Sept. 1, 1925. 1,552,235

M. H. RUSSELL

SYSTEM AND APPARATUS FOR DELAYING RESPONSE OF ELECTRORESPONSIVE DEVICES

Filed Dec. 18, 1923 2 Sheets-Sheet 1

Fig. 1.

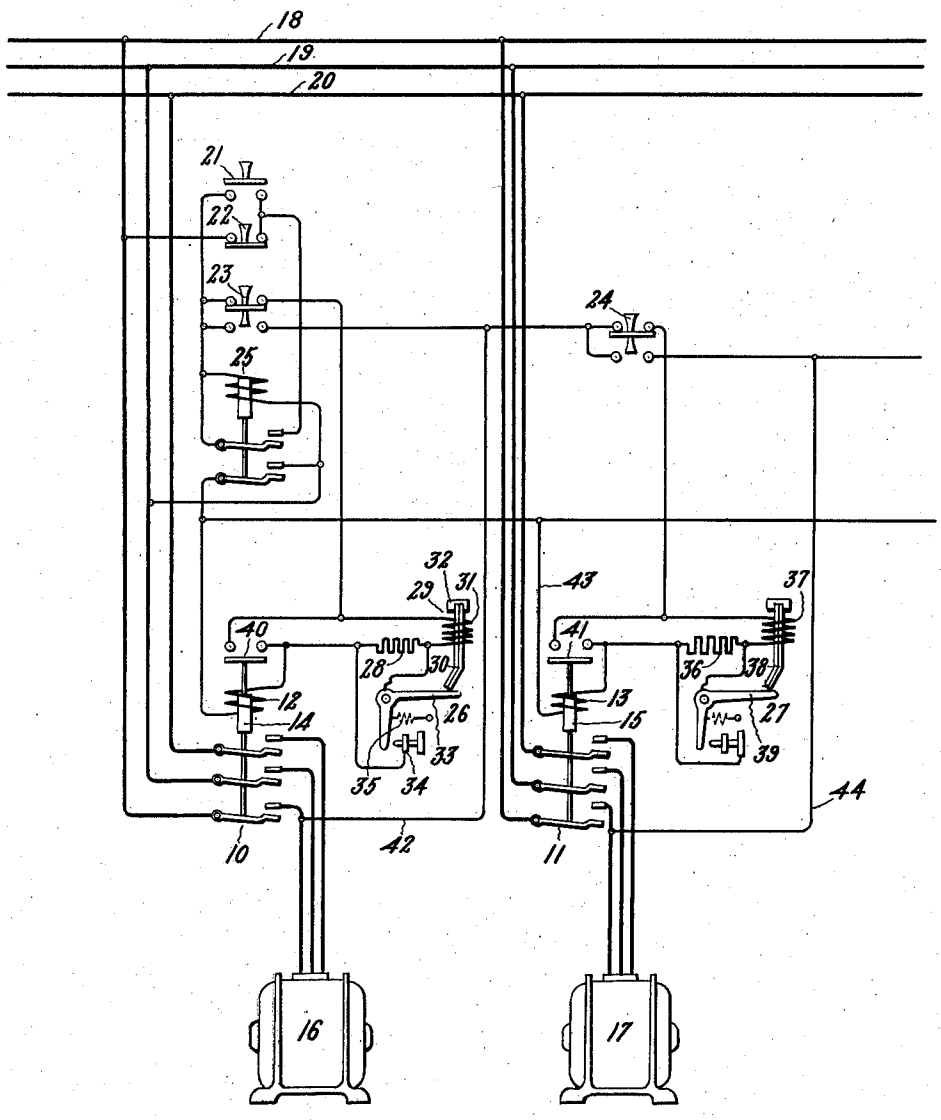

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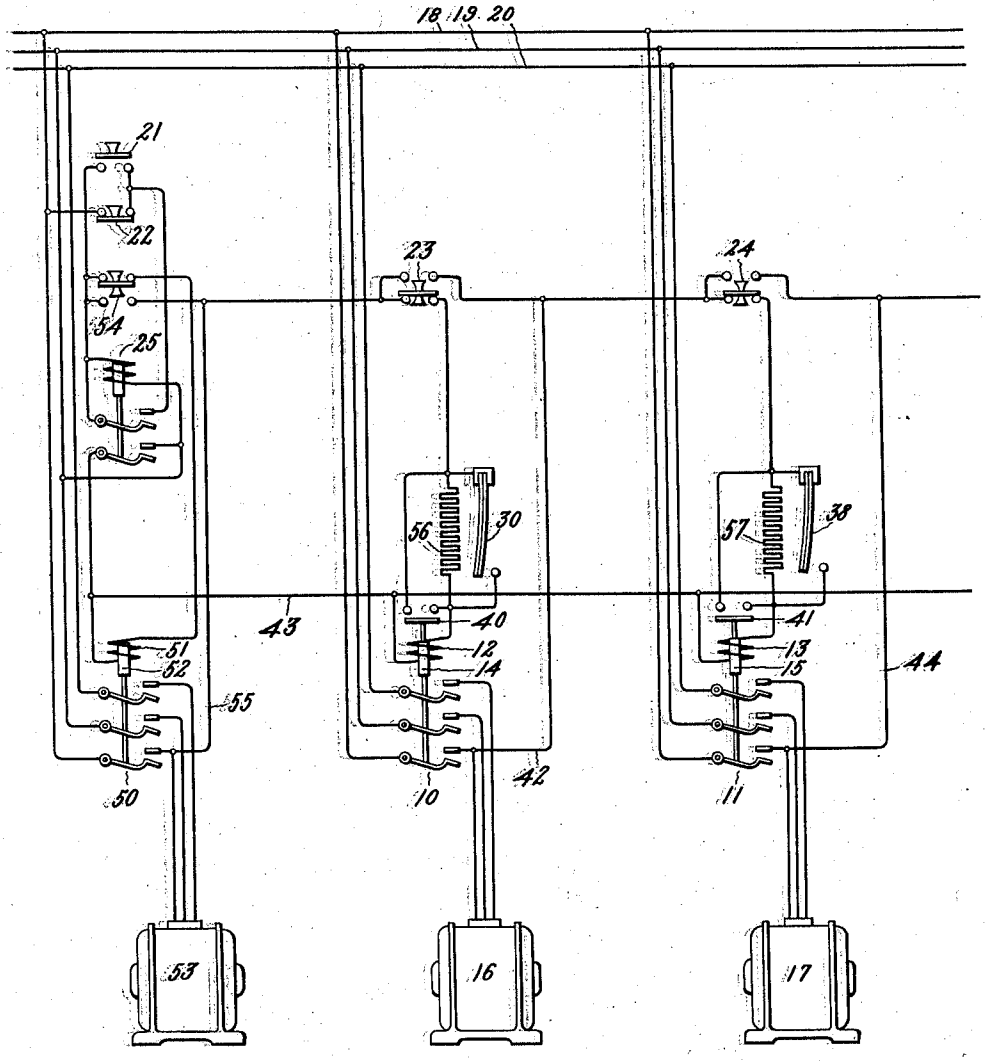
Fig. 2.



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Patented Sept. 1, 1925. 1,552,235

UNITED STATES PATENT OFFICE.

MARSHALL H. RUSSELL, OF CINCINNATI, OHIO, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

SYSTEM AND APPARATUS FOR DELAYING RESPONSE OF ELECTRORESPONSIVE DEVICES.

Application filed December 18, 1923. Serial No. 681,451.

To all whom it may concern:

Be it known that I, MARSHALL H. RUSSELL, a citizen of the United States, residing at Cincinnati, in the county of Hamilton, State of Ohio, have invented certain new and useful Improvements in Systems and Apparatus for Delaying Response of Electroresponsive Devices, of which the following is a specification.

My invention relates to electro-responsive devices and more particularly to electrically actuated control systems and apparatus for delaying the response of such devices.

One of the objects of my invention is to provide an improved electrically actuated control system and apparatus by means of which the response of an electro-responsive device is delayed for a predetermined time interval after the initial energization thereof.

Another object of my invention is the provision of means for normally preventing the response of an electro-responsive device together with an electrically actuated timing mechanism arranged to be energized simultaneously with the initial energization of the electro-responsive device for disabling the said means after a predetermined time interval so as to then permit response of the device and also of additional means actuated upon the response of the electro-responsive device for maintaining the first means disabled independently of the timing mechanism.

A further object of my invention is to provide an improved electrically actuated control system and apparatus for a series of electro-responsive devices in which the several devices respond successively at predetermined time intervals after the initial energization of the first device.

My invention is of particular utility in delaying the response of electro-magnetic switches employed in control systems although it will be evident that my invention may also be employed to delay the response of other electro-responsive devices.

For a better understanding of my invention, reference may be had to the following description together with the accompanying drawings in which Fig. 1 diagrammatically illustrates the invention applied to delay the response of a series of electromagnetic switches which control a plurality of electric motors and Fig. 2 shows a motor control system embodying a modified form of the invention. The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims.

Referring to Fig. 1 of the drawings, the electromagnetic switches 10 and 11 are provided with operating windings 12, 13, and movable magnetic members 14, 15, respectively, and constitute the electro-responsive devices to which my invention is applied. The electromagnetic switches 10 and 11 are arranged to independently connect the electric motors 16 and 17 respectively to the power supply lines 18, 19 and 20 through suitable electrical conductors. As shown, the motors 16 and 17 are each of the three phase alternating current type and the supply lines 18, 19 and 20 correspondingly represent a three phase alternating current source, although it will be evident that any other desired type of translating device may be arranged to be connected to a suitable supply source by the electromagnetic switches 10 and 11.

To control the energizing circuits of the operating windings 12 and 13 of the switches 10 and 11, the manually operated control buttons 21, 22, 23 and 24 are provided, the first two of which are biased by suitable means to the position shown and the last two are operable at will from the position shown to the position in which a circuit is closed at the lower contacts, together with the electromagnetic switch 25, which is biased to the position shown, and the several control buttons and switches are connected with the energizing circuits of the motors 16 and 17 in a manner which will be more fully described in connection with the operation of my invention.

In accordance with my invention, the electromagnetic switches 10 and 11 are each provided with an electrically actuated timing mechansim, indicated as 26 and 27 respectively, for delaying the response of the corresponding switches a predetermined time interval after the initial energization thereof. In the motor control system shown, this insures that the motors 16 and 17 are successively connected to the supply lines 18, 19 and 20 and accelerated to running speed, whereby the current required in starting the

several motors is materialy less than if they are simultaneously started.

The electrically actuated timing mechanism 26, in the preferred form shown, comprises an electrical controlling means such as the resistor 28 and an electrically heated thermal responsive relay 29 arranged to disable the controlling means. The resistor 28 is normally connected in series circuit with the operating winding 12 of electromagnetic switch 10 and is of sufficient ohmic resistance to prevent response of the latter when the energizing circuit of the winding 12 is closed. The thermal relay 29 includes a suitable thermal responsive member 30, which as shown is of the bi-metallic thermostatic type, and a heating coil 31, which is arranged in close thermal relation with the thermal responsive element 30 and is connected so as to be energized simultaneously with the energization of the operating winding 12 of electromagnetic switch 10. One end of the bi-metallic element 30 is fixed in a suitable support 32 and the free end is biased when cool to the position shown. When the coil 31 is energized, the thermal responsive element 30 is heated and the free end of the latter bends to the left and permits the pivoted switch 33 to be moved into engagement with the adjustable contact 34 by a suitable tension spring 35.

The electrically actuated timing mechanism 27 comprises a resistor 36, a heating coil 37, a thermal responsive element 38 and a pivoted switch 39, each of which is similar to the corresponding part of timing mechanism 26 and is arranged in the same manner, as previously described.

The electromagnetic switches 10 and 11 are provided with the auxiliary contacts 40 and 41 respectively which are moved to the closed position and short circuit the resistor and the heating coil of the corresponding electrically actuated timing mechanism 26 and 27 when each switch responds to energization of its operating winding.

As thus constructed and arranged and with the parts in their respective positions shown, the operation of my invention in delaying the response of electromagnetic switches 10 and 11 is as follows: Assume that the supply lines 18, 19 and 20 are suitably energized to operate the motors 16 and 17 when the electromagnetic switches 10 and 11 are operated to the closed position. Closure of control button 21 will initiate the successive operation of electromagnetic switches 10 and 11 by first establishing an energizing circuit for the operating winding of electromagnetic switch 25 from the supply line 18 through the control button 22 and control button 21 in series, and the operating winding of electromagnetic switch 25 to the other supply line 19.

Electromagnetic switch 25 at once closes and an energizing circuit for the operating winding 12 of electromagnetic switch 10 is completed from supply line 18 through the control button 22, the upper blade of switch 25, the control button 23, the heating coil 31 and the resistor 28 of the electrically actuated timing mechanism 26 in series, the operating winding 12 and thence through the lower blade of switch 25 to the other supply line 19. It will be observed that closure of the upper blade of electromagnetic switch 25 also completes a holding circuit for the operating winding of this switch in shunt with the control button 21 and the latter may then be released to return to the open position according to its bias.

As previously poined out, the resistor 28 limits the initial energizing current of operating winding 12 below the value at which the movable magnetic member 14 will respond. The heating coil 31, however, is energized by this initial energizing current of the operating winding 12 and gradually heats the thermal responsive element 30. After a predetermined time interval the thermal responsive element 30 will be sufficiently heated to bend to the left and permit the pivoted switch 33 to be moved into engagement with the adjustable contact 34 by tension spring 35. It will be understood that by proper adjustment of the contact 34, the time interval between the initial energization of operating winding 12 and the closure of pivoted switch 33 may be varied at will. Closure of the pivoted switch 33 short circuits the resistor 28 and thereupon the energizing current of operating winding 12 is increased to full value. This at once effects the response of movable magnetic member 14 to close the electromagnetic switch 10 and energize the motor 16 from the supply lines 18, 19 and 20. At the same time the auxiliary contact 40 of electromagnetic switch 10 is closed and short circuits both the resistor 28 and the heating coil 31 of the electrically actuated timing mechanism 26. Upon the deenergization of the heating coil 31, the thermal responsive element 30 is permitted to cool and return to the position shown in the drawing according to its bias, thus actuating the pivoted switch 33 against the strain of the tension spring 35 to the open position in preparation for a subsequent operation.

It will be observed that upon the closure of electromagnetic switch 10 and the consequent energization of motor 16, an energizing circuit for the operating winding 13 of electromagnetic switch 11 is completed from the supply line 18 through the lower blade of electromagnetic switch 10, the conductor 42, the control button 24, the heating coil 37 and resistor 36 of the electrically actuated timing mechanism 27 in series, the winding 13, the conductor 43, and the lower

blade of electromagnetic switch 25 to the other supply line 19. The resistor 36, however, prevents sufficient energization of the operating winding 13 to effect response of the movable magnetic member 15. The heating coil 37, is energized and heats the thermal responsive element 38 and the latter gradually moves to the left and after a predetermined time interval permits the pivoted switch 39 to close and short circuit the resistor 36. Thereupon the energization of operating winding 13 is increased to full value and effects response of movable magnetic member 15. The electromagnetic switch 11 is thus operated to the closed position and the motor 17 is energized from the supply lines 18, 19 and 20, the resistor 36 and the heating coil 37 are short circuited by means of the auxiliary contact 41, and the conductor 44 is connected to the supply lines 18 through the lower blade of switch 11.

Although I have illustrated only two electromagnetic switch which respond in sequence a predetermined time interval after the closure of the energizing circuits thereof, it will be understood that any desired number of additional electromagnetic switches may be operated in similar manner and I have shown the conductors 43 and 44 extended to the right to indicate connections to such additional electromagnetic switches.

Should it be desired to omit operation of the electromagnetic switch 10 and initially energize the electromagnetic switch 11 by the operation of control button 21, the control button 23 is first operated from the position shown so as to open the energizing circuit of the operating winding 12 of electromagnetic switch 10 at the upper contacts thereof and to close the energizing circuit of operating winding 13 of electromagnetic switch 11 at the lower contacts thereof. Closure of control button 21 and the consequent response of electromagnetic switch 25 will then initially complete an energizing circuit for operating winding 13 of electromagnetic switch 11 as follows: from supply line 18 through the control button 22, the upper blade of electromagnetic switch 25, the control button 23 in its lower position, the control button 24 and the heating coil 37 and resistor 36 of the electrically actuated timing mechanism in series, the operating winding 13, conductor 43 and the lower blade of electromagnetic switch 25 to the other supply line 19. This effects the response of electromagnetic switch 11 after a predetermined time interval in exactly the same manner as previously described. It will be evident that when additional electromagnetic switches are connected to the conductors 43 and 44, the control button 24 may be operated from the position shown to the position in which its lower contacts are closed in order to omit the operation of electromagnetic switch 11 and effect the delayed operation of the next succeeding switch.

At any time after the operation of control button 21 and the response of electromagnetic switch 25, further operation of my improved electrically actuated control system and apparatus may be stopped by the actuation of control button 22 from the closed position shown to the open position. Opening of control button 22 effects the deenergization of the operating winding of electromagnetic switch 25 and the latter opens according to its bias to deenergize all of the other apparatus in the system.

In case it should be desirable to eliminate the delay in the response of the first electromagnetic device in the series to which my invention is applied, a control system and apparatus such as shown in Fig. 2 may be employed.

In the arrangement shown in Fig. 2 the additional electromagnetic switch 50 having an operating winding 51 and a movable magnetic member 52 is provided for connecting the motor 53 to the supply lines 18, 19 and 20 before the electromagnetic switches 10 and 11 are successively operated to connect the motors 16 and 17 to the supply lines in a similar manner to that described in connection with Fig. 1.

The electromagnetic switch 50 may be similar in all respects to the electromagnetic switches 10 and 11 except that the former is not provided with an electrically actuated timing mechanism. The operating winding 51 of electromagnetic switch 50 is so connected in the control system that upon closure of control button 21 and the resulting response of electromagnetic switch 25, the winding 51 is immediately energized through a circuit extending from the supply line 18, the control button 22, the upper blade of electromagnetic switch 25, the control button 54 which is similar in construction to the control buttons 23 and 24 as previously described, the winding 51 and the lower blade of electromagnetic switch 25 to the other supply line 19. Upon the resulting closure of electromagnetic switch 50 the motor 53 is connected to the supply lines and the operating winding 12 of electromagnetic switch 10 is also energized through the lower blade of switch 50 and the conductor 55.

It will be observed in Fig. 2 that the electrically actuated timing mechanisms 26 and 27 of electromagnetic switches 10 and 11 are a modification of the form shown and described in connection with Fig. 1. In the modified form illustrated, the resistors 56 and 57 are arranged to perform the combined functions of heating the thermal re-

sponsive elements 30 and 38 as well as preventing operative energization of the windings 12 and 13 of the electromagnetic switches 10 and 11 respectively. Furthermore the thermal responsive elements 30 and 38 are arranged to bend to the right when heated and directly short circuit the resistors 56 and 57.

From the foregoing it will be readily understood that after the closure of control button 21 and the resulting response of electromagnetic switches 25 and 50, the energizing circuit for the operating winding 12 for electromagnetic switch 10 is established from the supply line 18 through the lower blade of switch 50, the conductor 55, control button 23, the resistance 56, winding 12, conductor 43, and the lower blade of electromagnetic switch 25 to the other supply line 19. The resistance 56 maintains the initial energizing current through the winding 12 at a value below that required to effect operation of the movable magnetic member 14. This value of current through the resistor 56 however heats the thermal responsive element 30 and the latter gradually bends to the right and after a predetermined time interval short circuits the resistance 56. The energization of operating winding 12 is thereupon increased to full value and the switch 10 is operated to the closed position to connect the motor 16 to the supply line 18, 19 and 20, and at the same time to independently short circuit the resistance 56 by closure of the auxiliary contact 40, and also establish an energizing circuit for the operating winding 13 and electromagnetic switch 11 through the conductor 44 and the control button 24. The resulting operation of electromagnetic switch 11 to connect the motor 17 to supply lines 18, 19, 20, after a predetermined time interval is obviously similar to that of switch 10 as just described.

The features of selectively omitting operation of any of the electromagnetic switches shown in Fig. 2 and of connecting additional switch units to the extensions of the conductors 42 and 43 are the same as described in connection with Fig. 1.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

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

1. The combination with an electro-responsive device, of means normally arranged to prevent response thereof, an electrically actuated timing mechanism energized simultaneously with the initial energization of said device and having a movable member for disabling the said means after a predetermined time interval to permit response of the said device and means actuated upon the response of said device for maintaining the said first means disabled independently of the said timing mechanism.

2. The combination with an electro-responsive device, of a resistor in circuit therewith and normally preventing response thereof, an electrically actuated timing mechanism energized responsively to the current in the said circuit and having a movable element for short circuiting the said resistor after a predetermined time interval to permit response of the said device, and switch mechanism actuated upon the response of said device for maintaining the said resistor short circuited independently of the said timing mechanism.

3. The combination with an electro-responsive device, of a resistor in the energizing circuit of the said device and normally preventing operative energization thereof, a thermal element heated responsively to the current in the said circuit for short circuiting the said resistor after a predetermined time interval to permit operative energization of the said switch, and switch mechanism actuated upon the response of said device for maintaining the said resistor short circuited independently of the said element.

4. The combination with an electro-responsive device, of a resistor in circuit with the operating winding of the said device and normally preventing operative energization thereof, a thermal electric timing mechanism comprising a heating coil electrically connected in said circuit, and a thermal responsive member thermally related to said coil, and switch mechanism operated by the said member for short circuiting the said resistor a predetermined time interval after the energization of said winding and said coil to permit operative energization of the said switch.

5. A sequence control system for a series of electrically operated devices, comprising resistors in circuit with each of said devices for preventing operative energization thereof, electrically actuated timing mechanism energized responsively to the energizing current of each device for short circuiting the corresponding resistor to permit operative energization of each device a predetermined time interval after the initial energization thereof, and switch mechanism actuated upon the response of each device for maintaining the corresponding resistor short circuited independently of the said timing mechanism and for energizing the next succeeding device in the series.

6. A sequence control system for a series

of electrically operated devices, comprising resistors in the energizing circuit of each of said devices for preventing operative energization thereof, a thermal responsive member heated responsively to the energizing current of each device for short circuiting the corresponding resistor to permit operative energization of each device a predetermined time interval after the initial energization thereof, and switch mechanism actuated upon the response of each device for maintaining the corresponding resistor short circuited independently of the said timing mechanism and for energizing the next succeeding device in the series.

7. A sequence control system for a series of electrically operated devices, comprising resistors in the energizing circuit of each of said devices for preventing operative energization thereof, electrically heated thermal timing means initially energized responsively to the energizing current of each device, the said means comprising thermal responsive members operable between cool and hot positions for controlling the corresponding resistor to permit operative energization of each device a predetermined time interval after the initial energization thereof, and switch mechanism controlled by said devices and electrical connections whereby upon the operation of each of said devices the next succeeding device in the series is energized.

8. A sequence starting system for a plurality of electric motors, comprising a series of separately operated electromagnetic switches for independently connecting each motor to a source of supply, resistors in series circuit with the operating windings of said switches for preventing operative energization thereof, thermal timing means comprising heating coils in series circuit with the said operating windings and energized responsively to the energizing current of each switch, and thermal responsive elements thermally related to said coils and operable between cool and hot positions for controlling the corresponding resistor to permit operative energization of each switch a predetermined time interval after the initial energization thereof, and electrical connections controlled by each switch whereby upon the operation of said switch, the corresponding heating coil and resistor are short circuited and the next succeeding switch in the series is energized.

In witness whereof, I have hereunto set my hand this 14th day of December, 1923.

MARSHALL H. RUSSELL