary winding 50 of the transformer is used an autotransformer and has a number of tappings of which three are shown by references 53*a*, 53*b* and 53*c* as indicating voltage supplies of, say, 550, 440 and 220 volts.

The voltage sensitive relay 19 and capacitance 18 of the phase sequence sensitive circuit are connected permanently across a fixed voltage, e.g., 440 volts as shown and the only variable component is the resistor of the phase sequence sensitive circuit which is shown by reference 54 and which is provided with tappings 55*a*, 55*b* and 55*c* to correspond to the tappings 53*a*, 53*b* and 53*c* on the primary winding 52. Input connections A and B are connected with appropriate tappings on the primary winding 52 and the resistor 54 by a switch 56 having movable contacts 57, 58.

The starter circuits may be connected directly across two phases of the supply as described above, or they may equally be fed through a transformer from live to neutral or from a separate AC or DC supply.

The control circuit of the present invention thereby prevents operation of the actuator until the external electrical supply is properly phase connected. In addition, the circuit subsequently prevents operation of the starter circuits upon failure of any one of the supply phases.

I claim:

1. A three-phase electric motor operated actuator having a reversing starter circuit which forms an integral part of the actuator assembly and which is operable to change the phase rotation of the motor supply to reverse the direction of rotation of the motor, and a control circuit which is sensitive to the phase sequence of the electrical supply when connected to the actuator and which is operative to prevent energization of the starter circuit of the actuator if the phase sequence is incorrect, said phase sequence sensitive control circuit comprising three elements connected respectively across the three power supply lines to the actuator in the form of a star, said elements comprising a voltage sensing relay, an impedance and a capacitor, the voltage across the relay being greater or less than that across the impedance depending on the direction of rotation of the three-phase supply to the actuator, said voltage sensing relay comprising a contact in the reversing starter circuit which prevents operation of the starter circuit until the relay is energized by a voltage level corresponding to one particular direction of rotation of the three-phase supply to the actuator, said reversing starter circuit being fed from the two-phase lines of the actuator not directly connected to the voltage sensing relay so that operation of the starter circuit is prevented also on failure of any one of the phases of the three-phase supply.

2. An electric actuator as claimed in claim 1, wherein the relay contact is normally open and is common to a pair of parallel connected starting circuits each of which includes a start button and static switching components controlling contacts in the motor supply lines of the actuator.

3. An electric actuator as claimed in claim 2, wherein the voltage sensing relay is selected from the group consisting of electromagnetic, thermal, thermionic and semiconductor relays.

4. An electric actuator as claimed in claim 1, further comprising a visual indicating means in the reversing starter circuit for indicating incorrect phase sequence and failure of any one phase of the actuator supply.

5. An electric actuator as claimed in claim 1, in which the reversing starter circuit is fed by means of a transformer from two of the phase supply lines.

6. An electric actuator as claimed in claim 5, in which the primary winding of the transformer and the impedance of the phase sequence sensitive circuit are both provided with a number of voltage tappings for connection to the corresponding phases of the actuator supply so as to provide a wide voltage range.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,551,749 Dated December 29, 1970

Inventor(s) DONALD L. HORE

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The assignee should be

ROTORK CONTROLS LIMITED

Signed and sealed this 6th day of April 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents