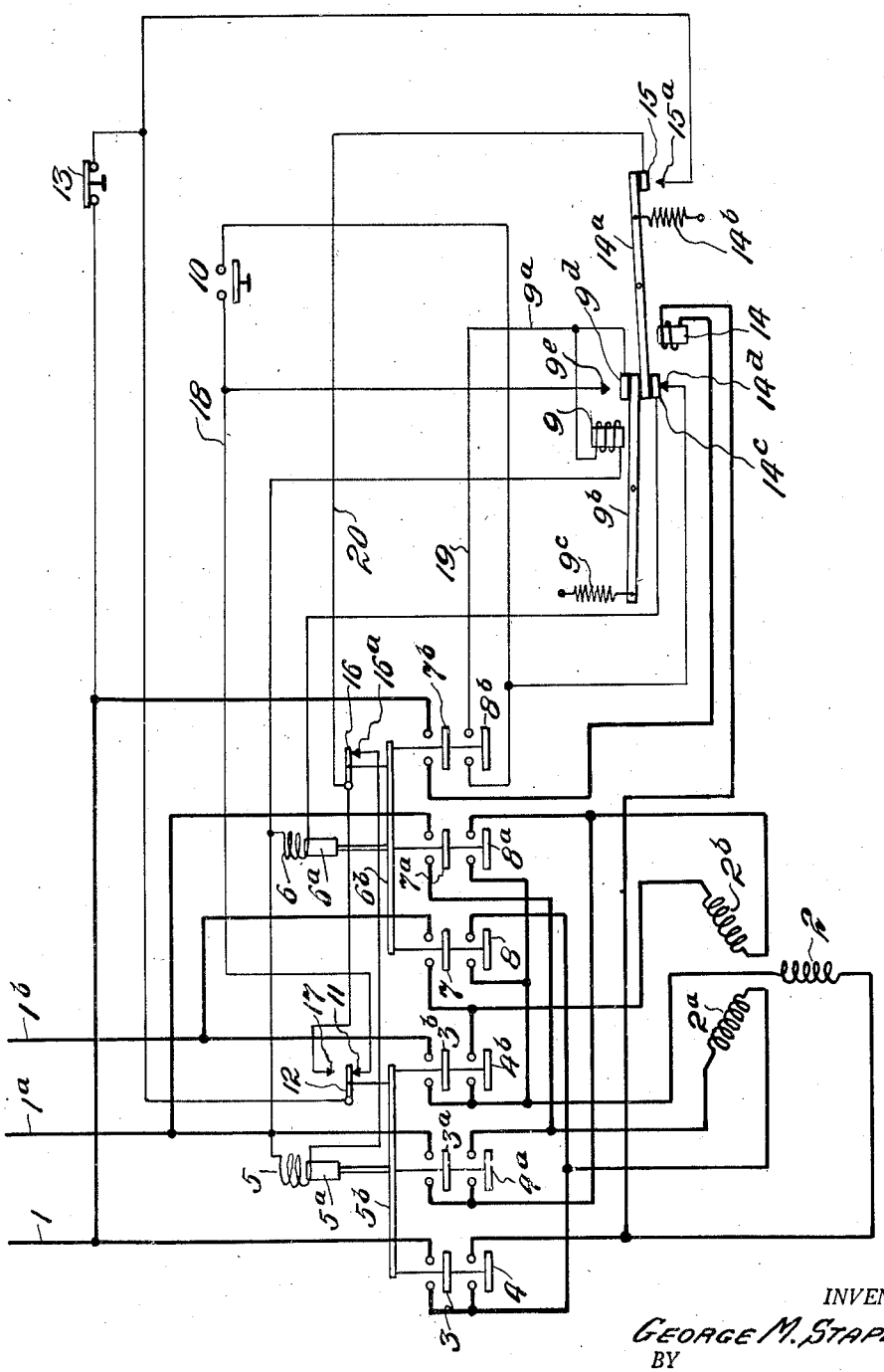
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ELECTRIC CONTROLLING APPARATUS

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ELECTRIC CONTROLLING APPARATUS

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This invention relates to apparatus for starting an electric motor by the sequential movement automatically of various controlling parts, the control being dependent upon the change of the starting current as the motor is brought up to speed.

The main object is to so interlock and interrelate the various controlling parts as to insure their proper sequence of operation in starting the motor. Another object is to prevent at all times the improper functioning of the apparatus even if it be attempted to actuate the controlling parts improperly. Other objects and advantages of the invention will be understood from the following description and accompanying drawing which illustrates one embodiment of the invention as applied to the starting of a three-phase induction motor by first connecting its windings in star relationship and then in delta relationship to the source.

The drawing is a diagram showing the various controlling parts and connections and the mechanical and electrical interlocking relationships.

The three-phase supply lines 1, 1*a* and 1*b* supply energy to the three-phase motor windings 2, 2*a* and 2*b*. For this particular method of starting, the running contactor switch is composed of two sets of three movable bridging contacts, the upper set 3, 3*a* and 3*b* serving as line switch connections and the lower set 4, 4*a* and 4*b* serving to connect the motor windings in delta relationship. This contactor is moved to closed position upon the energization of a relay winding 5 having an armature 5*a* which actuates the bridging contacts to their closed or open positions by connection to a cross bar 5*b* which in turn supports and insulates the bridging movable contacts. When this switch is closed, the bridging contacts will engage fixed contacts which are connected to the supply line and to the motor windings as shown.

The starting contactor is moved to closed position upon the energization of its relay winding 6 having a movable armature 6*a* which in turn is connected to a cross member 6*b*. The bridging contacts of the starting contactor are supported by and insulated from the cross member 6*b* and are arranged in two sets of contacts, the upper set 7, 7*a* and 7*b* serving as line connectors and two of the lower set 8 and 8*a* serving to form the junction of the star connection. The right-hand contact 8*b* serves to energize a controlling shunt relay and also the winding 6 of the starting contactor.

The controlling shunt relay winding 9 is shown connected at one terminal to the middle supply line 1*a* and a lead 9*a* from the other terminal is connected to one of the fixed contacts engaged by the bridging contact 8*b*, the other fixed contact engaged thereby being connected through a starting button 10 to an auxiliary fixed contact 11 of the running contactor. The fixed contact 11 is engaged by a movable contact 12 when the running contactor is open and in turn is connected through a stop button 13 to the supply line 1. When the shunt relay 9 is energized and attracts its movable pivoted armature 9*b* against the action of a restraining spring 9*c*, a movable contact 9*d* carried by the armature engages a fixed contact 9*e*. This fixed contact is connected to the fixed auxiliary contact 11 of the running contactor; and the movable contact 9*d* is connected to a terminal of the shunt winding 9.

The current or series relay comprises a winding 14 which is connected in series with one of the motor windings when the starting contactor is closed. When this series relay is energized it will attract a pivoted armature 14*a* against the action of a restraining spring 14*b* and then cause its movable contact 14*c* to engage a fixed contact 14*d*. The movable contact 14*c* is connected to one terminal of the winding 6 of the starting contactor, the other terminal of the winding 6 being connected to the supply line 1*a*. The fixed contact 14*d* is connected to a terminal of the starting button 10 and to a fixed contact engaged by the bridging contact 8*b* of the starting contactor. When the series relay is deenergized, it will cause a movable contact 15 to engage a fixed contact 15*a*. The fixed contact 15*a* is connected to the supply line 1 through the stop button 13. The movable contact 15 is connected to the movable auxiliary contact 16 operated by the starting contactor; and when the latter is open, the contact 16 engages a fixed contact 16*a* which is connected to one terminal of the winding 5 of the running contactor, the other terminal thereof being connected to the supply line 1*a*. When the running contactor is moved to the closed position, it causes its movable contact 12 to engage a fixed contact 17 which is connected to the movable auxiliary contact 16 of the starting contactor.

The armatures of the controlling shunt relay and of the series current relay are mechanically interlocked in any suitable manner so that whenever the shunt relay is deenergized, the armature of the series relay is forced to its attracted position. In the drawing, for simplicity of illustration, one end of the armature 9*b* is shown extending over one end of the armature 14*a*;

and, by reason of the force of the spring 9c overpowering the pull of the spring 14b, the armature 9b of the shunt relay forces the armature 14a of the current relay to the position shown in the drawing whenever the shunt relay is deenergized. In this position the contact 14c of the current relay is in engagement with the fixed contact 14d; and the contact 15 of the relay is out of engagement with the fixed contact 15a.

The drawing shows the parts in position for starting the motor. The starting is accomplished by merely closing the push button 10 momentarily. This closes a circuit through the winding 6 of the starting contactor by a circuit from the supply line 1 through the stop button 13, then through the movable contact 12 of the running contactor to its fixed contact 11 and then through the lead 18 and the starting button 10 through the contacts 14d and 14c of the current relay through the winding 6 of the starting contactor and thence to the supply line 1a. This energization of the winding 6 results in closing the starting contactor by moving its bridging contacts to engage their respective fixed contacts. It also results in separating the auxiliary contact 16 from the fixed contact 16a which introduces an additional break in the circuit of the winding 5 of the running contactor. This electrical interlock insures that the running contactor cannot be energized until after the starting contactor has moved to open circuit position.

The closing of the starting contactor closes the starting circuits of the motor and in this particular instance connects the motor windings 2, 2a and 2b in star connection and causes the starting current of one of the motor windings to pass through the current winding 14 of the series relay. These starting motor circuits may be traced as follows: from the supply line 1 through the bridging contact 7b, through the current winding 14 and through the motor winding 2 to a neutral connection formed by the closing of the bridging contacts 8 and 8a; also from the supply line 1a through the bridging contact 7a, through the motor winding 2a to the neutral point; and also from the supply line 1b through the bridging contact 7 and through the motor winding 2b to the neutral connection.

When the starting contactor closes, it also energizes the winding 9 of the shunt relay by a circuit from the supply line 1 through the stop button 13 and through the auxiliary contacts 12 and 11 of the running contactor, through the starting button 10, bridging contact 8b and through the lead wire 19 to the shunt winding 9 and thence to the supply line 1a. This results in attracting the armature 9b of the shunt relay which moves the contact 9d into engagement with the fixed contact 9e. This maintains the shunt relay winding energized after the starting button 10 is opened, by a circuit from the supply line 1 through the stop button 13, contacts 12 and 11, line 18 to the contacts 9e and 9d and thence through the relay winding 9 to the supply line 1a. The energization of the shunt relay also maintains closed the winding 6 of the starting contactor after the starting button 10 is opened by a circuit from the supply line 1, stop button 13, contacts 12 and 11 through line 18 to the contacts 9e and 9d and thence through line 19 and bridging contact 8b through contacts 14d and 14c and then through the starting contactor winding 6 to the supply line 1a. The attraction of the armature 9b by the energization of the shunt relay has no immediate effect in mechanically releasing the armature of the current relay because the passage of the starting current through the current winding 14 serves to retain the armature 14a in the position shown.

As the motor increases in speed the value of the starting current gradually decreases to the drop-out value of the current relay at which time the armature 14a is released. This separates the contact 14c from the contact 14d which opens the previously traced circuit of the winding 6 of the starting contactor and permits this contactor to move to the open position shown. This opens the motor starting circuits and also causes the auxiliary movable contact 16 to engage its fixed contact 16a. This results in closing the circuit through the winding 5 of the running contactor by a circuit from the supply line 1a through the winding 5, contacts 16a and 16 and through wire 20 to contacts 15 and 15a, which have been closed by the release of the armature of the current relay, and thence through the stop button 13 to the supply line 1. This energization of the winding 5 of the running contactor closes its bridging contacts connecting the motor windings in delta, and thereby brings the motor to its normal running speed condition. These circuits may be traced as follows: from supply line 1 through bridging contactor 3 to the motor winding 2a, thence through bridging contacts 4a and 3a to the supply line 1a; also from the supply line 1a through the bridging contact 3a through the motor winding 2b and thence through the bridging contacts 4b and 3b to the supply line 1b; and also from the supply line 1b through the bridging contact 3b through the motor winding 2 and to the bridging contacts 4 and 3 to the supply line 1.

The closing of the running contactor separates the auxiliary contact 12 from the contact 11 which opens the maintaining circuit of the shunt relay and thereby deenergizes this relay, permitting its armature 9b to force the armature 14a to the position shown in the drawing by the mechanical interlock of the armatures. This places the current relay in position for enabling the starting of the motor again by the starting button after the running contactor is opened; and also introduces a break in the circuit of the winding 6 so that the running contactor cannot be closed during the starting operation until the starting current has been reduced to the proper value. The separation of the auxiliary contact 12 from its contact 11 also introduces a break in the circuit to the starting button 10 so that even if this button be closed it cannot have any effect upon the starting contactor and thereby prevents the closure of the starting contactor whenever the running contactor is closed. The closure of the running contactor also moves the auxiliary contact 12 to engage the fixed contact 17 and this maintains closed the circuit of the winding 5 of the running contactor by a circuit from the supply line 1a through the winding 5, auxiliary contacts 16a and 16 of the starting contactor, thence through contacts 17 and 12 and through the stop button 13 to the supply line 1.

The motor is stopped by momentarily opening the push button 13 which opens the maintaining circuit of the winding 5 of the running contactor and causes the parts to assume the position shown in the drawing.

It is apparent from the foregoing that the starting contactor cannot be closed unless the running contactor is open and the running contactor cannot be closed until the starting contac-

tor is opened after previously starting the motor. Also the running contactor cannot be closed until the starting current has been reduced to a proper value as the closing of the running contactor is dependent upon the release of the armature of the current relay after the current has been reduced to the proper drop-out value. Furthermore by reason of the mechanical interlock of the controlling relays, the shunt relay when deenergized, places the armature of the current relay in position to permit the energization of the closing winding of the starting contactor by the starting button provided the running contactor is open; and after the shunt relay is energized it permits the current relay to release its armature at the proper value of starting current to thereby deenergize the winding of the starting contactor and energize the winding of the running contactor. The control provides low voltage protection at all times during the starting and running periods.

Although this improvement is disclosed as applying to the starting of an induction motor by changing its windings from star to delta connection, it may readily be applied to other starting methods such as to the removal of starting resistances from the motor circuit, the changing of transformer connections and various other methods of control. Also various modifications of this disclosure may be made for adaptation to particular requirements without departing from the scope of the invention.

I claim:

1. Motor starting apparatus comprising an electromagnetic starting contactor, a current relay subjected to the starting current of the motor, said relay in the attracted position of its armature having a pair of engaged contacts in the exciting circuit of the magnet of the starting contactor, and a controlling relay having its armature mechanically interlocked with the armature of said current relay for forcing the armature of the current relay to its attracted position when the controlling relay armature is in its unattracted position, said controlling relay having its energizing circuit dependent upon the closing of said starting contactor for thereby attracting its armature for mechanically releasing the armature of the current relay for enabling the armature of the current relay to be moved to its unattracted position upon the starting current of the motor decreasing to the drop-out value of the current relay and thereby separating said engaged contacts for deenergizing said starting contactor.

2. Motor starting apparatus comprising an electromagnetic starting contactor, an electromagnetic running contactor, a current relay subjected to the starting current of the motor, said relay in the attracted position of its armature having a pair of separated contacts in the exciting circuit of the magnet of the running contactor, and a controlling relay having its armature mechanically interlocked with the armature of said current relay for forcing the armature of the current relay to its attracted position when the controlling relay armature is in its unattracted position, said controlling relay having its energizing circuit dependent upon the closing of said starting contactor for thereby attracting its armature for mechanically releasing the armature of the current relay for enabling the armature of the current relay to be moved to its unattracted position upon the starting current of the motor decreasing to the drop-out value of the current relay and thereby closing said separated contacts for energizing said running contactor.

3. Motor starting apparatus comprising an electromagnetic starting contactor, an electromagnetic running contactor, a current relay subjected to the starting current of the motor, said relay in the attracted position of its armature having a pair of engaged contacts in the exciting circuit of the magnet of the starting contactor and having a pair of separated contacts in the exciting circuit of the magnet of the running contactor, and a controlling relay having its armature mechanically interlocked with the armature of said current relay for forcing the armature of the current relay to its attracted position when the controlling relay armature is in its unattracted position, said controlling relay having its energizing circuit dependent upon the closing of said starting contactor for thereby attracting its armature for mechanically releasing the armature of the current relay for enabling the armature of the current relay to be moved to its unattracted position upon the starting current of the motor decreasing to the drop-out value of the current relay and thereby separating said engaged contacts for deenergizing said starting contactor and closing said separated contacts for energizing said running contactor.

4. A motor starting apparatus comprising an electromagnetic starting contactor, a current relay subjected to the starting current of the motor, said relay in the attracted position of its armature having a pair of engaged contacts in the exciting circuit of the magnet of the starting contactor, a controlling relay having its armature mechanically interlocked with the armature of said current relay for forcing the armature of the current relay to its attracted position when the controlling relay armature is in its unattracted position, a starting switch, said controlling relay having its initial energizing circuit dependent upon the closing of said starting switch and of said starting contactor for thereby attracting its armature for mechanically releasing the armature of the current relay for enabling the armature of the current relay to be moved to its unattracted position upon the starting current of the motor decreasing to the drop-out value of the current relay and thereby separating said engaged contacts for deenergizing said starting contactor, said controlling relay having contacts closed upon its energization for maintaining closed its own energizing circuit and the energizing circuit of the starting contactor after the opening of said starting switch, and the deenergization of said controlling relay being dependent upon the separation of said engaged contacts and the opening of the starting contactor.

5. Motor starting apparatus comprising an electromagnetic starting contactor, an electromagnetic running contactor, a current relay subjected to the starting current of the motor, said relay in the attracted position of its armature having a pair of engaged contacts in the exciting circuit of the magnet of the starting contactor and having a pair of separated contacts in the exciting circuit of the magnet of the running contactor, a starting switch, and a controlling relay having its armature mechanically interlocked with the armature of said current relay for forcing the armature of the current relay to its attracted position when the controlling relay armature is in its unattracted position, said controlling relay having its initial

energizing circuit dependent upon the closing of said switch and of said starting contactor for thereby attracting its armature for mechanically releasing the armature of the current relay for enabling the armature of the current relay to be moved to its unattracted position upon the starting current of the motor decreasing to the drop-out value of the current relay and thereby separating said engaged contacts for deenergizing said starting contactor and closing said separated contacts for energizing said running contactor, said controlling relay having contacts closed upon its energization for maintaining closed its own energizing circuit and the energizing circuit of the starting contactor after the opening of said starting switch, and the deenergization of said controlling relay being dependent upon the separation of said engaged contacts and the opening of the starting contactor and the closing of the running contactor.

6. Motor starting apparatus comprising an electromagnetic starting contactor, an electromagnetic running contactor, a current relay subjected to the starting current of the motor, said relay in the attracted position of its armature having a pair of engaged contacts in the exciting circuit of the magnet of the starting contactor and having a pair of separated contacts in the exciting circuit of the magent of the running contactor, a starting switch, and a controlling relay having its armature mechanically interlocked with the armature of said current relay for forcing the armature of the current relay to its attracted position when the controlling relay armature is in its unattracted position, said controlling relay having its initial energizing circuit dependent upon the closing of said switch and of said starting contactor for thereby attracting its armature for mechanically releasing the armature of the current relay for enabling the armature of the current relay to be moved to its unattracted position upon the starting current of the motor decreasing to the drop-out value of the current relay and thereby separating said engaged contacts for deenergizing said starting contactor and closing said separated contacts for energizing said running contactor, said controlling relay having contacts closed upon its energization for maintaining closed its own energizing circuit and the energizing circuit of the starting contactor after the opening of said starting switch, the energization of said controlling relay being dependent upon the separation of said engaged contacts and the opening of the starting contactor, and auxiliary contacts separated upon the closing of the running contactor for introducing a break in the circuit of said starting switch and in the maintaining circuit of said controlling relay.

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