H. L. KEITH.

CONTROL SYSTEM.

APPLICATION FILED DEC. 17, 1919.

1,387,990. **Patented Aug. 16, 1921.**

2 SHEETS—SHEET 1.

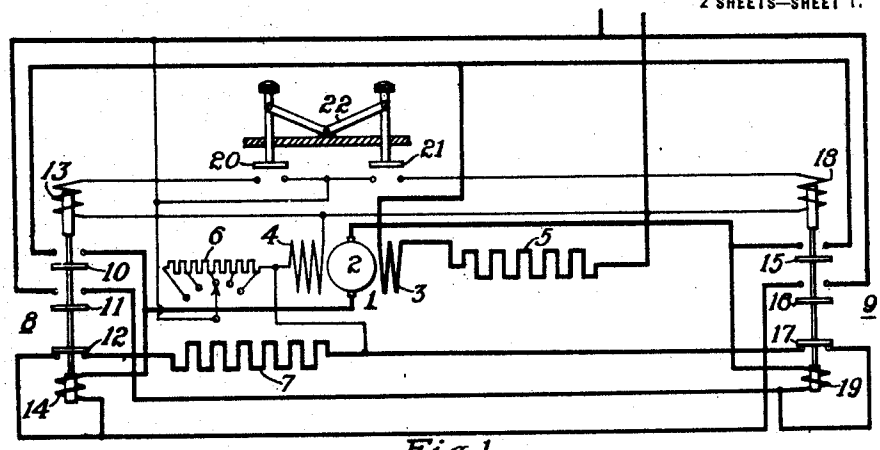


Fig. 1.

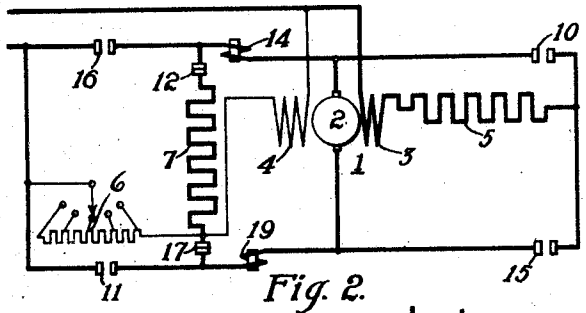


Fig. 2.

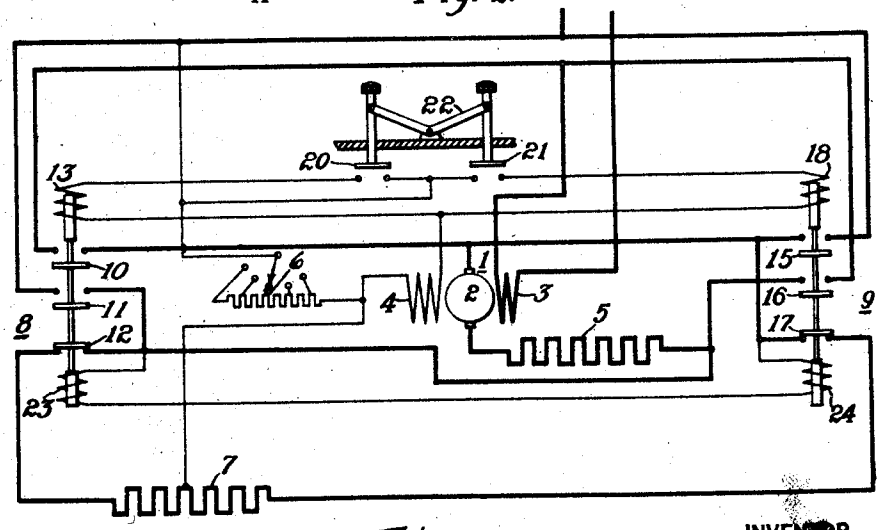


Fig. 3.

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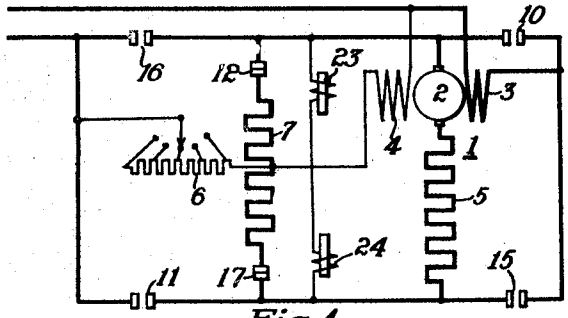


Fig. 4.

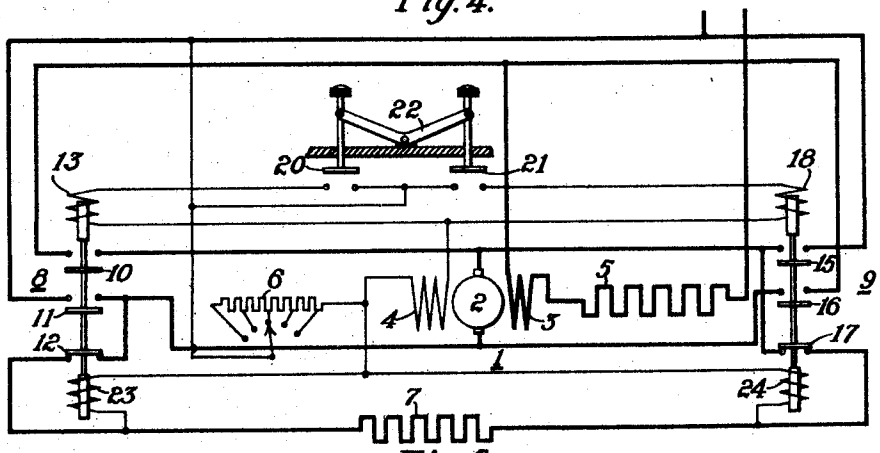


Fig. 5.

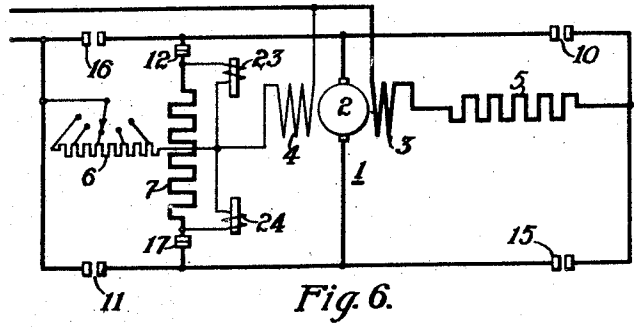


Fig. 6.

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CONTROL SYSTEM.

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Application filed December 17, 1919. Serial No. 345,600.

To all whom it may concern:

Be it known that I, HAROLD L. KEITH, a citizen of the United States, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Control Systems, of which the following is a specification.

My invention relates to control systems for electric motors and particularly to systems for controlling motors subjected to quick reversals of their direction of operation.

One object of my invention is to provide an improved and simplified system of control in which plugging of the motor is prevented when an attempt is made either to reverse the motor or to establish dynamic-braking connections.

Another object of my invention is to provide an electrical interlocking system which shall prevent the simultaneous closure of both directional contactors when, through accident or mistake, push buttons for both forward and reverse directions of operation are depressed.

Figure 1, Fig. 3 and Fig. 5 of the accompanying drawings are diagrammatic views of systems of control embodying my invention. Fig. 2, Fig. 4 and Fig. 6 are schematic diagrams of the main portions of the control systems respectively shown in Fig. 1, Fig. 3 and Fig. 5.

The system of control illustrated in Fig. 1 comprises an electric motor 1 having an armature 2, a series field-magnet winding 3, and a shunt field-magnet winding 4. A starting resistor 5 is provided for limiting the initial value of current supplied to the motor armature 2, and a field resistor 6 is adapted to control the degree of energization of the field-magnet winding 4. A plurality of directional switches 8 and 9, respectively corresponding to the forward and reverse directions of operation of the motor 1, are adapted to establish the various circuit relations for the motor 1.

The directional switch 8 is provided with contactors 10 and 11, which establish circuits for operating the motor 1 in a forward direction, and with a back contactor 12 which establishes dynamic-braking connections for the motor. The directional contactors 10 and 11 are actuated to their closed positions by an electromagnet coil 13. The back contactor 12 is maintained in a closed position by the energization of electromagnet coil 14 which also maintains contactors 10 and 11 in their open positions.

Directional switch 9 is provided with contactors 15 and 16, which establish circuits for operating the motor in a reverse direction, and with a back contactor 17 which establishes dynamic-braking connections for the motor. The directional contactors 15 and 16 are actuated to their closed positions by an electromagnet coil 18 which also actuates contactor 17 to an open position. Switches 15 and 16 are maintained in an open position by means of electromagnet coil 19 which also maintains contactor 17 in a closed position.

Energizing circuits for coils 13 and 18 are respectively controlled by push-button switches 20 and 21. The push-button switches 20 and 21 are interlocked by means of a pivotally mounted bar 22, or similar means, in such manner that only one push-button may be depressed at a time. When one button is depressed, the remaining button will be raised from engagement with the contact members.

Fig. 2 shows more clearly the circuit relations established during the operation of the system shown in Fig. 1. Similar apparatus performing similar functions is designated by like characters throughout the various figures of the drawings.

To operate the motor illustrated in Fig. 1 and Fig. 2 in a forward direction, push button 20 is depressed to establish an energizing circuit for coil 13. Directional switch 8 is thereby actuated to close contactors 10 and 11 and open back contactor 12. A circuit is thereby established from the positive side of the supply circuit, through contactor 11, coil 19, armature winding 2, contactor 10, starting resistor 5 and series field-magnet winding 3, to the negative side of the supply circuit. The shunt field-magnet winding 4 is energized through contactors 11 and 17 which shunt the field rheostat 6 from the circuit to establish a relatively strong field excitation for the motor during forward operation.

Coil 19 serves as an interlocking means for maintaining directional switch 9 in an open position when the system is energized through directional switch 8 for forward operation of the motor.

If it is desired to arrest the operation of the motor or to reverse its direction of operation, push-button 21, which corresponds to the reverse direction of operation of the motor, is depressed. The opening of push-button switch 20 interrupts the energizing circuit for coil 13 and, if reverse operation of the motor is desired, push-button 21 is depressed sufficiently to establish an energizing circuit for coil 18.

When the energizing circuit for coil 13 is interrupted, directional switch 8 drops to its open position. Back contactor 12 is closed when switch 8 is open and a braking circuit for armature winding 2 is established which includes coils 14 and 19, grouped in series-circuit relation with resistor 7, and contactors 12 and 17. The energization of coil 19, by the braking current traversing the armature winding, is of sufficient degree to prevent the actuation of reverse directional switch 9 so long as the current traversing the armature winding 2 exceeds a predetermined value.

When dynamic-braking connections are established by closing contactors 12 and 17, the rheostat 6 is inserted in series with field-magnet winding 4. The motor-field excitation may, therefore, be maintained at any desired degree during dynamic braking by regulating the resistance of rheostat 6.

It should be noted, in this connection, that, since the field excitation and the resistance of the dynamic-braking circuit are substantially constant, the excitation of coil 19 will be substantially proportional to the speed of operation of the motor. A reversal in the direction of operation of the motor may be adjusted by changing the relative pulls of coils 18 and 19 by altering the degree of excitation of the coils.

When the braking current decreases to a predetermined minimum value, coil 18 overcomes the pull exerted by series coil 19, which is energized by the current traversing the armature winding circuit, and actuates the reverse directional switch 9 to its closed position. The contactors 15 and 16 establish a circuit from the positive side of the supply circuit through contactor 16, coil 14, armature winding 2, contactor 15, series field-magnet winding 3 and resistor 5 to the negative side of the supply circuit.

This system of connection maintains the same polarity in field-magnet winding 4 that obtains during forward operation of the motor. The direction of the current traversing the circuit of the armature winding 2 is reversed, however, and the motor operates in the opposite direction. When switch 9 occupies its closed position, back contactor 17 is open and the motor field-magnet winding 4 is energized from the supply circuit through contactors 12 and 16 and braking resistor 7. Switches 12 and 16 substantially constitute a shunt for the field rheostat 6, since the relatively low resistance of the braking resistor 7 does not materially decrease the energization of the field-magnet winding during the operation of the motor in the reverse direction.

Operation of the system illustrated in Figs. 3 and 4 is effected in substantially the same manner as the operation of the system just described. If it is desired to operate the motor illustrated in Figs. 3 and 4 in the forward direction, push button 20 is depressed to close contactors 10 and 11. A circuit is established from the positive side of the supply line through contactor 11, starting resistor 5, armature winding 2, contactor 10 and series field-magnet winding 3 to the negative side of the supply line.

Coils 23 and 24 are connected, in parallel relation, to the motor armature winding 2 and starting resistor 5 and perform the same general functions as coils 14 and 15 of Fig. 1. Coils 23 and 24 are, however, energized throughout the operation of the system either when running connections are established or when the system is connected for dynamic-braking operation.

In view of the fact that the system cannot be energized until either directional contactor 8 or directional switch 9 is closed, contactor 8 will be actuated to its closed position before coils 23 and 24 are energized. The closure of switch 8 removes the magnetizable core member fror the magnetic field set up by the co-acting coil 23.

The pull exerted by coil 23, tending to open directional switch 8, is of a relatively small value when the magnetic core co-acting with the coil 23 is removed from the influence of the coil. The energized coil 13 can, therefore, maintain switch 8 closed during the forward operation of the motor and, since directional switch 9 occupied an open position when the associated coil 24 was energized, switch 9 will be definitely locked in place by the electromagnet coil 24.

The field-magnet winding 4 is, in this case, connected to a point intermediate the terminals of the resistor 7 to which the field rheostat 6 is also connected. Since contactor 11 is closed during forward operation of the motor, energy will be supplied to the field-magnet winding 4 through contactors 11 and 17 and coils 23 and 24 and a portion of the braking resistor 7. In view of the fact that the resistance of rheostat 7 is of relatively small value, as compared with the resistance of rheostat 6, switches 11

and 17 will substantially constitute a shunt circuit for rheostat 6.

If it is desired to arrest the operation of the motor, push button 21 is depressed to such degree as to interrupt the energizing circuit for coil 13. Switch 8 immediately opens and enables contactor 12 to close. Coils 23 and 24 are already energized and maintain switches 8 and 9 in their open positions, thereby closing back contactors 12 and 17 and establishing dynamic-braking connections for the motor armature 2. The braking circuit thus established comprises the armature winding 2, the contactor 12, brake resistor 7 and starting resistor 5. Coils 23 and 24 are energized in accordance with the electromotive force of the armature winding 2 and maintain the dynamic-braking connections for the motor so long as the motor speed exceeds a predetermined value, even though an actuating coil for one of the directional contactors is energized.

If the push button 21 is depressed to such degree to establish an energizing circuit for coil 18, switch member 9 will not be actuated to its closed position until the speed of the motor decreases to a predetermined minimum value. When the energization of coil 24, which maintains switch 9 in an open position and maintains back contactor 17 closed, decreases to a predetermined minimum value by reason of the slowing down of the motor armature 2, the pull of coil 18 overcomes that of coil 24, and switch member 9 is actuated to its closed position. The switch 9 establishes a circuit from the positive side of the supply line, through contactors 16, armature winding 2, starting resistor 5, contactor 15 and series field-magnet winding 3, to the negative side of the supply line.

The field-magnet winding 4 is energized from the supply circuit through contactors 11 and 17 or 12 and 16, depending upon the direction of operation of the motor, during the normal operation of the motor. When dynamic-braking connections are established, a degree of excitation of the motor field-magnet winding is maintained by inserting the field rheostat 6 in series relation with the field-magnet winding 4. By adjusting the resistance of rheostat 6, the dynamic-braking of the motor may be regulated through a wide range to effect the deceleration of the motor at a desired rate when braking connections are established.

Since the electromagnet coils 23 and 24 are permanently connected in shunt relation to the motor armature, they will be energized whenever the system is energized. It is, therefore, not necessary to build up the magnetic field for the coils 23 and 24 when dynamic-braking connections are established, and the operation of the co-acting parts of the switch members 8 and 9 is rendered rapid and certain.

The system of control illustrated in Figs. 5 and 6 employs coils 23 and 24, corresponding to the coils similarly designated in Figs. 3 and 4, for maintaining the directional switches in their off positions. With this system of connection, coils 23 and 24 are disposed in shunt relation to the armature winding 2 and the brake resistor 7 when contactors 12 and 17 occupy closed positions.

It is deemed unnecessary to completely trace the circuit relations for Figs. 5 and 6 since the distinguishing feature of this system is the connection of the field rheostat 6 and the field-magnet winding 4 to a common point intermediate the coils 23 and 24, which are grouped in series relation. As in the preceding system, rheostat 6 will be substantially shunted from the energizing circuit for the field-magnet winding 4 during motoring operation.

In the control systems illustrated, coils 14, 19, 23 and 24 function to interlock the directional contactors 8 and 9; to maintain an effective contact pressure on the back contacts during braking; and to prevent plugging the motor by too suddenly reversing its direction of operation.

The various methods of connecting the field-magnet winding in such manner that the excitation of the motor is automatically reduced during dynamic braking, are suggestive of other connections that may be employed for the same purpose.

Although I have described simple and preferred forms of my invention, it is apparent that the principles involved are capable of more general application and I desire, therefore, that only such limitations shall be imposed as are set forth in the appended claims.

I claim as my invention:

1. A control system comprising a supply circuit, a motor, a plurality of directional contactors for controlling the direction of operation of said motor, means comprising a braking contactor for establishing a braking circuit for said motor, a resistor included in said braking circuit, and electromagnet coils for positioning said directional contactors and said braking contactor, said coils being connected in series relation with each other and across the motor terminals inside said contactors, whereby, upon the closure of either of said directional contactors, said coils are energized from the supply circuit.

2. A control system comprising a motor having a field-magnet winding, field-reducing means associated with said winding, a plurality of directional contactors for controlling the direction of operation of said

motor, a braking contactor for establishing a braking circuit for said motor, and electromagnet coils for positioning said directional contactors and said braking contactors, said directional contactors being adapted to jointly render said field-reducing means ineffective when motoring conditions prevail in said system.

3. A control system comprising a motor having a field-magnet winding, a resistor for reducing the excitation of said field-magnet winding, a plurality of directional contactors for controlling the direction of operation of said motor, a braking contactor for establishing a braking circuit for said motor, said directional contactors being adapted to jointly shunt said resistor when motoring conditions prevail in said system.

4. A control system comprising a motor, having a field-magnet winding, directional contactors for controlling the direction of operation of said motor, braking contactors for establishing a braking circuit for said motor, means comprising a plurality of said directional contactors for reducing the excitation of said motor field when said braking circuit is established, and means for maintaining one pair of said directional contactors in their open positions when the other pair of said contactors are closed and for preventing the establishment of motoring connections when predetermined conditions prevail in said braking circuit.

5. A control system comprising a motor having a field-magnet winding, directional contactors for reversing the direction of operation of said motor, contactors for establishing a braking circuit for said motor, and means comprising a plurality of said directional contactors for changing the energization of said field-magnet winding when said braking circuit is established.

6. A control system comprising a motor having a field-magnet winding, directional contactors for reversing said motor, a braking circuit for said motor, a resistor included in said braking circuit, a rheostat for controlling the degree of energization of said field-magnet winding, a plurality of series-connected electromagnet coils for positioning said switches and for precluding the simultaneous operation of two pairs of directional contactors, said field-magnet winding and said field rheostat being connected to a point intermediate said coils.

7. A control system comprising a motor having a field-magnet winding, directional contactors for reversing said motor, a dynamic-braking circuit for said motor comprising a resistor, a rheostat for controlling the degree of energization of said field-magnet winding, and coils positioning said switches connected in shunt relation with said resistor, said field-magnet winding and said rheostat being connected to a common point of said resistor.

8. The combination with a motor, of reversing and dynamic braking means therefor and a plurality of coils for biasing said means and connected in shunt relation to the motor armature during normal operation and during dynamic braking.

9. The combination with an electric motor and reversing means therefor, of a plurality of coils connected in shunt relation to said motor and energized by the actuation of said reversing means for maintaining said reversing means inoperative.

10. The combination with a motor and a control switch therefor, of a coil for biasing the switch in one position, and a second coil in shunt relation to the motor, energized when said switch is biased, and operable upon deënergization of the first-named coil to return said switch to its initial position.

11. The combination with an electric motor and a plurality of controlling contactors therefor, of means comprising a plurality of coils, simultaneously energized with and in shunt relation to the armature of the motor for preventing the closure of one of said contactors while another is closed.

12. The combination with an electric motor and a plurality of controlling contactors therefor, of means comprising a plurality of coils, simultaneously energized with and in shunt relation to the armature of the motor for preventing the closure of one of said contactors while another is closed and for maintaining said contactors open under predetermined conditions.

13. The combination with a motor, of reversing and dynamic-braking means therefor, and a plurality of coils connected in shunt relation to the motor for biasing said reversing means during dynamic braking, both of said coils being energized in the normal operation of said motor.

14. The combination with a source of energy and a circuit-controlling device having a pair of coils for connection in shunt relation to said source of energy, one of said coils for actuating said circuit-controlling device and the other of said coils becoming energized by said actuation to restore said device when one of said coils is deënergized.

15. The combination with a shunt motor and a controlling switch therefor, of a coil controlled by the shunt field current during normal operation for retaining said switch in its open position.

16. The combination with an electric motor having a shunt field-magnet winding and a plurality of circuit controlling switches, of means controlled by the current traversing said winding for preventing the simultaneous closure of said switches.

17. The combination with an electric motor having a shunt field-magnet winding and a pair of controlling switches, of means controlled by an electrical condition of said field winding for retaining one of said switches in its open position when the other of said switches is closed.

18. The combination with an electric motor having a shunt field-magnet winding, and reversing means therefor, of means depending upon the degree of excitation of said field-magnet for restraining said reversing means.

19. The combination with an electric motor having a shunt field-magnet winding and reversing means therefor, of a coil for connection, successively, in circuit with said field winding and in circuit with the armature of said motor for controllng said reversing means.

20. The combination with an electric motor having a shunt field-magnet winding and reversing and dynamic-braking means therefor, of a pair of coils connected in circuit with the field-magnet winding, during normal operation, and energized by current traversing the armature during dynamic braking for controlling said reversing means.

In testimony whereof I have hereunto subscribed my name this 8th day of December, 1919.

HAROLD L. KEITH.