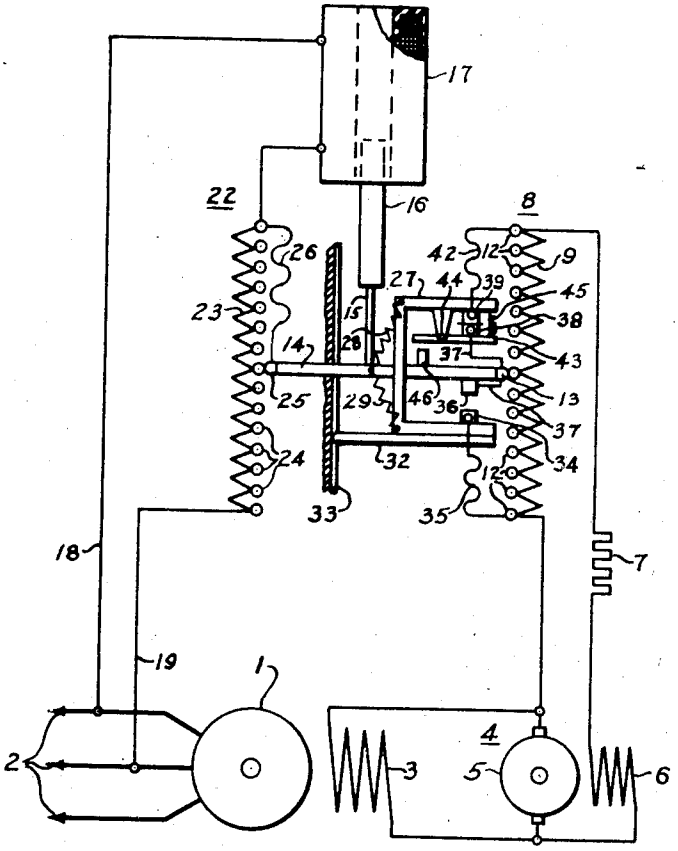
July 4, 1939. L. L. FOUNTAIN 2,165,043

VOTAGE REGULATOR

Filed Oct. 27, 1937



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Patented July 4, 1939

2,165,043

UNITED STATES PATENT OFFICE

2,165,043

VOLTAGE REGULATOR

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Application October 27, 1937, Serial No. 171,365

6 Claims. (Cl. 171—229)

My invention relates to regulator systems, and particularly to regulators for controlling the excitation of a dynamo-electric machine in accordance with the variations in a regulated characteristic thereof from the desired value. My invention is particularly adapted for use in controlling the voltage of electric generators.

It is an object of my invention to provide a regulator of simple construction, that is prompt and accurate in its operation and is inexpensive to manufacture.

It is another object of my invention to provide a voltage regulator having no parts that are movable so long as the regulated voltage remains at its desired value.

Other objects and advantages of my invention will be apparent from the following description of one preferred embodiment, reference being had to the accompanying drawing, in which the single figure illustrates apparatus and circuits comprising such an embodiment.

Referring to the drawing, a generator 1 is provided for supplying alternating-current energy to a power circuit 2, the generator having a field winding 3 that is supplied with energy from an exciter generator 4 having an armature winding 5 and a field winding 6. The field winding 6 is connected in a circuit comprising a fixed resistor 7 and a field regulating rheostat 8 having a variable resistor 9 connected to a plurality of contact buttons 12 that are adapted to be engaged by a movable contact member 13 carried by a rheostat arm 14. The rheostat arm 14 is operatively connected by a stem 15 to a core armature 16 that is adapted to move axially into a central bore within a solenoid 17. The core 16 is attracted by the solenoid 17 against a biasing force, which, in the arrangement illustrated, is gravity. The solenoid 17 is connected to be energized from conductors 18 and 19 forming an energizing or regulating circuit therefor, and connected to the power circuit conductors, the energizing circuit including a recalibrating rheostat 22 having a variable resistor 23 to which a plurality of contact buttons 24 are connected at spaced intervals and adapted to be engaged by a movable contact member 25 carried by the rheostat arm 14 and connected by a conductor 26 to the upper end of the resistor 23.

A bracket 27 is operatively connected through resilient or biasing spring members 28 and 29 to the rheostat arm 14 so as to be biased through the resilient spring members to move in a direction corresponding to the motion of the rheostat arm 14. A retarding or damping member 32 is carried by the bracket 27 and so mounted as to have frictional engagement with a guideway or track 33 to resist the biasing force of the springs 28 and 29. A field forcing contact 34 is mounted on the lower arm of the bracket 27 and connected by a conductor 35 to the lower end of the resistor 9. This field forcing contact member is adapted to engage a contact member 36 carried by the rheostat arm 14 and connected through conductor 37, field forcing contacts 38 and 39, and conductor 42 to the upper end of the resistor 9.

The field forcing contact member 38 is carried by the upper arm of the bracket 27 and is normally held in engagement with the contact member 38 carried by the arm 43 that is pivotally mounted at 44 by means of a spring 45 biasing the contact carrying end of the lever 43 toward the upper arm of the bracket 27. A projection 46 extends upwardly from the rheostat arm 14 adjacent the opposite end of the lever 43 that is adapted upon a sudden upward movement of the rheostat arm to move the lever 43 in a direction to separate the contact members 38 and 39.

The coil of the solenoid 17 is relatively long so as to permit a relatively large movement of the core 16 and rheostat arm 14 to control the exciter field current over a range required to maintain normal generator voltage from no load to full load. The large movement of the core 16 in response to slight variations in the regulated voltage from the desired value is obtained by the use of the calibrating rheostat 22, which so adjusts the current in the solenoid 17 upon movement of the core 16 as to compensate for the varying pull on the core with changes in position thereof, so that, for any given position of the core 16, the current supplied to the solenoid 17 that will be just sufficient to overcome the pull of gravity on the core 16 and the parts connected thereto, will be a constant for a constant or predetermined voltage applied to the energizing circuit conductors 18 and 19. A change from the desired value in the voltage applied to the energizing circuit conductors 18 and 19 will, therefore, cause a movement of the armature 16 in the one or the other direction, depending upon the direction of voltage change, and the return of the applied voltage to its desired value will be just sufficient to hold the armature 16 at rest against the force of gravity in any position of the armature within the solenoid.

If the regulated voltage increases above its desired value, the corresponding increase in the energization of the solenoid 17 will cause the

armature 16 to move upwardly as viewed in the drawing, carrying the rheostat arm 14 with it to decrease the number of turns of the field regulating resistor 9 shunted through conductor 42, between the rheostat contact member 13 and the upper end of the resistor, thus increasing the resistance of the rheostat 8 in circuit with the field winding 6 to decrease the energization of the excited generator 4 and of the main generator 1. As the rheostat arm 14 moves upwardly the contact member 25 also moves upwardly, decreasing the number of turns of the recalibrating rheostat 22 that is shunted through contact member 25 and conductor 26 to increase the rheostat resistance in series with the solenoid 17 at such rate as to prevent the force of the solenoid on the armature 17 from being increased as a result of the motion of the armature along the axis of the solenoid. Thus the pull of the solenoid 17 on the armature 16 is determined solely by the voltage between conductors 18 and 19 and is just sufficient to hold the armature 16 in a position balanced against gravity when the voltage applied to the energizing circuit 18—19 corresponds to the desired value.

If the upward motion of the rheostat arm 14 takes place gradually, as it will in response to a gradual change in the voltage applied to conductors 18—19, the force of the springs 28 and 29 will move the bracket 27 upwardly against the retarding or damping force of the member 32 with comparatively slight displacement of the bracket 27 from its illustrated position with respect to the rheostat arm 14. If, however, the change in voltage is sudden, causing a sudden upward movement of the armature 16 and of the rheostat arm 14, the retarding effect of the damping member 32 will be sufficient to prevent an immediate corresponding upward movement of the bracket 27, and this upward motion of the rheostat arm 14 will cause the projection 46 thereon to engage the inner end of the lever 43, causing it to pivot about the pin 44 separating the field forcing contact member 39 from the contact member 38, thus interrupting the circuit through these contact members and introducing into the field winding circuit that portion of the resistor 9 connected between the movable rheostat contact member 13 and the upper end of the resistor 9 to cause an abrupt decrease in the excitation of the exciter generator 4 and of the generator 1. This field forcing action will cause the core 16 to move downwardly, thus decreasing the force on the biasing members 28 and 29 and bringing the bracket 27 into a centered position with respect to the rheostat arm 14 at some lower position thereof than that initially resulting from the abrupt rise in generator voltage.

If the generator voltage drops below its desired value at a gradual rate, the decreasing energization of the solenoid 17 resulting therefrom permits the armature 16 to be moved downwardly by the force of gravity, thus shunting a larger number of turns of the field regulating rheostat 8 between the movable contact member 13 and the upper end of the resistor 9 to decrease the rheostsat resistance in series with the field winding 6, causing the excitation of the exciter generator 4 and of the main generator 1 to increase. As the rheostat arm 14 moves downwardly, the number of turns of the recalibrating rheostat 22 that are shunted through the contact member 25 and conductor 26 are likewise increased, leaving a lesser number of turns in series with the solenoid 17 to compensate for the characteristic of a plunger type solenoid to vary its pull upon a centrally moving armature as the position of the armature changes, so that the pull on the core 16 remains a constant value for a constant voltage applied to the conductors 18 and 19 of the energized circuit.

If the decrease in voltage applied to the solenoid energizing circuit takes place at a rapid rate, the downward movement of the armature 16 and of the rheostat arm 14 also takes place at a correspondingly rapid rate, but the movement of the bracket 27 in response to the biasing influence of the springs 28 and 29 is retarded by the damping member 32, permitting the contact member 36 carried by the rheostat arm 14 to engage the contact member 34 carried by the lower arm of the bracket 27, thus shunting the entire resistor 9 of the field controlling rheostat 8 from the circuit of the exciter generator field winding 6 to effect a rapid increase in the excitation of the exciter 4 and of the main generator 1. This field forcing action causes a sudden rise in generator voltage and a corresponding upward movement of the armature 16 to separate the contact members 36 and 34 and reinsert that portion of the resistor 9 below the contact member 13 in series with the exciter generator field winding 6. The rheostat arm 14 finally comes to rest at such position as to insert that part of the field controlling resistor 9 in series with the exciter generator field winding 6 that is necessary to produce the desired voltage on the main generator 1.

If desired, the circuit represented by conductors 18 and 19 may be energized from a three-phase rectifier connected between the three-phase conductors 2 and the solenoid energizing circuit conductors 18—19 to supply a unidirectional voltage thereto that represents the average three-phase alternating voltage.

Many modifications may be made in the apparatus and circuits described without departing from the spirit of my invention, and I do not wish to be limited otherwise than by the scope of the appended claims.

I claim as my invention:

1. In a regulator system, a dynamo-electric machine having a field winding, means responsive to a regulated characteristic of said dynamo-electric machine for governing the excitation thereof comprising a field regulating resistor, electroresponsive means including an armature acting against a biasing force of constant value for varying the effective value of said field controlling resistor and having a varying pull-with-position characteristic, a regulating circuit for said electroresponsive means, means for energizing said regulating circuit at a voltage that is a measure of the regulated quantity, and a recalibrating resistor in said regulating circuit having a plurality of intermediate values, means for gradually varying said resistor throughout those intermediate values in response to changes in the position of said armature throughout its operative range for so recalibrating said electroresponsive means that it will remain in a state of rest in any operative position upon the application of a predetermined voltage to the energizing circuit that is a measure of the desired value of the regulated quantity.

2. In a regulator system, a dynamo-electric machine having a field winding, means responsive to a regulated characteristic of said dynamo-electric machine for governing the excitation thereof comprising a field regulating resistor,

electroresponsive means including an armature acting against a biasing force of constant value for varying the effective value of said field controlling resistor and having a varying pull with position characteristic, an energizing circuit for said electroresponsive means, means for applying a voltage to said energizing circuit the value of which is a measure of the regulated quantity, a variable recalibrating resistor in said energizing circuit having a plurality of intermediate values controlled in accordance with the position of said armature throughout its operative range for so recalibrating said electroresponsive means that it will remain in a state of rest in any operative position upon the application of a predetermined voltage to the energizing circuit corresponding to the desired value of the regulated quantity, and field forcing contacts operative through biasing means responsive to rapid changes in position of said electroresponsive means for abruptly varying the excitation of said field winding.

3. In a regulator system, a dynamo-electric machine having a field winding, means responsive to a regulated characteristic of said dynamo-electric machine for governing the excitation thereof comprising a field regulating resistor, means for varying the effective value of said field controlling resistor comprising a solenoid and an armature movable axially of the solenoid against a constant force, an energizing circuit for the solenoid and means for applying a voltage thereto that is a measure of regulated quantity, and a variable recalibrating resistor in the energizing circuit controlled in response to the movement of said armature for so recalibrating the solenoid that the armature will remain in any operative position upon the application of a predetermined voltage to the energizing circuit that is a measure of the desired value of the regulated quantity, said field regulating resistor and said recalibrating resistor having movable contact arms operatively connected to said armature for simultaneously varying the setting of said two resistors in accordance with variations in the position of said armature.

4. In a regulating system, a dynamo-electric machine having a field winding, means responsive to a regulated characteristic of said dynamo-electric machine for governing the excitation thereof comprising a field regulating rheostat, means for varying the effective value of said field regulating rheostat comprising a solenoid and an armature movable axially of the solenoid against a constant force, an energizing circuit for the solenoid and means for applying a voltage thereto that is a measure of regulated quantity, a variable recalibrating rheostat in the energizing circuit controlled in response to the movement of said armature for so recalibrating the solenoid that the armature will remain in any operative position upon the application of a predetermined voltage to the energizing circuit, a rheostat arm operatively connected to said armature for varying the setting of said field regulating rheostat and said recalibrating rheostat, a bracket operatively connected through resilient means to said rheostat arm to follow the movements of said rheostat, retarding means attached to said bracket for resisting movement thereof by said rheostat arm, and field forcing contact members operatively related to the relative positions of said rheostat arm and said bracket for temporarily forcing the excitation of said field winding in the one or the other direction in response only to a rapid rate of motion of the rheostat arm.

5. In a voltage regulator for dynamo-electric machines having a field winding, means responsive to the regulated voltage for governing the excitation of said dynamo-electric machines comprising a field regulating resistor, electroresponsive means including an armature having a varying pull-with-position characteristic acting against a constant biasing force for varying the effective value of said field controlling resistor, a regulating circuit for energizing said electroresponsive means, means for applying the regulated voltage to said regulating circuit, a recalibrating resistor in said regulating circuit having a plurality of intermediate values, and means for gradually varying said resistor throughout those intermediate values in response to the operation of said electroresponsive means for so recalibrating said electroresponsive means that the armature will remain in a state of rest in any operative position upon the application of the same predetermined voltage to the regulating circuit.

6. In a voltage regulator for dynamo-electric machines having a field winding, means responsive to the regulated voltage for governing the excitation of said dynamo-electric machines comprising a field regulating rheostat having a resistor controlling arm, means for varying the effective value of said field regulating rheostat comprising a solenoid, an energizing circuit for the solenoid and means for applying a voltage thereto that is a measure of regulated quantity, and a recalibrating rheostat in the energizing circuit having a resistor controlling arm, an armature movable by said solenoid against an opposing force and operatively connected to simultaneously actuate the resistor controlling arms of both said rheostats to effect settings thereof variable with changes in the position of the armature.

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