Oct. 1, 1940. S. MINNECI 2,216,599

REGULATOR SYSTEM

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Fig. 1.

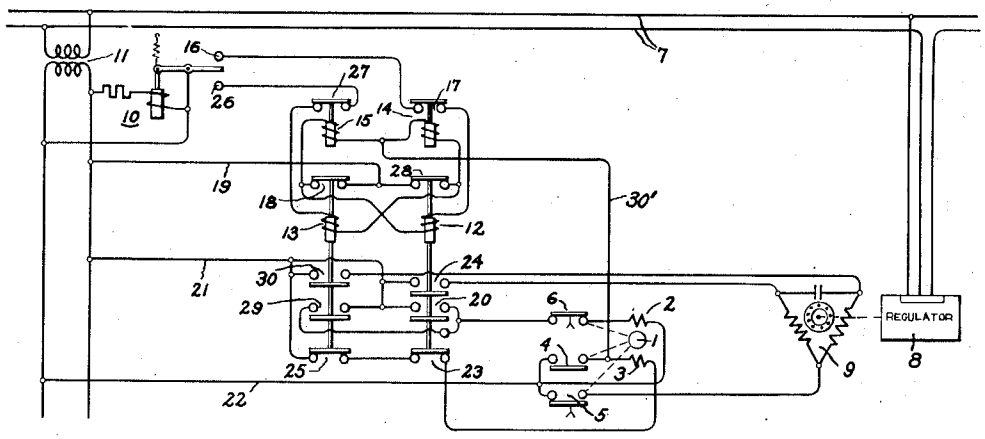
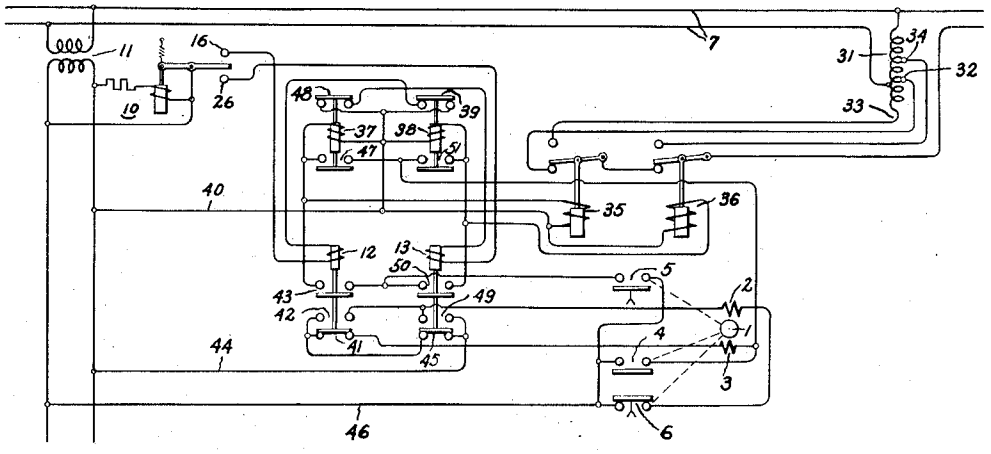


Fig. 2.



Inventor:
Salvatore Minneci,
by Harry E. Dunham
His Attorney.

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REGULATOR SYSTEM

Salvatore Minneci, Pittsfield, Mass., assignor to General Electric Company, a corporation of New York

Original application January 15, 1938, Serial No. 185,180. Divided and this application November 3, 1938, Serial No. 238,637

5 Claims. (Cl. 171—119)

This invention relates to regulator systems, and more particularly to improvements in time delay control systems for automatic regulators.

This application is a division of my co-pending application Serial No. 185,180, filed January 15, 1938, and assigned to the assignee of the present application.

Many regulated quantities contain continual relatively small fluctuations which it is unnecessary for the regulator to correct and which would cause excessive operation of the regulator if it did attempt their correction. Consequently, time delay means are often included in the control of automatic regulators, so that they will only respond when the regulated condition or quantity deviates from its normal value for a predetermined length of time.

In accordance with this invention a novel time delay system is employed in which the time delay is positive and is independent of changes in ambient temperature, circuit voltage and various other quantities which might affect the duration of the time interval.

An object of the invention is to provide a new and improved time delay control circuit for automatic voltage regulators.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing, in which similar reference characters denote similar elements throughout the several views, Fig. 1 is a circuit diagram of a control system for a motor-operated regulator which employs my invention, and Fig. 2 is a modification of the circuit of Fig. 1 which is adapted for use with a 2-step regulator.

Referring now to the drawing and more particularly to Fig. 1, there is shown therein a time delay contactor having a reversible motor 1 consisting of an element 2 for producing forward rotation of the motor and an element 3 for producing reverse rotation of the motor. The details of the contactor are described and claimed in my above referred to parent application so that only those features of its construction and operation which are necessary to an understanding of the invention are described herein.

Operated by motor 1 are three sets of contacts 4, 5 and 6. These contacts are illustrated in their normal or re-set positions in which contacts 4 and 5 are open and contacts 6 are closed. When the forward element 2 is energized, contacts 4 close immediately, and after a predetermined time, contacts 5 close and contacts 6 open. As will be described in greater detail hereinafter, contacts 4 control a run-back circuit for reversing motor element 3, contacts 5 control the time delayed operation of the regulator and contacts 6 control the stopping of the forward operation of the contactor. When the contactor is reversed by energizing motor element 3, contacts 6 reclose at once, contacts 5 reopen at once and after a predetermined time, contacts 4 reopen and stop the contactor.

The automatic voltage regulating system is illustrated with an alternating current power circuit 7. The voltage is regulated by a regulator 8 of any suitable and well-known construction. Such regulators are typically induction regulators or step regulators which change taps on a transformer under load. Both these types of regulators consist essentially of a variable ratio transformer. For driving the regulator 8 there is provided a reversible operating motor 9 shown by way of example as a conventional reversible single phase fractional horse power capacitor motor. The primary control of the regulator in response to the voltage of circuit 7 is controlled by a primary relay 10 which may be of any suitable type and which is illustrated by way of example as a contact-making voltmeter. This device is connected across the main circuit through a potential transformer 11. Interposed between the primary relay and the motor 9 is the time delay contactor but in order to reduce the contact duty on the contacts of the contact-making voltmeter and in order that a required plurality of control circuits may readily be opened and closed, there are provided a pair of auxiliary relays 12 and 13. In order to prevent improper operation of the time delay control system in response to intermittent making and breaking of the contacts of the main control device, there are provided a pair of supplementary relays 14 and 15.

The parts are all in the positions they occupy when the main circuit voltage is normal.

The normal operation of Fig. 1 is such that if the voltage of the main circuit falls to an abnormally low value, a set of raise contacts 16 on the primary relay will close which will then complete a circuit from the left-hand side of the secondary of the potential transformer 11 through the contacts 16, a set of normally closed contacts 17 on the supplementary relay 14, the operating winding of the raising auxiliary relay 12, a set of normally closed interlock contacts 18 on the lowering auxiliary relay 13 and through

a conductor 19 to the other side of the transformer 11. The energization of the raising auxiliary relay 12 causes it to close a set of normally open contacts 20 which complete a circuit from the right-hand side of the transformer 11 through a conductor 21, the contacts 20, the normally closed time delayed opening contacts 6 of the time delay contactor, the forward motor element 2 and back to the other side of the transformer 11 through a conductor 22.

This starts the forward operation of the time delay contactor which immediately closes its contacts 4 as previously described, but this does not cause energization of the reversing motor element 3 because the contacts 4 are connected in series with a set of contacts 23 on the raising auxiliary relay 12 and which are now open by reason of the energization of this relay. As soon as the contactor reaches its timed out position, its contacts 5 close and its contacts 6 open. The closing of the contacts 5 completes a circuit from the right-hand side of the transformer 11 through the conductor 21, a set of contacts 24 on the auxiliary raising relay 12, through the motor 9, the contacts 5 and back to the other side of the transformer through the conductor 22. This causes the motor 9 to drive the regulator 8 in such direction as to raise the main circuit voltage.

The opening of the contacts 6 breaks the circuit through the forward motor element 2 and thus deenergizes the operating motor of the time delay contactor which then comes to rest.

As soon as the main circuit voltage returns to normal, the contact-making voltmeter opens its raise contacts, thereby causing the raising auxiliary relay 12 to drop out. This causes the immediate stopping of the motor 9 by reason of the opening of the contacts 24 and completes a reversing circuit for the time delay contactor by reason of the closing of the contacts 23. This reversing circuit is from the right-hand side of the transformer 11 through the conductor 21, a set of normally closed contacts 25, on the lowering auxiliary relay 13, the contacts 23, the reversing motor element 3, the closed contacts 4 and back to the other side of the supply transformer through conductor 22. This will cause the time delay contactor to continue to run back toward its reset position and when this position is attained, the contacts 4 open, thus deenergizing the contactor. As soon as the time delay contactor starts to run back, its contacts 5 open and its contacts 6 close. This then completes a regulating cycle in one direction and restores all the parts to their illustrated starting positions.

Similarly, if the voltage of the main circuit is too high, a set of lower contacts 26 on the contact-making voltmeter will close, thus completing an energizing circuit for the lowering auxiliary relay 13 through a normally closed set of contacts 27 on the supplementary relay 15 and a set of interlock contacts 28 on the raising auxiliary relay 12. The energization of the lowering auxiliary relay 13 immediately starts the time delay contactor by means of the closure of a set of contacts 29 and as soon as the time delay contactor times out and its time delay closing contacts 5 close, a reversing circuit for the motor 9 is completed through a set of contacts 30 on the relay 13. The reversal of the motor 9 causes the regulator to lower the voltage until normal voltage is restored, whereupon the contacts 26 of the primary relay open, causing the auxiliary relay 13 to drop out immediately, whereupon the previously described run back circuit for the time delay contactor is completed through contacts 4, 23 and 25 in series.

It sometimes happens that the contact-making voltmeter contacts will not stay closed during the time delay interval and a condition may also arise in which the raise or the lower contacts open and close successively a number of times and then the relay will swing over and close the opposite set of contacts. The result is that after several successive openings and closings of the raise contacts, for example, a substantial portion of the time delay interval is used up; that is to say, the time delay contactor has been operated to a position somewhere between its reset position and its timed out position so that when the contact-making voltmeter suddenly reverses and closes its lower contacts, the time delay interval between the closing of these contacts and the operation of the regulator will be very much diminished. It is in order to prevent this operation that the supplementary relays 14 and 15 are provided.

The operation of the supplementary relays 14 and 15 is such that once either set of contacts on the primary relay closes and then opens again, the primary relay loses control of the regulating system until the time delay contactor is restored to its reset position. The detailed explanation of this operation is as follows: One side of the supplementary relay 14 is energized from the right-hand side of the transformer 11, through the conductor 19 and the normally closed contacts 28 of the auxiliary relay 12, while one side of the supplementary relay 15 is energized in a similar manner through the normally closed contacts 18 of the auxiliary relay 13 and the other side of each of the supplementary relays is connected to a common conductor 30' and through the contacts 4 of the time delay contactor back to the other side of the transformer through the conductor 22. In other words, as soon as the contacts 4 close, thus indicating that the time delay contactor is not in its reset position, relay 14 will be actuated if contacts 28 are closed and relay 15 will be actuated if contacts 18 are closed and these latter contacts will be closed whenever the raise contacts 16 or the lower contacts 26 are open. Thus, for example, whenever a raising operation is started by the closure of the contacts 16, supplementary relay 15 opens as soon as the time delay contactor closes its contacts 4 thus causing the contacts 18 of the lowering auxiliary relay 13 to remain closed. If now the raise contacts 16 open before the time delay contactor has timed out, the closing of the contacts 28 caused by the dropping out of the raising auxiliary relay 12 in response to the opening of the raise contacts 16, will immediately complete an energizing circuit for the supplementary relay 14. Consequently, as both the contacts 17 and 27 are open the contact-making voltmeter 10 has lost all control of the system and this control will not be re-established until the time delay contactor is run back to its reset position at which time the opening of the contacts 4 will simultaneously deenergize both the supplementary relays 14 and 15.

It should be understood, however, that relays 14 and 15 are not always necessary or even desirable. Thus, a cumulative action of the time delay contactor is desirable in order to correct a fluctuating voltage which is slowly departing from a normal mean value. In Fig. 2, the regu-

lator consists of an auto-transformer 31 provided with a neutral tap 32, a raise tap 33 and a lower tap 34. These three taps are connected to a pair of tap-changing contactors 35 and 36, the arrangement being such that with both contactors 35 and 36 deenergized the neutral tap 32 and the contacts of the contactors 35 and 36 are connected in series in the main circuit. When the contactor 35 is actuated a connection is made to the raise tap 33, thus inserting one step of voltage raise in the main circuit, whereas when the contactor 36 is actuated, the lower tap 34 is connected in the circuit, thus inserting one step of voltage lower therein. This arrangement of taps and tap-changing switches is disclosed and claimed in an application, Serial No. 183,661, filed January 6, 1938, in the name of Frederick F. Brand, and assigned to the assignee of the present application.

In order to control the making and breaking of a number of supplementary control circuits in accordance with the position of the main tap-changing contactors 35 and 36, a pair of supplementary relays 37 and 38 have their operating windings connected respectively, in parallel with the operating windings of the contactors 35 and 36. It will, of course, be understood that this arrangement is the equivalent of adding supplementary contacts to the main contactors 35 and 36 but as these are relatively large and rugged devices which are insulated for high voltage, it is more convenient and less expensive to operate the supplementary contacts by relatively inexpensive low voltage supplementary relays 37 and 38.

As in Fig. 1, the parts have been illustrated in the positions they occupy when the main circuit voltage is normal.

The operation of Fig. 2 is as follows: If an abnormally low circuit voltage occurs, the closure of the raise contacts 16 will energize the raising auxiliary relay 12 through a set of interlock contacts 39 on the supplementary relay 38, the return connection being through a conductor 40. The actuation of the relay 12 causes it to open a set of contacts 41 and close two sets of contacts 42 and 43. The contacts 41 are in series with the reversing motor element 3 and the normally open instantaneous closing contacts 4 of the time delay contactor, so that the opening of the contacts 41 breaks the run back circuit of the time delay contactor. The closing of the contacts 42 completes a forward energizing circuit for the time delay contactor through a conductor 44, a set of contacts 45 on the lower auxiliary relay 13, the contacts 42, the forward motor element 2 and the normally closed time delayed opening contacts 6 and back to the other side of the transformer through a conductor 46. The closing of the contacts 43 sets up an energizing circuit for the raising contactor 35 and the supplementary relay 37 so that when the time delayed closing contacts 5 close, a circuit is completed through the conductor 46, the contacts 5 and 43 in series, through the operating windings of the relays 35 and 37 in parallel and back to the transformer 11 through the conductor 40. As previously described, the operation of the contactor 35 inserts one step of voltage raise in the main circuit. The operation of the supplementary relay 37 causes it to close a set of seal-in contacts 47 and open a set of interlock contacts 48. The closing of the contacts 47 completes a seal-in connection for the contactor 35 and the relay 37 through the contacts 4 of the time delay relay, while the opening of the contacts 48 breaks the controlling circuit for the lowering auxiliary relay 13 so that this relay cannot be energized by the closing of the lower contacts 26 at this time.

Consequently, as soon as the time delay contactor has timed out, the primary relay loses immediate control of the raise contactor 35 and the supplementary contactor 37. So long as the raise contacts remain closed the timer will remain in its timed out position and the raise contactor 35 will remain energized. If now the voltage returns to normal the auxiliary relay 12 immediately drops out but the previously described seal-in circuit through the contacts 4 and 47 in series will maintain the contactor 35 and the relay 37 energized. However, the drop out of the auxiliary relay 12 causes it to close its contacts 41 thereby completing the run back circuit for the timer through its contacts 4. As soon as the timer runs back to its reset position, the opening of its contacts 4 breaks the seal-in circuit, thus deenergizing the contactor 35 and the relay 37 and restoring the parts to their illustrated positions.

If instead of merely opening its contacts 16, the contact-making voltmeter is reversed so as to close its lower contacts 26 before the timer has run back to its reset position nothing will happen because the open interlock contacts 48 prevent energization of the lowering auxiliary relay 13.

However, as soon as the contactor has been fully run back and the supplementary relay 37 drops out, a closure of the lower contacts 26 will energize the lowering auxiliary relay 13 which then picks up and closes a set of contacts 49 which start the timer and as soon as the timer times out the closure of its contacts 5 will complete a circuit through a set of contacts 50 for simultaneously energizing the lowering contactor 36 and the supplementary relay 38. As soon as the supplementary relay 38 pulls in it closes a set of contacts 51 in series with the closed contacts 4 of the timer which then completes a seal-in circuit for the lowering contactor 36 and the supplementary relay 38. Therefore, as soon as the voltage is returned to normal and the contact-making voltmeter opens its lower contacts 26, the lowering auxiliary relay 13 will drop out, thus completing the reversing circuit for the timer through the contacts 4, 41, and 45 in series and as soon as the timer is reset the opening of its contacts 4 breaks the holding circuit for the contactor 36 and the relay 38 and these devices drop out, thus restoring the parts to their illustrated positions.

During this run back of the timer, the interlock contacts 39 of the supplementary relay 38 are open, thus preventing the energization of the raising auxiliary relay 12 in case the contact-making voltmeter should close its raise contacts 16 before the timer has been completely run back.

While there have been shown and described particular embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein without departing from the invention and, therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. In combination, a regulator for selectively

performing raising and lowering operations, a reversible motor-operated time delay contactor having a forward direction of operation when going from a reset position to a timed out position and having a reverse direction of operation at the same speed and power when going from said timed out position to said reset position, a primary relay having raise and lower circuit closing positions on opposite sides of a neutral position, and secondary relay means controlled by said primary relay in each of its circuit closing positions for starting said contactor in its forward direction and preselecting the operation of the regulator corresponding to the position of the primary relay, said time delay contactor being provided with means for delaying the regulator operation until said timed out position is reached, said secondary relay means being responsive to the primary relay occupying its neutral position for completing a circuit for causing reverse operation of said contactor.

2. In combination, a regulator for selectively performing raising and lowering operations, a reversible motor-operated time delay contactor having a forward direction of operation when going from a reset position to a timed out position and having a reverse direction of operation at the same speed and power when going from said timed out position to said reset position, a primary relay having raise and lower circuit closing positions on opposite sides of a neutral position, and secondary relay means controlled by said primary relay in each of its circuit closing positions for starting said contactor in its forward direction and preselecting the operation of the regulator corresponding to the position of the primary relay, said time delay contactor being provided with means for delaying the regulator operation until said timed out position is reached, said secondary relay means being responsive to the primary relay occupying its neutral position for completing a circuit for causing reverse operation of said contactor which is maintained closed until said contactor reaches its reset position regardless of a subsequent actuation of the primary relay to either of its circuit closing positions during said reverse operation.

3. In combination, a reversible motor-operated regulator for selectively performing raising and lowering operations in accordance with opposite directions of rotation thereof, a reversible motor-operated time delay contactor having a forward direction of operation when going from a reset position to a timed out position and having a reverse direction of operation at the same speed and power when going from said timed out position to said reset position, a primary relay having raise and lower circuit closing positions on opposite sides of a neutral position, and secondary relay means controlled by said primary relay in each of its circuit closing positions for starting said contactor in its forward direction and preselecting the direction of operation of said regulator corresponding to the position of the primary relay, said time delay contactor being provided with means for delaying the starting of said regulator until said timed out position is reached, said secondary relay means being responsive to the primary relay occupying its neutral position for completing a circuit for causing reverse operation of said contactor, said contactor being provided with means for stopping the regulator operation as soon as it leaves its timed out position.

4. In combination, a regulator for selectively performing raising and lowering operations, a reversible motor-operated time delay contactor having a forward direction of operation when going from a reset position to a timed out position and having a reverse direction of operation at the same speed and power when going from said timed out position to said reset position, a primary relay having raise and lower circuit closing positions on opposite sides of a neutral position, and secondary relay means controlled by said primary relay in each of its circuit closing positions for starting said contactor in its forward direction and preselecting the operation of the regulator corresponding to the position of the primary relay, said time delay contactor being provided with means for delaying the regulator operation until said timed out position is reached, said secondary relay means being responsive to the primary relay occupying its neutral position for completing a circuit for causing reverse operation of said contactor which is maintained closed until said contactor reaches its reset position independently of said primary relay occupying its other circuit closing position during said reverse operation of said contactor.

5. In combination, a regulator provided with a pair of selectively energizable windings for respectively causing said regulator to produce predetermined amounts of raising and lowering operation so long as they are energized, a reversible motor-operated time delay contactor having a forward direction of operation when going from a reset position to a timed out position and having a reverse direction of operation at the same speed and power when going from said timed out position to said reset position, a primary relay having raise and lower circuit closing positions on opposite sides of a neutral position, and secondary relay means controlled by said primary relay in each of its circuit closing positions for starting said contactor in its forward direction and preselecting the regulator winding to be operated corresponding to the position of the primary relay, said time delay contactor being provided with means for delaying the energization of the regulator winding until said timed out position is reached, said secondary relay means being responsive to the primary relay occupying its neutral position for completing a circuit for causing reverse operation of said contactor, said secondary relay means maintaining said regulator winding energized until said contactor reaches its reset position.

SALVATORE MINNECI.