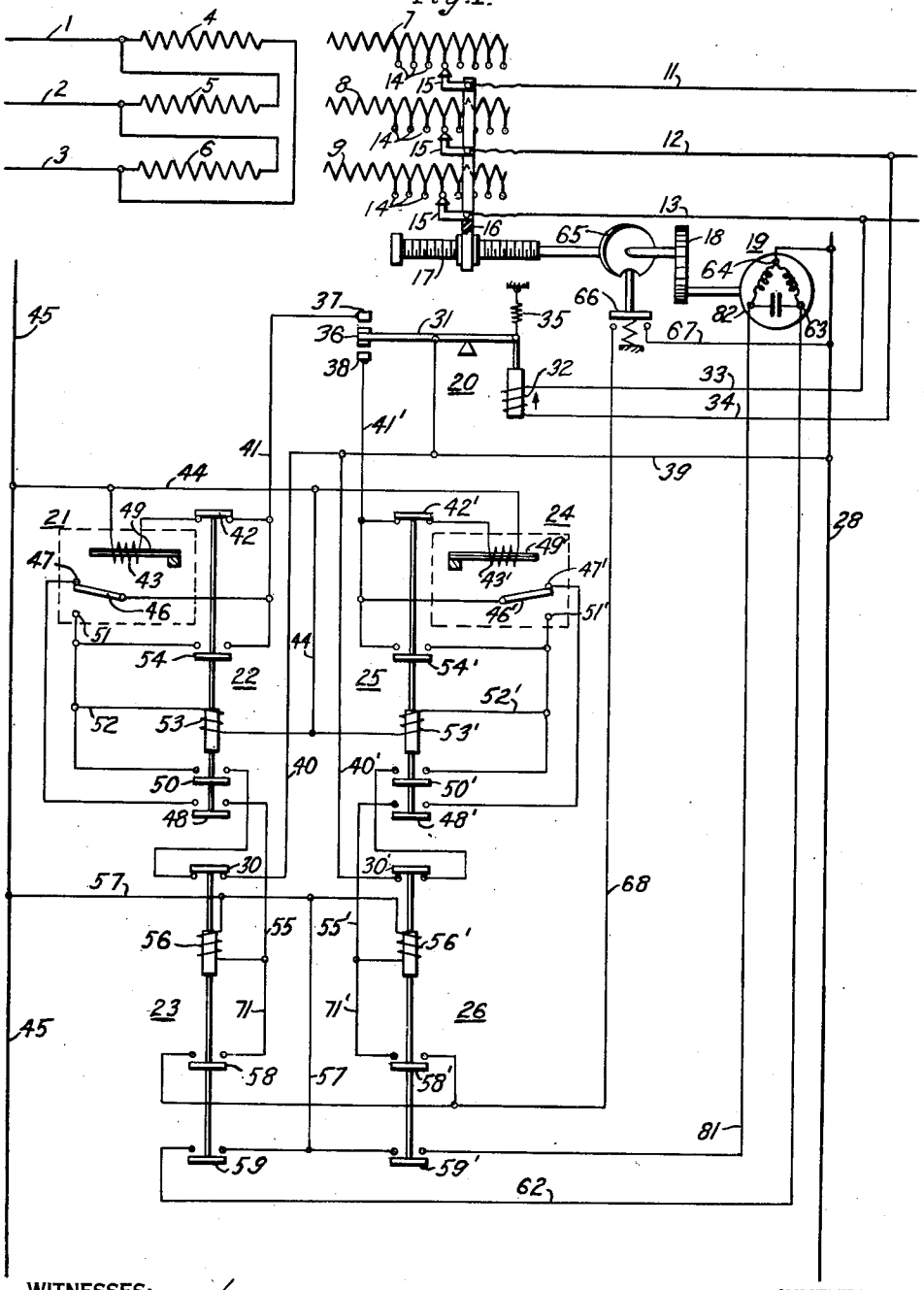
July 20, 1948. P. NARBUTOVSKIH 2,445,450

ELECTRICAL INDUCTION APPARATUS

Filed June 11, 1943 2 Sheets-Sheet 1

Fig. 1.



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ELECTRICAL INDUCTION APPARATUS

Filed June 11, 1943 2 Sheets-Sheet 2

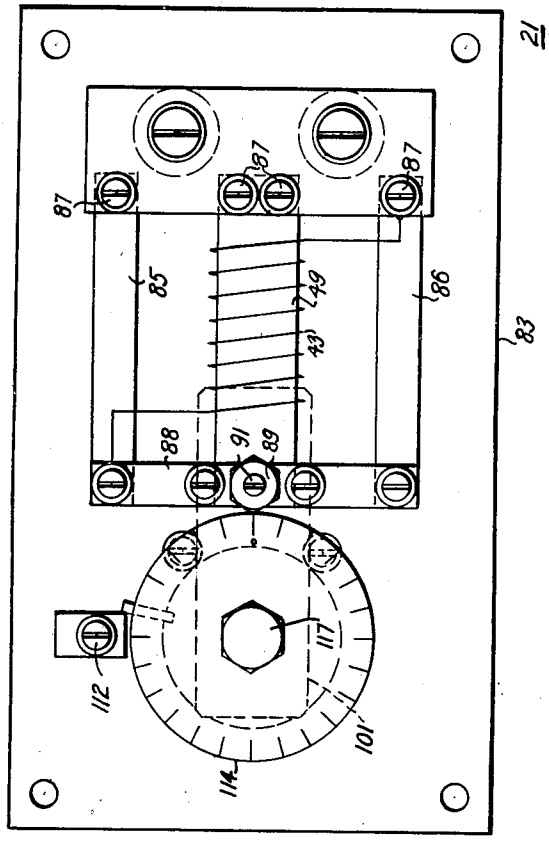


Fig. 2.

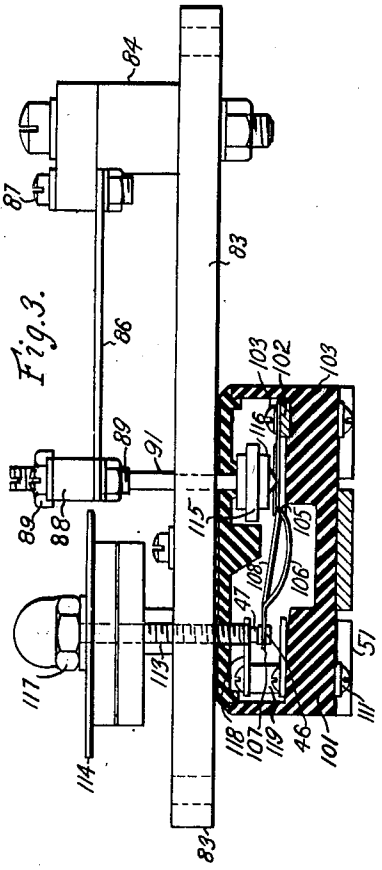


Fig. 3.

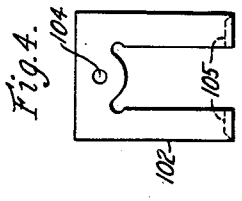


Fig. 4.

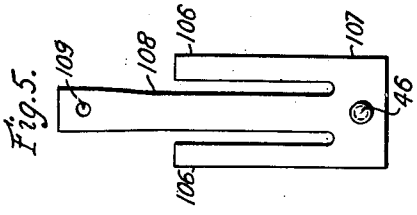


Fig. 5.

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ELECTRICAL INDUCTION APPARATUS

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Application June 11, 1943, Serial No. 490,445

8 Claims. (Cl. 323—55)

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My invention relates to electrical regulating systems having a step-by-step operating characteristic, and more particularly to improvements in the control of such automatic electrical regulating systems.

In many automatic electrical regulator systems employing step-type equipment, such as underload tap changers for transformers, it is desirable that the tap changing mechanism once set in operation continue its operation until the completion of a particular tap change, thus effecting one step of operation of the tap changing mechanism and a corresponding step of change in the output or secondary voltage.

It is also desirable that the mechanism shall not operate frequently between adjacent tap positions upon slight changes in voltage such as those of short duration which may be caused by temporary fluctuations in the secondary voltage, such as by switching operations or otherwise. In order to prevent unnecessary operation of the mechanism as a result of slight and temporary changes in the voltage, it has become customary to provide a time delay relay for delaying the operation of the tap changing mechanism for a short time interval after the operation of the primary relay, so that if the secondary voltage readjusts itself within the time delay interval the operation of the regulating mechanism will not be required and will not take place.

In the usual type of regulating systems, a mechanical time-delay relay having a dashpot or similar time-delaying mechanism has been used in the control circuit between the primary relay, initiating the operation of the regulator, and the secondary relay, completing the circuits controlling the regulator motor. In accordance with my invention, a thermal relay is employed which is very light in weight and requires little energy to operate. The time interval is dependent upon the time necessary for heating a bimetal element to a predetermined temperature after the relay is energized and the time interval required for dissipation of this stored heat and the cooling of the bimetal element to a lower predetermined temperature after the heating element of the relay is deenergized.

It is an object of the invention to provide a regulator equipment that is automatically controlled in accordance with an electrical characteristic of a circuit to be regulated, in which a time interval is introduced between the closing of the primary relay contacts and the operation of the regulating mechanism.

A further object of the invention is the provision of a regulator system of the character indicated in which the means for introducing the time interval into the operation of the system is a thermal relay requiring a small amount of energy only to operate it and having a cycle of operation in which the temperature responsive element is first heated to a predetermined value and then cooled to a lower predetermined value.

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Other objects and advantages of the invention will be apparent from the following description of a preferred embodiment of the invention, reference being had to the accompanying drawing, in which:

Figure 1 is a diagrammatic view of circuits and apparatus illustrating a regulator system arranged in accordance with the invention;

Fig. 2 is a front elevational view of the timing relay;

Fig. 3 is a side view of the timing relay, parts being shown in section; and

Figs. 4 and 5 are details of the switch element of the timing relays.

Referring particularly to Fig. 1, conductors 1, 2 and 3 represent the conductors of a three-phase alternating-current power circuit connected to primary transformer windings 4, 5 and 6 that are inductively related to secondary windings 7, 8 and 9 through which energy is supplied to the three-phase load circuit represented by conductors 11, 12 and 13. A tap changing mechanism is provided for varying the voltage ratio between the primary conductors 1, 2 and 3 and the secondary conductors 11, 12 and 13 which is diagrammatically illustrated as comprising a plurality of tap changing switch contact members 14 connected to tapped points on the secondary windings 7, 8 and 9 and cooperating with movable switch contact members 15 in each of the three phases that are similarly operated by a mechanism illustrated as an arm 16 controlled by a screw-threaded shaft 17 that is operated through suitable gearing mechanism 18 by a motor 19. Control equipment for the motor operated tap changing equipment is provided comprising a circuit controlling element or primary relay 20 for operating the motor 19 in one direction through control of a timing relay 21, an auxiliary relay 22 and a secondary relay 23, or for operating the motor 19 in the opposite direction through control of a timing relay 24, an auxiliary relay 25 and a secondary relay 26.

The primary relay 20 is provided with a pivoted movable arm 31 and an electromagnet having an armature energized by an operating winding 32 connected by conductors 33 and 34 to the secondary circuit conductors 12 and 13 for oper-

ating the relay 20 in accordance with the voltage of the secondary circuit conductors. The lever 31 is also biased by a spring 35, the combined influence of the winding 32 and spring 35 being effective to operate the arm 31 to move the relay contact member 36 into engagement with the one or the other of the contact members 37 or 38 as the voltage of the secondary circuit drops below or increases above the desired voltage.

If, for example, the voltage of the secondary circuit drops below the desired value, thus causing the contact 36 to engage the contact 37, a circuit is closed from the supply conductor 28 through conductor 39, arm 31, contact members 36 and 37, conductor 41, contact 42 in its illustrated position, the winding 43 comprising the heating element of the timing relay 21, conductor 44 to the supply conductor 45. In the initial or illustrated position of the timing relay switch, the movable contact member 46 is in engagement with contact member 47 closing one point in a circuit which is held open by the contact member 48 of the auxiliary relay 22 in its illustrated or deenergized position. Upon the heating of the bimetal element 49 to a predetermined temperature, this element causes the movable element 46 of the switch to move with a snap action from the contact member 47 into engagement with the contact member 51 to close a circuit through the primary relay contact members 36 and 37 and conductor 52, winding 53, and conductor 44 to the supply conductor 45 thus energizing the auxiliary relay 22, causing its several contact members to move upwardly, as illustrated in the drawings, thus interrupting the circuit formerly closed through the contact member 42 and closing contact members 48, 50, and 54. The contact 54 in moving to a circuit closing position closes a holding circuit in shunt to the circuit through switch contact members 46 and 51 of the timing relay, which holding circuit is completed through the contact members 36 and 37 of the primary relay. The upward movement of the relay contact member 42 interrupts the circuit through the winding 43 of the timing relay constituting the heating element of that relay, thus permitting the bimetal element 49 to cool. The contact member 48 closes one point in a circuit for energizing the secondary relay 23 which circuit is, however, interrupted so long as the switch contact member 46 remains in engagement with the contact 51.

The contact member 50 closes a holding circuit in shunt relation to the holding circuit through the contact member 54. This circuit extends from the supply conductor 28, through the conductors 39 and 40, contact 30 on the relay 23, contact 50 on the relay 22, conductor 52, winding 53, and conductor 44 to the supply conductor 45. The purpose of the holding circuit through the contact members 30 and 50 is to discontinue the control of the relay 22 by the primary relay 20 for the interval of time after the relay 22 has been energized during which the bimetal 49 is cooling. If this is not done, and if, during the cooling period of the bimetal, the contacts of the primary relay keep opening and closing, this will cause repeated operation of the relay 22, causing excessive wear.

When the bimetal element 49 of the timing relay 21 has cooled to a predetermined value, the contact member 46 moves by a snap action from engagement with the contact member 51 into engagement with the contact member 47, thus completing a circuit from the supply conductor 28 through the primary relay contact members 36 and 37, conductor 41, timing relay contact members 46 and 47, auxiliary relay contact 48, conductor 55, secondary relay winding 56, conductor 57 to the supply conductor 45.

If the contacts 36 and 37 are separated when the above traced circuit is closed, then the operation of the relay 23 is only momentary and lasts only long enough to deenergize the coil 53 and permit the auxiliary relay 22 to drop to its deenergized position and thus to interrupt the circuit through the winding 56 of the relay 23, so that this relay 23 drops to its deenergized position before it has been closed long enough to cause any movement of the motor 19. If, when the above traced circuit energizing the winding 56 is closed, the contacts 36 and 37 are in engagement, then the winding 53 of the relay 22 remains energized through the circuit including the contacts 36 and 37 and the contact member 54.

The secondary relay 23 is thus energized and operated to its upper or circuit closing position, bringing contact members 58 and 59 to their circuit closing positions. The contact member 59 completes a circuit from supply conductor 45 through conductor 57, contact member 59, conductor 62, to one terminal 63 of the motor 19, and from the terminal 64 to the supply conductor 28 causing the motor to operate in a direction to raise the voltage of the secondary circuit. Upon starting of the motor 19, a cam 65 is operated, closing a switch contact member 66 which completes a holding circuit from supply conductor 28 through conductor 67, switch 66, conductor 68, secondary relay contact member 58, conductor 71, relay winding 56, and conductor 57 to supply conductor 45, thus holding the relay 23 in its circuit closing position until the motor has operated through a sufficient number of revolutions to bring the tap changing mechanism to its next tap changing position, thus interrupting the holding circuit through the cam operated contact member 66.

If, prior to the opening of the switch 66, the primary relay contacts 36 and 37 have separated, thus deenergizing the auxiliary relay 22 and causing movement of the auxiliary relay contact member 48 to its illustrated or circuit interrupting position, the secondary relay 23 will become deenergized and drop to its illustrated or circuit opening position causing the motor 19 to stop when the mechanism completes a tap changing operation causing the cam switch 66 to open. If, however, the voltage between the secondary circuit conductors 12 and 13 is still below the desired value, the primary relay contact members 36 and 37 will remain closed, thus maintaining a circuit through the holding contact 54 and the winding 53 of the auxiliary relay closed, and likewise retaining the circuit through timing relay contact members 46 and 47 and the auxiliary relay contact member 48 closed, so as to maintain the winding 56 of the secondary relay 23 energized and continue the operation of the motor in spite of the opening of the holding circuit of the secondary relay by the contact 66. As soon as the operation of the motor has continued the movement of the mechanism beyond a tap position the switch 66 is again closed thus ensuring the completion of another step in the operation of the tap changing mechanism.

When the contact members 36 and 37 separate as the desired voltage on the secondary circuit of the regulated system is reached, the next succeeding completion of a tap changing operation by the motor operated tap-changing mechanism,

resulting in separation of the holding circuit by the contact member 66 will cause the secondary relay 23 to drop to its circuit interrupting position, thus discontinuing the regulating operation.

It will be seen that if, at any time after the initial closing of the contact members 36 and 37 of the primary relay, and prior to the operation of the secondary relay 23 to a circuit closing position, the contacts 36 and 37 are again separated, the relay 23 will not be operated to a circuit closing position to cause operation of the motor 19. If the contact members 36 and 37 separate after remaining in engagement for a sufficient length of time to cause the contact member 46 to engage the contact member 51, thus energizing the winding 53 and operating the auxiliary relay to its upper position, there will be a momentary energization of the winding 56 upon movement of the contact member 46 to again engage the contact member 47 sufficient to interrupt the holding circuit through the contact 36 to deenergize the winding 53 and cause the relay 22 to drop to its lower position and deenergize the winding 56 by opening the contact 48. The cycle of operation effecting the energization of the operating winding 56 of the relay 23 which is started upon engagement of the contact members 36 and 37 includes the heating of the bimetal 49 to a predetermined temperature to cause the switch contact member 46 to engage the contact member 51, thus energizing the auxiliary relay 22 to close the preset contact member 48 and a subsequent cooling of the bimetal 49 to cause the switch member 46 to again engage the contact member 47 while the contact member 48 is closed. Separation of the contact members 36 and 37 prior to the completion of the heating portion of the cycle during which the temperature of the bimetal 49 is being raised, interrupts the cycle by interrupting the energization of the timing relay winding 43.

The operation of the mechanism in the reverse direction is caused by operation of the primary relay 20 to close the contact members 36 and 38, thus effecting a cycle of operation resulting from operation of the timing relay 24, the auxiliary relay 25 and the secondary relay 26 that are identical with that described for the timing relay 21, auxiliary relay 22 and secondary relay 23, except that when the secondary relay 26 closes, a circuit is completed from the supply conductor 45 through conductor 57, contact member 59 of relay 26, conductor 81 to the motor terminal 82, through the motor winding to terminal 64 and supply conductor 28 to cause the motor to operate the tap changing mechanism in a voltage lowering direction. The various parts of the two timing relays, the two auxiliary relays, and the two secondary relays are similar and are similarly numbered except that the parts associated with relays 24, 25 and 26 are primed.

Referring to Figs. 2, 3, 4 and 5, the timing relay is shown mounted on a panel 83 upon which is mounted a support 84 carrying three bimetal elements 49, 85 and 86, the corresponding ends of which are fixedly attached to the support 84 by screws 87. The outer or movable ends of the three bimetal elements are attached by a yoke member 88 and carry an operating member 89 engaging a switch plunger shaft 91. The winding 43 constituting the heating element of the relay is shown wound about the middle one 49 of the three bimetal elements causing actuation of the operating member 89 toward or away from the plunger 91.

The switch member of the thermal relay is shown mounted on the opposite side of the panel 83 from the bimetal elements 49, 85 and 86 and comprises a casing 101 attached to the panel 83 by any suitable means, and through which the switch plunger shaft 91 extends. The switch includes an anchor member 102 held in place upon the casing by a screw 103, the outer end of which provides a terminal for the switch connecting to the movable contact member 46. The anchor member 102 is generally U-shaped as best shown in Fig. 4, and is provided with an opening 104 through which the screw 103 passes. The ends of the two legs forming the U are provided with V-shaped notches 105 which pivotally receive the ends of a pair of compression springs 106 of the snap-acting switch member 107, best shown generally in Fig. 5. A tension member 108 comprises a part of the snap-acting member 107 and is provided with a hole 109 which is also engaged by the screw 103 holding the snap mechanism in position with the members 106 bent downwardly and under compression, as shown in Fig. 3. The tension members 106 and the compression member 108 together constitute a thin leaf spring strip joined to each other at the ends carrying the contact member 46.

The lower contact member 51 is connected to a terminal screw 111 and the upper contact member 47 is connected to a terminal screw 112 shown in Fig. 2. The upper terminal 47 is mounted on the lower end of a screw-threaded member 113 extending through the panel 83 for adjusting the position of the contact member 47 to various positions, as indicated on a timing dial 114, which may be operated to vary the pressure required to snap the switch upon the heating of the bimetal 46 from its illustrated position, in which contacts 46 and 47 are in engagement, to the position in which the contacts 46 and 51 are in engagement to determine the timing cycle of the switch.

The spring members 106 and 108 are adapted to move the contact member 46 between the two stationary contact members 47 and 51 with a snap action. The thin leaf compression members 106 are pivotally supported in the notches 105 of the anchor member 102 and the tension member 108 is supported in cantilever fashion under the head of the screw 103 at the base of the U-shaped anchor member 102, and passes near the pivotal axis of the two compression members 106 at the notches 105. If the tension center line of the member 108 is deflected across the pivotal axis of the two compression members 106, the spring members 106 and 108 will act to snap the free end of the leaf spring member 107 carrying the contact member 46 from engagement with one of the contact members 47 or 51 into engagement with the other. The anchor 102 and the stationary contact members 47 and 51 which serve as stops for the snap-acting spring member 107, are so aligned and positioned that when no pressure is applied to the tension spring 108, the springs will move the contact member 46 upwardly into normal engagement with the contact member 47 as illustrated in Fig. 3. Accordingly, the tension member 108 only lies slightly above the axis of the pivotal support of the compression springs 106 as shown in Fig. 3.

The plunger shaft 91 carries a plunger 115 on its end having a projection 116 normally in en-

gagement with the leaf spring 108 and bearing against the upper surface thereof as viewed in Fig. 3, at a point intermediate its support under the head of the screw 103, and a pivoted support of the compression members 106 in the notches 105. When the bimetal element 49 is heated by current flowing through the heating coil 43, causing the actuating member 89 and plunger shaft 91 to be moved downwardly, as viewed in Fig. 3, a very slight movement of the tension member 108, so as to carry the tension axis below the point of the V-shaped notches 105 forming the pivot point for the leaf springs 106, causes the end of the spring members carrying the contact member 46 to snap downwardly into engagement with the contact member 51. When this pressure is released, the tension member 108 moves about the pivot within the notches 105, causing the contact member 46 to snap back to its illustrated position in engagement with the contact member 47.

The positioning of the upper contact member 47 by turning the head of the timing dial by the nut 117, adjusts the timing of the relay by adjusting the predetermined temperature to which the bimetal must be raised in order to operate the switch from its illustrated to its other circuit closing position. In order to limit the movement of the spring member 107 carrying the movable contact 46, should the upper contact member 47 be withdrawn by removing the screw-threaded shaft 113, a stop 118 is provided mounted on a support 119 within the casing 101 of the switch member.

It will be appreciated that the particular structure shown as a part of the thermal relay is not itself the subject matter of this invention, and that the particular thermally responsive element or heating element therefor disclosed need not necessarily be employed. A relay is provided having a characteristic that when a thermal responsive element is heated to a predetermined temperature a switch is operated from one of two circuit closing positions to another, and that when the thermal responsive element is cooled to another predetermined temperature, the switch is operated from the second to the first or original of its two circuit closing positions, and that the cycle of the relay as a timing relay includes both the heating and the cooling of the thermal element to operate the switch controlled thereby from its first to its second closing position and back again to its first circuit closing position.

Since modifications in the circuits and apparatus illustrated may be employed within the spirit of my invention, I do not wish to be limited otherwise than by the spirit of the appended claims.

I claim as my invention:

1. In a time delay control system for an automatic step-type reversible motor driven regulator, in combination, means including a primary relay responsive to the value of a condition, and relay means controlled thereby for initiating the operation of the control system, said relay means including a timing relay, an auxiliary relay and a secondary relay, the timing relay having a thermal responsive element and a heating element therefor, a circuit closed through contacts on the primary relay and contacts on the auxiliary relay for energizing the heating element of the timing relay, said timing relay having contacts operable upon a predetermined temperature of the heating element for closing a circuit for operating the auxiliary relay to a preset position, said auxiliary relay being operative upon movement to its preset position for interrupting the circuit energizing the heating element of the timing relay and for closing a holding circuit for retaining the auxiliary relay in its reset position, contacts on said auxiliary relay that are closed in the preset position of the relay for closing one point in a circuit for operating the secondary relay, the timing relay being operative upon the cooling of the thermal element to a predetermined temperature for completing the circuit for operating the secondary relay, the auxiliary relay being operative to its initial position for preventing operation of the secondary relay unless the primary relay contacts are closed upon completion of the above defined cycle of operation of the several relays for completing the circuit for operating the secondary relay.

2. In a time delay control system for an automatic step-type reversible motor driven regulator, in combination, means including a primary relay responsive to the value of a condition, an auxiliary relay, a timing relay and a secondary relay controlled by the primary relay, said timing relay having a thermal responsive element and a heating element therefor, a circuit closed by the contacts of the primary relay for energizing the heating element of the timing relay, the thermal responsive element being operative upon a predetermined temperature for effecting the operation of the auxiliary relay to a preset position for interrupting the energizing circuit for the heating element and for closing one point in a circuit for effecting the operation of the secondary relay to a circuit closing position, the thermal responsive element being operative upon reduction to a lower predetermined temperature for completing the circuit for effecting the operation of the secondary relay to a circuit closing position, said circuit including the closed contacts of the primary relay, the auxiliary relay being operative to its initial position upon completion of the above defined cycle for preventing operation of the secondary relay unless the primary relay contacts are closed upon completion of the above-defined cycle of operation of the several relays between the closing of the primary relay contacts and the secondary relay.

3. In a time delay control system for an automatic step-type reversible motor driven regulator, in combination, means including a primary relay responsive to the value of a condition, and relay means controlled thereby for initiating the operation of the control system, said relay means including a timing relay, an auxiliary relay and a secondary relay, the timing relay having a thermal responsive element and a heating element therefor, a circuit closed through contacts on the primary relay and contacts on the auxiliary relay for energizing the heating element of the timing relay, said timing relay having contacts operable upon a predetermined temperature of the element for closing a circuit for operating the auxiliary relay to a preset position, said auxiliary relay being operative upon movement to its preset position for interrupting the circuit energizing the heating element of the timing relay and for closing a holding circuit for retaining the auxiliary relay in its preset position during the cooling of the thermal responsive element, contacts on said auxiliary relay that are closed in the preset position of the relay for closing one point in a circuit for operating the secondary relay to a predetermined position, the timing relay being operative upon the cooling of the thermal element to a predetermined

temperature for completing the circuit for operating the secondary relay, the auxiliary relay being operative to its initial position for preventing operation of the secondary relay to its predetermined position unless the primary relay contacts are closed upon completion of the above-defined cycle of operation of the several relays, circuit controlling means for sealing said secondary relay in its circuit closing position upon operation of said regulator for effecting continued operation of the mechanism throughout one operating step independently of the separation of the primary relay contacts.

4. In a time delay control system for an automatic step-type reversible motor driven regulator, in combination, means including a primary relay responsive to the value of a condition, an auxiliary relay having an operating winding, a timing relay and a secondary relay controlled by the primary relay and having two relay positions, said timing relay having a thermal responsive element and a heating element therefor, a circuit closed by the contacts of the primary relay for energizing the heating element of the timing relay, the thermal responsive element being operative upon a predetermined temperature for effecting the energization of the operating winding of the auxiliary relay and the operation of the auxiliary relay to a preset position for interrupting the energizing circuit for the heating element and for closing one point in a circuit for effecting the operation of the secondary relay to its energized position, a holding circuit for the operating winding of the auxiliary relay including contacts on said auxiliary relay that are closed when the auxiliary relay is in its energized position and contacts on said secondary relay when the secondary relay is in its deenergized position, the thermal responsive element being operative upon reduction to a lower predetermined temperature for completing the circuit for effecting the operation of the secondary relay to its energized position, said circuit including the closed contacts of the primary relay, the auxiliary relay being operative to its initial position upon completion of the above-defined cycle for preventing operation of the regulator unless the primary relay contacts are closed upon completion of the above-defined cycle of operation of the several relays between the closing of the primary relay contacts and the secondary relay.

5. In a time delay control system for an automatic step-type reversible motor driven regulator, in combination, means including a primary relay responsive to the value of a condition, and relay means controlled thereby for initiating the operation of the control system, said relay means including a timing relay, an auxiliary relay and a secondary relay, the timing relay having a thermal responsive element and a heating element therefor, a circuit closed through contacts on the primary relay and contacts on the auxiliary relay for energizing the heating element of the timing relay, said timing relay having contacts operable upon a predetermined temperature of the heating element for closing a circuit for operating the auxiliary relay to a preset position, said auxiliary relay being operative upon movement to its preset position for interrupting the circuit energizing the heating element of the timing relay and for closing a holding circuit for retaining the auxiliary relay in its reset position, said holding circuit including contacts on said auxiliary relay that are closed when the auxiliary relay is in its reset position and contacts on said

secondary relay when the secondary relay is in its non-operating position, a second holding circuit for retaining the auxiliary relay in its reset position including contacts on said auxiliary relay and contacts on the primary relay, contacts on said auxiliary relay that are closed in the preset position of the relay for closing one point in a circuit for operating the secondary relay to its operating position, the timing relay being operative upon the cooling of the thermal element to a predetermined temperature for completing the circuit for operating the secondary relay, the auxiliary relay being operative to its initial position upon separation of the primary relay contacts for preventing operation of the regulator unless the primary relay contacts are closed upon completion of the above-defined cycle of operation of the several relays, circuit controlling means for sealing said secondary relay in its circuit closing position upon operation of said regulator for effecting continued operation of the regulator throughout one operating step independently of the separation of the primary relay contacts.

6. In a time delay control system for an automatic step-type reversible motor driven regulator, in combination, means including a primary relay responsive to the value of a condition and a pair of secondary relays controlled thereby, the primary relay having contacts thereon for effecting the energization of a selected secondary relay, means for introducing a time delay between the closing of the primary relay contacts and the energization of the secondary relay comprising a thermal relay and an auxiliary relay, the thermal relay having a temperature responsive element, a heating element therefor, and a switch member having two circuit closing positions, the switch being closed in one of its two circuit closing positions when the thermal responsive element of the relay is heated above a predetermined temperature and closed in the other of its two circuit closing positions when the thermal responsive element of the relay is cooled below a predetermined temperature, a circuit including the primary relay contacts and contacts on the auxiliary relay when in its initial position for energizing the heating element of the thermal relay for effecting operation of the thermal relay switch, after a time interval, to its second circuit closing position, the thermal relay switch in operating from its first circuit closing position to its second circuit closing position being effective to interrupt the circuit through the heating element of the thermal relay and to close a circuit for operating the auxiliary relay to a preset position, the thermal relay switch being effective, upon cooling and return to its first circuit closing position to close a circuit including contacts on the auxiliary relay that are closed when the auxiliary relay is in its preset position for energizing the secondary relay, two holding circuits for the auxiliary relay for retaining it in its preset position, one holding circuit, including contacts on the auxiliary relay that are closed when the relay is in its preset position, and contacts on the primary relay, the other holding circuit including contacts on the auxiliary relay that are closed when the relay is in its preset position and contacts on the secondary relay that are closed when that relay is in its deenergized position.

7. In a time delay control system for an automatic step-type reversible motor driven regulator, in combination, a multiple-position switch operator, an electric motor for operating the switch operator from one of its positions to an-

other, a secondary relay having an operating winding and switch contact members for controlling the operation of the motor, a primary relay having contacts thereon for controlling the energization of the operating winding of the secondary relay, means for introducing a time delay between the closing of the primary relay contacts and the energization of the operating winding of the secondary relay comprising a thermal relay and an auxiliary relay, the thermal relay having a temperature responsive element, a heating element therefor, and a switch member having two circuit closing positions, the switch being closed in the first one of its two circuit positions when the thermal responsive element of the relay is below a predetermined temperature and closed in the second one of its two circuit closing positions when the thermal responsive element of the relay is heated above a predetermined temperature, a circuit including the primary relay contacts and contacts on the auxiliary relay when in its initial position for energizing the heating element of the thermal relay for affecting operation of the thermal relay switch, after a time interval, to its second circuit closing position, the thermal relay switch in operating from its first circuit closing position to its second circuit closing position being effective to interrupt the circuit through the heating element of the thermal relay and to close a circuit for operating the auxiliary relay to a preset position, the thermal relay switch being effective, upon cooling and return to its first circuit closing position to close a circuit including contacts on the auxiliary relay that are closed when the auxiliary relay is in its preset position for energizing the secondary relay, a control switch and means for operating the control switch to a circuit closing position upon operation of the motor to effect movement of the multiple position switch operator from one of its multiple positions to another and for operating the control switch to a circuit opening position upon completion of movement to another one of its positions, and a holding circuit for maintaining the secondary relay operating winding energized including the above defined motor operated control switch and contacts on the secondary relay that are closed when it is in its energized position.

8. In a time delay control system for an automatic step-type reversible motor driven regulator, in combination, an electric motor for operating the regulator, a secondary relay having an operating winding and switch contact members for controlling the operation of the motor, a circuit controller responsive to the value of a condition for initiating the operation of said control system, a thermal time delay means operative upon the operation of said circuit controller to a

circuit closing position for introducing a time delay between the operation of the circuit controller and the operation of the regulator, said thermal time delay means having two circuit closing positions and being operative to one of said two positions in response to the heating of the thermal means to a predetermined high temperature, and operative to the other of said two positions in response to the cooling of the thermal means to a predetermined lower temperature, an auxiliary relay controlled by said thermal time delay means, having two operative positions and being operable to a circuit closing position upon operation of said thermal time delay relay in response to a high predetermined temperature, a holding circuit completed through two sets of contacts one of which is controlled by the auxiliary relay and the other of which is controlled by said circuit controller for holding said auxiliary relay in its circuit closing position, a second holding circuit for said auxiliary relay including contacts on the auxiliary relay that are closed when the auxiliary relay is in its circuit closing position and contacts that are closed when said secondary relay is in its deenergized position, and preset contacts on said auxiliary relay that are closed when the auxiliary relay is in its circuit closing position for closing one point in a circuit for energizing the winding of the secondary relay which circuit is completed when the thermal time delay means is operated to its second circuit closing position upon the cooling of the thermal means to the lower predetermined temperature, the secondary relay being energized and operated to a motor starting position upon the completion of the cycle of operation of the time delay means and continued closure of the circuit controller, the cycle of operation of the time delay means including the interval during which the thermal responsive element is first heated to the predetermined higher temperature and the interval during which the thermal responsive element is then cooled to the predetermined lower temperature.

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