

June 12, 1928.

L. W. THOMPSON

1,673,718

ELECTRIC REGULATOR

Filed April 14, 1925

2 Sheets-Sheet 1

Fig. 1.

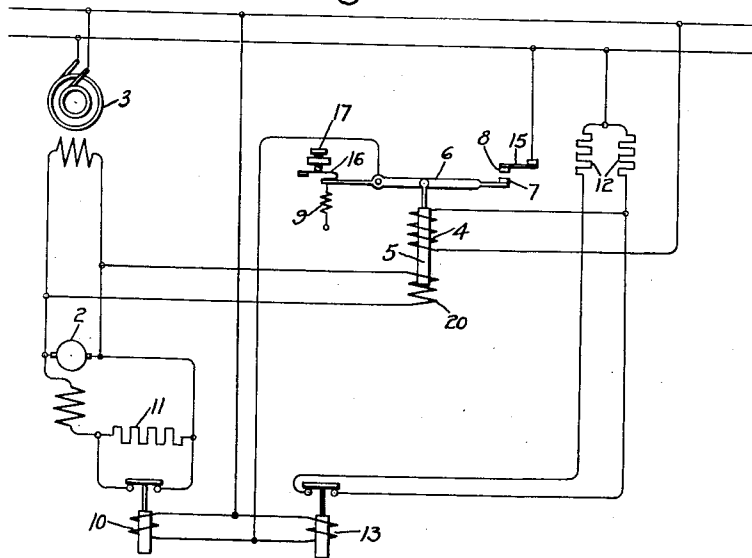
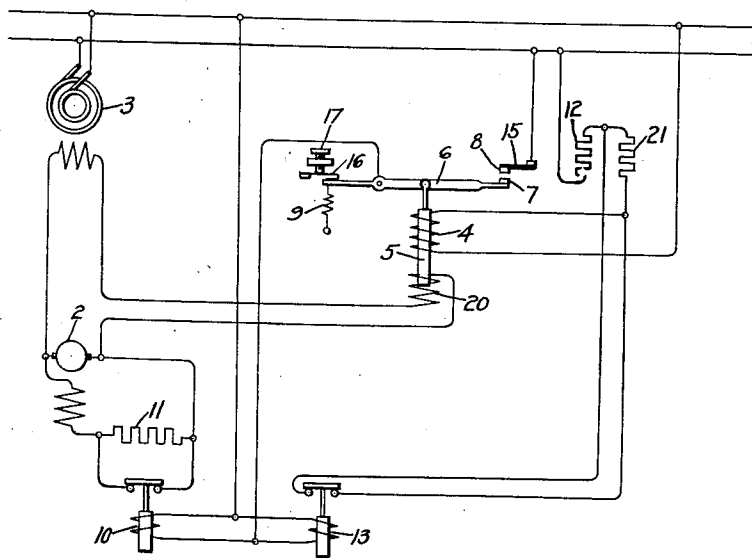


Fig. 2.



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2 Sheets-Sheet 2

Fig. 3.

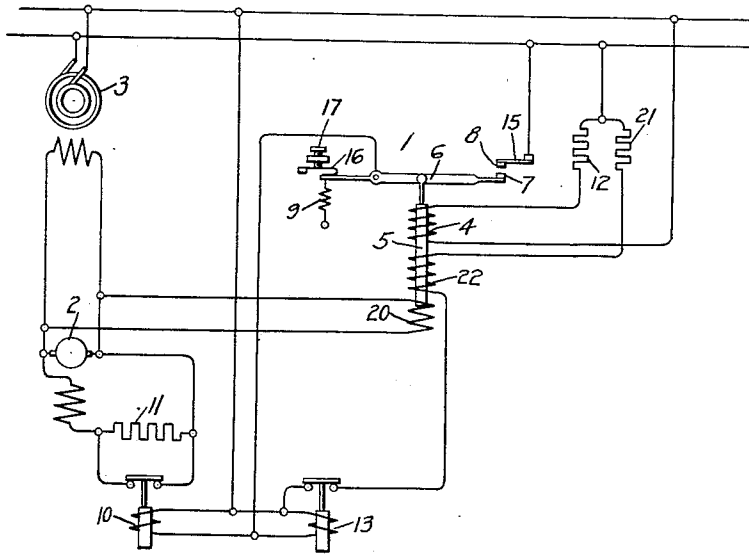
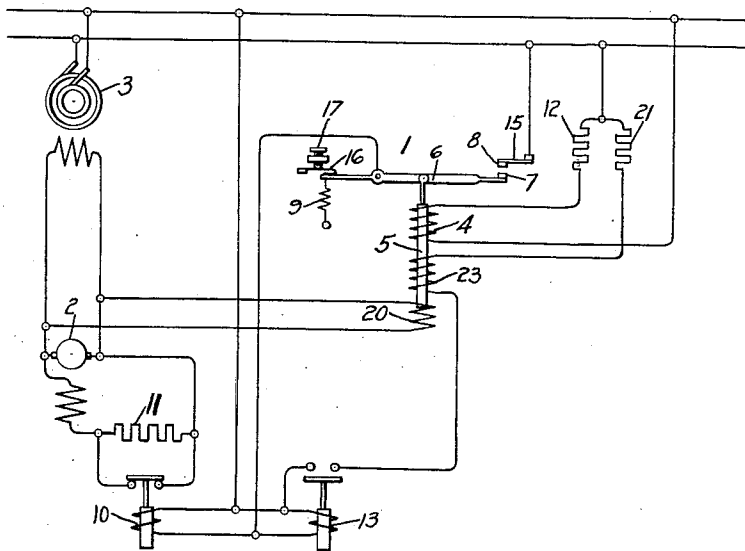


Fig. 4.



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UNITED STATES PATENT OFFICE.

LOUIS W. THOMPSON, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRIC REGULATOR.

Application filed April 14, 1925. Serial No. 23,157.

My invention relates to electric regulators and particularly to regulators of the well known vibratory type.

One object of my invention is to provide an improved regulator of the vibratory type which is simple, easy and cheap to construct, and which is quick and accurate in its operation.

Another object of my invention is to provide an improved alternating current voltage regulator of the vibratory type whereby the alternating current voltage can be maintained constant over a very wide range of load.

In accordance with my invention, I provide a regulator in which all dash pots and other similar slowly responding retarding devices are eliminated so that the regulator is free to respond quickly to any sudden changes in the condition being regulated. Also in accordance with the preferred form of my invention all of the control devices of a voltage regulator for an alternating current circuit are supplied from the alternating current circuit, the voltage of which is being maintained constant.

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

In the accompanying drawings, Figure 1 is a diagrammatic view of an alternating current voltage regulator embodying my invention and Figs. 2, 3 and 4 show modifications of the arrangement shown in Fig. 1 for preventing hunting and undercompounding of the regulator.

Referring to Fig. 1, 1 represents a vibratory voltage regulator which embodies my invention. It is to be understood, however, that my invention is not limited to a regulator for controlling the voltage of an electric circuit but is applicable to a regulator for controlling any electrical characteristic of an electric circuit. As shown in the drawings, the regulator 1 is arranged to control the excitation of an exciter 2 for an alternating current generator 3 so as to maintain the voltage of the generator constant.

The regulator 1 comprises a solenoid 4 which is connected so that it is energized in accordance with variations in the voltage of the generator 3 which is the condition being regulated. The solenoid 4 actuates a core 5

which carries a contact arm 6 having a contact 7 mounted thereon. The contact 7 is arranged to be moved into engagement with a contact 8 by the movement of the core 5 when the solenoid 4 is energized a predetermined amount. The usual voltage adjusting spring 9 is provided whereby the voltage, which the regulator maintains constant, may be varied. As shown one end of the spring 9 is connected to movable arm 6 and the other end is fastened to a suitable fixed portion of the regulator. The contacts 7 and 8, when in engagement, connect the control relay 10 across the generator 3. The control relay 10, when energized, removes a short circuit from around a resistor 11 in the shunt field circuit of the exciter 2. Therefore, each time the contacts 7 and 8 are in engagement, the resistor 11 is inserted in the exciter field circuit to effect a decrease in the excitation of the generator if the generator voltage exceeds the pickup value of the relay 10. If, however, the generator voltage is not high enough to cause the relay 10 to pick up, and the pick up value of the relay 10 preferably is made very high, the resistor 11 remains short circuited. Therefore if a sudden drop in voltage occurs, the control relay 10 maintains the resistor 11 short circuited independently of any operation of the main contacts 7 and 8 until the generator voltage is restored to a value sufficient to pick up the control relay. In this way the voltage is quickly restored to its normal value.

It is well known in the regulator art that in order to prevent hunting, when the desired regulation is obtained by varying the excitation of an exciter by means of a vibratory regulator, it is necessary to provide suitable means for causing the main contacts of the regulator to vibrate independently of variations in the condition being regulated. Various means, which are well known in the art, have been devised heretofore for accomplishing this result. One arrangement, which has been used, consists in mounting one of the contacts on a flexible spring and providing suitable means whereby each time the main contacts are opened and closed the energization of the main control magnet is varied. In this way, the contact which is actuated by the main control magnet is maintained in constant vibration independently of any variation in the condition being regulated.

Fig. 1 discloses one well known arrangement for causing the main contacts to vibrate independently of variations in the condition being regulated. It comprises mounting the contact 8 on a flexible spring 15 and providing the parallel resistors 12, which are connected in series with the solenoid 4, and a control relay 13 which is arranged to open the circuit through one of the parallel resistors 12 when the contacts 7 and 8 are in engagement with each other. In all of the known arrangements of this type which have been used heretofore, the flexible spring, on which one of the contacts was mounted, has been so arranged that without other retarding means the rate of vibration of the contacts would have been too great for satisfactory operation. In order to make the contacts vibrate at the proper rate, dash pots have been connected to the movable members of either the main control magnet or one of the auxiliary control relays. These dash pots, however, have the very undesirable feature of preventing the regulator from responding quickly enough to prevent a wide variation in the condition being regulated when a large load is connected to or disconnected from the circuit.

In accordance with my invention, I provide an arrangement whereby the desired frequency of vibration of the contact 7 is obtained without the use of dash pots or other similar retarding means which prevent the regulator from responding quickly to changes in the condition being regulated. This result is accomplished by properly constructing and arranging the resilient means which retards the movement of the main control magnet. In the arrangement shown in Fig. 1, I provide, in addition to the flexible spring 15, another spring 16 which the contact arm 6 is arranged to engage each time the contact 7 is moved out of engagement with the contact 8. By properly constructing and arranging these springs so that they engage the contact arm 6 or some other portion of the regulator, which is actuated by the solenoid 4, at the proper point of its movement, the contact 7 can be made to vibrate at the proper rate to obtain the desired results. I find that it is possible to obtain the desired regulation without using the spring 16 if the spring 15 has the proper resilience. The best rate of vibration, however, varies with the electrical conditions present in the regulating circuit so that it is impossible to obtain the best results for all regulators with a given spring 15. Therefore, it is desirable to arrange the resilient means that controls the frequency of vibration of the core 5 so that frequency of engagement of the contacts 7 and 8 may be varied to the best value for any particular regulating circuit. This result can be obtained very easily by using the two springs

15 and 16 and providing means for varying the position of the spring 16 relatively to the contact arm 6. As shown in the drawing, the thumb screw 17 is provided for adjusting the position of the spring 16.

It will be observed that as the load on the generator increases it is necessary to increase the excitation thereof in order to maintain the voltage constant. For accomplishing this result it is necessary to keep the resistor 11 short circuited more of the time, which means that the contacts 7 and 8 remain separated for a longer time during each vibration of the arm 6. Therefore, if no compensating means were provided the regulator would undercompound. In order to prevent this undercompounding I provided a coil 20 around the core 5 which is connected so as to be responsive to the voltage of the exciter 2. The coil 20 is arranged so that its pull on the core 5 opposes the pull of the coil 4. It will be evident that as the load increases the pull exerted by the coil 20 increases. Therefore by properly designing the coil 20 it is evident that any desired compounding effect of the regulator may be obtained. While I have shown the coil 20 connected so that it is responsive to the exciter voltage it is evident that it may be connected in any other suitable manner so that the excitation thereof varies with the output of the generator 3.

The operation of the system shown will be obvious from the above description. It will be observed that by means of the flexible springs 15 and 16 and the operation of the control relay 10 the contact 7 is made to vibrate at a proper rate to prevent hunting and that the length of time during which the contacts 7 and 8 are in engagement during each vibration of the contact 7 depends upon the energization of the coils 4 and 20.

It will be evident that since the main control element and the control relays are not retarded by dash pots or other similar retarding means which slow up their responsiveness but are freely movable, the regulator responds very quickly to sudden changes in voltage. Furthermore, since all of the control relays are supplied from the alternating current source the voltage of which is maintained constant the range of the regulator is not limited by the voltage range over which the relays can be made to operate satisfactorily as is the case when the control relays are energized from the exciter, the voltage of which varies over a wide range.

In the modification of Fig. 1 shown in Fig. 2 the rapid vibration of the contact 7, so as to prevent hunting, is effected by having the relay 13 arranged so that when it opens its contacts it inserts a resistor 21 in series with the resistor 12. Also in this modification the compensating winding 20 is

energized by the generator field current which is another characteristic which varies with the load on the generator.

In the modification of Fig. 1 shown in Fig. 3 the rapid vibration of the contact 7 is effected by a third winding 22 around the core 5 which acts accumulatively with winding 4. The circuit of this winding 22 is energized by the generator 3 and is interrupted when the contacts of the relay 13 are opened.

In the modification of Fig. 1 shown in Fig. 4 the rapid vibration of the contact 7 is effected by a third winding 23 around the core which acts differentially with respect to winding 4. In this modification the relay 13 is arranged to close its contacts and connect the winding 23 across the generator when the regulator contacts 7 and 8 are closed.

The operation of the modifications shown in Figs. 2 to 4 inclusive is believed to be obvious so that a detail description thereof is deemed unnecessary.

While I have, in accordance with the patent statutes, shown and described my invention as applied to a particular system and as embodying various devices diagrammatically shown, changes and modifications will be obvious to those skilled in the art, and I therefore aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. An electric regulator comprising two cooperating contacts, means for vibrating one of said contacts, and resilient means comprising a spring for supporting one of said contacts having such a length and resiliency as to modify the period of vibration of said contacts for effecting the desired regulation without hunting.

2. An electric regulator comprising two cooperating contacts, means responsive to the condition being regulated for actuating one of said contacts, means for effecting a vibration of one of said contacts, resilient means associated with one of said contacts for retarding the movement of said actuating means, and means for adjusting the retarding action of said resilient means to adjust the period of vibration of said contacts for effecting the desired regulation without hunting.

3. An electric regulator comprising two cooperating contacts, an electromagnet for actuating one of said contacts arranged to be energized in accordance with the variations in the condition being regulated, freely movable relays controlled by said contacts for controlling the condition being regulated and the energization of said electromagnet, and resilient means comprising a spring hav-

ing such a length and resiliency as to retard the movable portion of said electro-magnet during a portion of its travel for modifying the period of vibration of said contacts so that said contacts are vibrated at a rate to effect the desired regulation without hunting and said electromagnet is free to respond quickly to changes in the condition being regulated.

4. An electric regulator comprising two cooperating contacts, an electromagnet arranged to be energized in accordance with the condition being regulated for actuating one of said contacts, freely movable electromagnetically operated means controlled by said contacts for governing the condition being regulated and the energization of said electromagnet to cause it to vibrate, and resilient means comprising a spring for supporting one of said contacts having such a length and resiliency as to modify the period of vibration of the movable portion of said electro-magnet for effecting the desired regulation without hunting.

5. An electric regulator comprising two cooperating contacts, an electromagnet arranged to be energized in accordance with the condition being regulated for actuating one of said contacts, freely movable electromagnetically operated means controlled by said contacts for governing the condition being regulated and the energization of said electromagnet to cause it to vibrate, and resilient means for retarding the movement of said electromagnet comprising a spring on which one of said contacts is mounted and an adjustable spring adapted to be engaged by the movable portion of the electromagnet.

6. In a regulating system, the combination with an alternating current dynamo-electric machine, an exciter therefor, of regulating means for varying the excitation of said exciter comprising two cooperating contacts, an electromagnet for actuating one of said contacts having a winding responsive to the voltage of said machine, freely movable electromagnetically operated means for governing the excitation of the exciter and the energization of the electromagnet energized by said machine and controlled by said cooperating contacts, and resilient means comprising a spring for supporting one of said contacts and a spring adapted to be adjusted to different positions to engage the movable portion of said electro-magnet for modifying the period of vibration of said contacts to effect the desired regulation without hunting.

7. In a regulating system, the combination with an alternating current dynamo-electric machine, an exciter therefor, of regulating means for varying the excitation of said exciter comprising two cooperating contacts, an electromagnet for actuating one of said contacts having a winding responsive to

the voltage of said machine, electromagnetically operated means for governing the excitation of the exciter and the energization of said electromagnet energized from said machine and controlled by said cooperating contacts, and resilient means comprising a spring for yieldably retarding the movement of the movable portion of said electro-magnet in one direction of its travel and a spring adapted to be adjusted to different engaging positions relative to the movable portion of said electromagnet in the opposite direction of travel for controlling the movement of said electromagnet so that said electromagnet vibrates at the proper rate to effect the desired regulation without hunting.

8. In a regulating system, the combination with an alternating current dynamo-electric machine, an exciter therefor, of regulating means for varying the excitation of said exciter comprising two cooperating contacts, an electromagnet for actuating one of said contacts having a winding responsive to the voltage of said machine, and a winding connected so that its energization varies in accordance with the output of the machine, and electromagnetically operated means for governing the excitation of the exciter and the energization of said electromagnet energized from said machine and controlled by said cooperating contacts.

9. In a regulating system, the combination with an alternating current dynamo-electric machine, an exciter therefor, of regulating means for varying the excitation of said exciter comprising two cooperating contacts, an electromagnet for actuating one of said contacts having a winding responsive to the voltage of said machine and a differential winding responsive to an electrical characteristic of the exciter, electromagnetically operated means for governing the excitation of the exciter and the energization of said electromagnet, and circuits for said electromagnetically operated means energized from said machine and controlled by said cooperating contacts.

10. In a regulating system, the combination with an alternating current dynamo-electric machine, an exciter therefor, of regulating means for varying the excitation of said exciter comprising two cooperating contacts, an electromagnet for actuating one of said contacts having a plurality of windings, one of said windings being responsive to the voltage of said machine, and another one of said windings being responsive to the voltage of the exciter, a relay for varying the excitation of the exciter, another relay for controlling the circuit of one of the windings of the electromagnet so as to cause it to vibrate, and circuits for said relays energized by said machine and controlled by said cooperating contacts.

11. In a regulating system, the combina-

tion with an electric circuit and a dynamo-electric machine connected thereto, of regulating means for controlling the excitation of said dynamo-electric machine comprising two cooperating contacts, means for actuating one of said contacts comprising a winding responsive to the voltage of said electric circuit, electromagnetically operated means arranged when energized more than a predetermined amount to effect a decrease in the excitation of said machine, and a circuit for said electromagnetically operated means energized from said electric circuit and controlled by said cooperating contacts.

12. In a regulating system, the combination with an electric circuit and a dynamo-electric machine connected thereto, of regulating means for controlling the excitation of said dynamo-electric machine comprising two cooperating contacts, means for actuating one of said contacts comprising a winding responsive to the voltage of said electric circuit, electromagnetically operated means arranged when energized more than a predetermined amount to effect a decrease in the excitation of said machine, and a circuit for said electromagnetically operated means arranged to be completed across said electric circuit when said cooperating contacts are in engagement.

13. In a regulating system, the combination with an electric circuit and a dynamo-electric machine connected thereto, of regulating means for controlling the excitation of said dynamo-electric machine comprising two cooperating contacts, means for actuating one of said contacts comprising a winding responsive to the voltage of said electric circuit, electromagnetically operated means arranged when energized more than a predetermined amount to effect a decrease in the excitation of said machine and a variation in the energization of said actuating means, and a circuit for said electromagnetically operated means energized from said electric circuit and controlled by said cooperating contacts.

14. In a regulating system, the combination with an electric circuit and a dynamo-electric machine connected thereto, of regulating means for controlling the excitation of said dynamo-electric machine comprising two cooperating contacts, means for actuating one of said contacts comprising a winding responsive to the voltage of said electric circuit, a relay arranged when energized more than a predetermined amount to effect a decrease in the excitation of said machine, another relay arranged to vary the energization of said actuating means, and circuits for said relays energized from said electric circuit and controlled by said cooperating contacts.

15. In a regulating system, the combination with an electric circuit and a dynamo-

electric machine connected thereto, of regulating means for controlling the excitation of said dynamo-electric machine comprising two cooperating contacts, means for actuating one of said contacts comprising a winding responsive to the voltage of said electric circuit, a relay arranged when energized more than a predetermined amount to effect a decrease in the excitation of said machine, another relay arranged when energized more than a predetermined amount to vary the energization of said actuating means, and circuits for said relays arranged to be completed across said electric circuit when said cooperating contacts are in engagement.

In witness whereof, I have hereunto set my hand this 11th day of April, 1925.

LOUIS W. THOMPSON.