Aug. 29, 1950 W. NIEMI 2,520,689

VOLTAGE REGULATING APPARATUS

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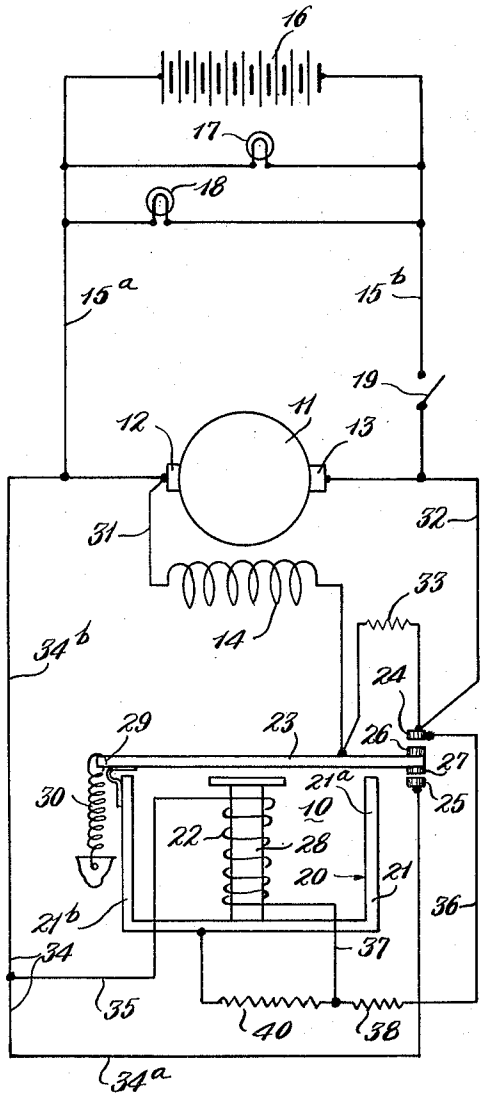


FIG. 1

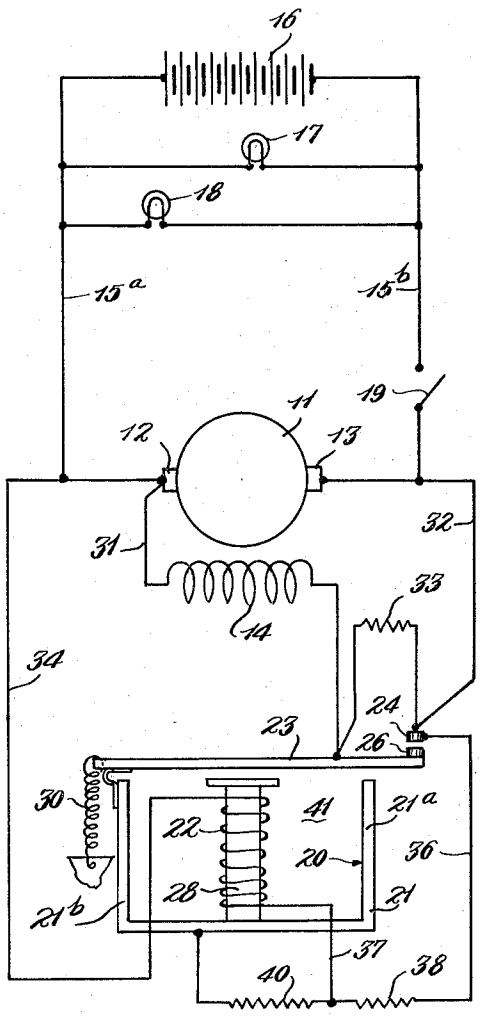


FIG. 2

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VOLTAGE REGULATING APPARATUS

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9 Claims. (Cl. 322—28)

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This invention relates to voltage regulating apparatus for controlling the terminal voltage of electric generators and, as one of its objects, aims to provide an improved and simplified apparatus of this kind which can be very economically manufactured and installed. Although the improved apparatus can be applied to electric generators designed for different types of service and current characteristics it is especially applicable to low voltage generators such as are used in the electrical systems of automotive vehicles and for that reason is hereinafter described in connection with a generating system of that kind but without any intention to limit the invention in this respect.

Another object of the present invention is to provide an improved voltage regulator of the vibratory-armature electromagnetic type having control contacts which are opened and closed by the armature and in which the rate of vibration of the armature is considerably higher than in prior devices of this character and produces a smoother regulating action by which the terminal voltage of the generator is more constantly maintained at the desired value.

A further object is to provide an improved voltage regulator of the character mentioned in which the armature will vibrate in a steadier and more reliable manner at a predetermined frequency for a given load value, such as will contribute to a long contact life and will permit a selection to be made for the contacts from various desirable contact materials, and in many cases will permit the use of a less expensive contact material with a regulating action equally efficient and comparable to the regulating action obtained when a more expensive contact material is used.

Still another object is to provide an improved voltage regulator of the electromagnetic vibratory type which employs a regulating resistance in such relation to the energizing circuit of the magnet as to produce a higher frequency rate and a steadier action for the vibratory opening and closing of the contacts by which a longer contact life and a more constant and satisfactory voltage regulating function are obtained.

Yet another object is to provide an improved voltage regulator of the character mentioned in which the magnet has only a single energizing coil thereon and the energizing circuit for the magnet includes a regulating resistance which effectively varies the ampere-turns of the coil in response to the vibratory opening and closing of the control contacts.

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The invention can be further briefly summarized as consisting in certain novel combinations and arrangements of parts hereinafter described and particularly set out in the claims hereof.

In the accompanying sheet of drawings:

Fig. 1 is an electric circuit diagram showing a generating system embodying the improved voltage regulating apparatus, and

Fig. 2 is another electric circuit diagram showing a generating system embodying a modified form of the voltage regulating apparatus.

As illustrating one practical application of this invention Fig. 1 of the drawing shows the improved voltage regulator 10 embodied in an electric generating system of the type used on automotive vehicles. The system here shown includes a low voltage direct current generator 11, for example a six volt generator, having terminals 12 and 13 and a shunt field winding 14. The system also includes an external load circuit represented by the load conductors 15*a* and 15*b* which are connected with the terminals 12 and 13. The load circuit may include various electrical devices carried by the vehicle such as the storage battery 16 and the electric lamps 17 and 18. The load circuit may also include a control switch 19 which can be a manually operated switch or, if desired, can be a conventional reverse current relay or so-called reverse current cut-out.

The improved voltage regulator 10 is of the vibratory electromagnetic type comprising a magnet 20 having a suitable frame 21 and an energizing coil 22. The voltage regulator also includes a vibratory armature 23 and two pairs of cooperating control contacts consisting of two spaced stationary contacts 24 and 25 and two movable contacts 26 and 27 carried by the armature and adapted to cooperate respectively with the stationary contacts 24 and 25.

The frame 21 of the magnet 20 includes a core 28 on which the energizing coil 22 is located and laterally spaced arm portions 21*a* and 21*b* located on opposite sides of the core. The armature 23 extends across the arm portions 21*a* and 21*b* and across one end of the core 28 so as to form a magnetic circuit and be responsive to energization of the frame by the coil 22. The armature 23 is adapted to cause a rapid opening and closing of the pairs of cooperating contacts in response to changes in the energization produced by the coil 22, as further explained hereinafter, and for this purpose the armature is pivoted or fulcrumed on the frame portion 21*b*

as by means of the flexible mounting member 29. A tension spring 30 connected with the armature 23 acts thereon to normally urge the armature in a direction to cause closing of the contacts 24 and 26. The energizing coil 22 of the magnet 20 is a voltage coil which is energized from the generator 11 by being connected across the terminals 12 and 13 thereof. The extent of energization of the coil 22 is variable for producing the voltage regulating function and is controlled by the action of the cooperating contacts 24—26, 25—27, as will be further explained hereinafter.

The field winding 14 of the generator 11 is contained in a field energizing circuit which is connected across the terminals 12 and 13 of the generator 11. As shown in the drawing, one end of the field winding 14 is connected with the terminal 12 by the conductor 31 and its other end is connected with the movable contact 26 through a portion of a vibratory armature 23. The field circuit is also formed in part by the conductor 32 which connects the stationary contact 24 with the generator terminal 13. A field resistance or so-called point resistance 33 is located in the field circuit and is connected across the cooperating contacts 24 and 26 so as to be included in the field circuit in series relation when these contacts are opened and short-circuited out of the field energizing circuit when these contacts are closed.

As shown in Fig. 1, the stationary contact 25 of the regulator 10 is connected with the generator terminal 12 through the conductor portions 34*a* and 34*b* of the conductor 34. One end of the magnet coil 22 is also connected directly with the generator terminal 12 by the conductor 35 and the conductor portion 34*b*. The other end of the coil 22 is connected with the stationary contact 24 through the conductors 36 and 37 and the series resistance 38 which may at times be referred to as a second resistance or a ballast resistance. Since the last-mentioned end of the coil 22 is connected with the stationary contact 24 and this contact is in turn connected with the generator terminal 13, it will be seen that the coil is always contained in an energizing circuit extending across the terminals of the generator for energization of this coil as a voltage coil, as mentioned above, and which will be responsive to changes in the operating condition of the generator.

An important feature of the improved voltage regulator 10 is the provision of a regulating resistance 40 in the energizing circuit for the magnet coil 22 and which resistance produces distinctly new and advantageous results in the voltage control function of the regulator. The regulating resistance 40 has one end thereof connected to the movable contacts 26 and 27 through the magnet frame 21 and the armature 23 and has its other end connected to the conductor 37 at a point between the coil 22 and the ballast resistance 38. When the regulating resistance 40 is embodied in the energizing circuit for the coil 22 in the relation just mentioned this resistance effectively varies the ampere-turns of the coil through circuit changes produced by the opening and closing of the control contacts in response to variations in the operating condition of the generator 11.

To further explain the function of the regulating resistance 40 it is pointed out that when the generator 11 is being operated under a condition such that the contacts 24 and 26 are being opened and closed by the vibratory movement of the armature 23, this resistance will be intermittently connected into and disconnected from a circuit arrangement in which the resistance is in shunt relation to the ballast resistance 38 and thus intermittenty increases the supply of current to the energizing coil 22 and hence the ampere-turns of the latter. On the other hand when the generator 11 is operating under a condition in which the contacts 25 and 27 are being opened and closed by the vibratory movement of the armature 23, the regulating resistance 40 will be intermittently connected in a circuit in which this resistance is in shunt relation to the coil 22 and hence decreases the ampere-turns of this coil.

To trace these energizing circuits for the coil 22 of the magnet 20 it is pointed out that when the contacts 24 and 26 are closed the energizing circuit for the coil 22 extends from the generator terminal 13 through the conductor 32 to the contact 24 and then through the conductor 36, the ballast resistance 38, the conductor 37 to the coil 22 and then back to the generator terminal 12 through the conductor 35 and the conductor portion 34*b*. A portion of this energizing circuit also extends at the same time from the contact 24 to the contact 26 and then through armature 23, frame 21, and regulating resistance 40 to the conductor 37. It will thus be seen that when the contacts 24 and 26 are closed the regulating resistance 40 is connected in shunt relation to the ballast resistance 38 and constitutes a second path through which additional energizing current can be supplied to the coil 22. The increased supply of current to the magnet coil 22 increases its ampere-turns thereby producing a stronger pull on the armature 23 and causing opening of the contacts 24 and 26 to insert the point resistance 33 into the field circuit of the generator.

When the contacts 25 and 27 are closed the energizing circuit for the magnet coil 22 extends from the generator terminal 13 through the conductors 32 and 36, the ballast resistance 38, the conductor 37 to the coil 22 and then back to the generator terminal 12 through the conductor 35 and the conductor portion 34*b*. At this same time the closed condition of the contacts 25 and 27 causes one end of the regulating resistance 40 to be connected with the generator terminal 12 through the frame 21, armature 23, contacts 27 and 25 and conductor portions 34*a* and 34*b*. Since the other end of the regulating resistance 40 remains connected with the stationary contact 24 and the generator terminal 13 through the ballast resistance 38, it will be seen that the regulating resistance is now connected in shunt relation to the coil 22 and will therefore decrease the ampere-turns of this coil and the resulting decrease in the energization of the magnet 20 will permit opening of the contacts 25 and 27.

During the operation of the improved regulator 10 the contacts 24 and 26 are initially held closed by the spring 30 while the generator 11 is being started up. For certain operating conditions of the system the regulator 10 will function with a vibratory opening and closing of the contacts 24 and 26 while the contacts 25 and 27 remain open. Under other operating conditions both pairs of control contacts 24, 26 and 25, 27 will remain open. For still other conditions of operation the regulator will function with a vibratory opening and closing of the contacts 25 and 27 while the contacts 24 and 26 remain open.

It has been found that the use of the regulating resistance 40 greatly simplifies the construction of the regulator 10 because only a single energizing coil is required for the magnet 20. The use of the regulating resistance 40 has also been found to produce a very effective and reliable voltage regulating action through its effect in varying the ampere-turns of the energizing coil 22 of the magnet. By reason of the use of the regulating resistance 40 it has also been found that the improved regulator 10 gives a very smooth regulating function in which the armature vibrates at a higher rate than has heretofore occurred in voltage regulating devices of this kind and that for a given load value on the generator the armature vibrates steadily at a predetermined frequency. Moreover, it has been found that by the use of the regulating resistance 40 the rate of vibration of the armature can be predetermined for giving load values such that the frequency rate can be so adapted as to permit the use in the control contacts of various selected contact materials. This feature is very important because it enables the manufacturer to select lower priced contact materials from various available materials and to obtain a voltage regulating action equally efficient and reliable to a voltage regulating action obtainable through the use of higher priced contact materials. By thus being able to establish a predetermined frequency of vibration for the armature 23, a frequency can be selected which will contribute to a long life for the control contacts thus rendering the voltage regulator capable of performing satisfactorily for a longer period of time with a minimum amount of attention and servicing.

Fig. 2 of the drawing shows another practical application of the present invention in which a modified form of the improved voltage regulator is used. In the electrical system shown in Fig. 2 the modified voltage regulator 41 has only one pair of control contacts 24 and 26 but in other respects is similar to the voltage regulator 10 described above, and the same reference characters have accordingly been used to designate corresponding parts. In the operation of the modified regulator 41 the opening and closing of the contacts 24 and 26 intermittently connects the point resistance 33 into and short-circuits the same out of the field circuit of the generator 11. The closing and opening of these contacts also intermittently connects the regulating resistance 40 into the energizing circuit for the coil 22 so that when the contacts are closed this resistance will be connected in shunt relation to the ballast resistance 38 and thus increase the ampere-turns of this coil and produce an increased energization of the magnet 20 which will result in opening of the contacts 24 and 26.

To enable those skilled in this art to further evaluate the practical importance of the improved voltage regulator, a set of specific values can be given for the apparatus illustrated in Fig. 1. For example when the generator 11 is a six volt generator having a shunt field whose resistance is approximately two and one-half ohms, the voltage regulator 10 may embody a point resistance 33 whose resistance value is approximately six and one-half ohms and a ballast resistance 38 whose resistance value is approximately thirteen ohms. The magnet coil 22 would have approximately one thousand turns of magnet wire and a resistance value of approximately ten ohms. For the circuit values just given above the regulating resistance 40 would have a resistance value of approximately one hundred and seventy ohms.

Although the improved voltage regulator has been referred to herein as being well suited for use with low voltage generators and a six volt generator has been mentioned specifically, it should be understood that the invention is not limited in this respect and that it is also applicable to generators of twelve volt, twenty-four volt, thirty-two volt and higher voltage ratings.

From the foregoing description and accompanying drawings it should now be readily understood that this invention provides an improved voltage regulator which is applicable to electric generators of various specific ratings and designs but is especially useful for controlling the terminal voltage of low voltage generators when embodied in electrical systems of the type used on automotive vehicles. It will now also be understood that the improved voltage regulator produces a highly efficient and more satisfactory regulating action and can be manufactured at a lower cost than similar devices heretofore proposed.

Although the improved voltage regulator provided by this invention has been illustrated and described herein to a somewhat detailed extent, it will be understood of course that the invention should not be regarded as being correspondingly limited in scope but includes all changes and modifications coming within the terms of the claims hereof.

Having thus described my invention, I claim:

1. In combination with a generator having terminals and a field circuit including a field winding and a field resistance, a voltage regulator comprising a magnet having a vibratory armature responsive to energization of said magnet and cooperating contacts adapted to be opened and closed by vibration of said armature for intermittently removing said field resistance from said field circuit, said magnet having an energizing coil, circuit connections connecting said coil across said terminals to establish a regulator circuit for energizing said coil from said generator, a second resistance in said regulator circuit, a regulating resistance, and circuit connections controlled by said contacts and adapted to intermittently connect said regulating resistance in shunt relation to said second resistance for increasing the energization of said coil, said field resistance and said regulating resistance having respectively a relatively low and a relatively high resistance value and said second resistance having a resistance value intermediate said low and high resistance values.

2. In combination with a generator having terminals and a field circuit including a field winding and a field resistance, a voltage regulator comprising a magnet having a vibratory armature responsive to energization of said magnet and a pair of cooperating contacts adapted to be opened and closed by vibration of said armature and to short-circuit said field resistance out of said field circuit when the contacts are closed, said magnet having only a single energizing coil, circuit connections connecting said coil across said terminals to establish a regulator circuit for energizing said magnet from said generator, a second resistance in said regulator circuit in series with said coil, a regulating resistance, and circuit connections controlled by said contacts and adapted to connect said regulating resistance in shunt relation to said second resistance when said contacts are closed, said field resistance and

said regulating resistance having respectively a relatively low and a relatively high resistance value and said second resistance having a resistance value intermediate said low and high resistance values.

3. In combination with a generator having terminals and a field circuit including a field winding and a field resistance, a voltage regulator comprising a magnet having a frame and a vibratory armature responsive to energization of said magnet and also having cooperating contacts adapted to be opened and closed by vibration of said armature for intermittently short-cuiting said field resistance out of said field circuit, said magnet having an energizing coil, circuit connections connecting said coil across said terminals to establish a regulator circuit for energizing said coil from said generator, a ballast resistance in said regulator circuit, a regulating resistance, and circuit connections controlled by said contacts and including a circuit portion extending through said frame for intermittently connecting said regulating resistance in shunt relation to said ballast resistance for increasing the energization of said coil, said field resistance and said regulating resistance having respectively a relatively low and a relatively high resistance value and said ballast resistance having a resistance value intermediate said low and high resistance values.

4. The combination with a generator having terminals and a field circuit including a field winding and a field resistance, a voltage regulator comprising a magnet having a vibratory armature responsive to energization of said magnet and pairs of cooperating contacts adapted to be opened and closed by vibration of said armature, one pair of said contacts being in said field circuit and being effective for intermittently removing said field resistance from said field circuit, said magnet having an energizing coil, circuit connections connecting said coil across said terminals to establish a regulator circuit for energizing said coil from said generator, a second resistance in said regulator circuit, a regulating resistance, and circuit connections controlled by said pairs of contacts and by which said regulating resistance is adapted to be connected in shunt relation to said second resistance when said one pair of contacts is closed and to be connected in shunt relation to said coil when another pair of said contacts is closed.

5. In combination with a generator having terminals and a field circuit containing a field winding, a voltage regulator comprising a magnet having a vibratory armature responsive to energization of said magnet and a voltage coil for energizing said magnet, cooperating contact means adapted to be opened and closed by said armature and comprising two pairs of cooperating contacts, a field resistance controlled by one pair of said contacts for varying the energization of said field winding, circuit connections connecting said coil across said terminals for energization by said generator, a series resistance in the energizing circuit for said coil, and a regulating resistance in the energizing circuit for said coil and controlled by said contact means, said energizing circuit including circuit connections for connecting said regulating resistance in shunt relation to said series resistance for increasing the ampere turns of said coil when one pair of said contacts is closed and in shunt relation to said coil for decreasing the ampere turns thereof when the other pair of said contacts is closed.

6. In apparatus of the character described, a generator having terminals and a field winding, a voltage regulator comprising a magnet having an armature adapted to be vibrated and two pairs of contacts adapted to be opened and closed by vibration of said armature, a field circuit having said field winding and one pair of said contacts therein, a field resistance connected across and controlled by said one pair of contacts, said magnet having only a single energizing coil, circuit connections connecting said coil across said terminals for energization of the coil from said generator, a second resistance in the coil energizing circuit, a regulating resistance, and circuit connections for connecting said regulating resistance in shunt relation to said second resistance when said one pair of contacts is closed and in shunt relation to said coil when the second pair of contacts is closed.

7. In apparatus of the character described, a generator having terminals and a field winding, a voltage regulator comprising a magnet having an armature adapted to be vibrated and two pairs of contacts adapted to be opened and closed by vibration of said armature, said contacts comprising fixed contacts in spaced apart relation and a movable contact carried by said armature and adapted to cooperate with the fixed contacts in response to vibration of the armature, a field circuit having therein said field winding and one pair of said contacts consisting of said movable contact and one of said fixed contacts, a field resistance connected across and controlled by said one pair of contacts, an energizing coil for said magnet, circuit connections connecting said coil across said terminals for energization of said coil from said generator, a ballast resistance in the coil energizing circuit, a regulating resistance, and circuit connections connecting said regulating resistance with said movable contact and said coil energizing circuit such that said regulating resistance is in shunt relation to said ballast resistance when said one pair of contacts is closed and in shunt relation to said coil when the second pair of contacts is closed.

8. In combination with a generator having terminals and a field winding, a regulator comprising a magnet having a frame including a vibratory armature and a coil for energizing said frame to produce the vibratory movement of said armature, said regulator also having a pair of cooperating contacts one of which is a stationary contact electrically connected with one of the terminals of said generator and the other contact being movable and carried by said armature, circuit connections connecting said coil across said terminals to establish a regulator circuit for energizing said coil from said generator, a ballast resistance in said regulator circuit in series with said coil, said field winding having one end connected with the other of said terminals and its other end electrically connected with said movable contact to provide a field circuit, a field resistance connected across said contacts to be intermittently connected into and short-circuited out of said field circuit by the opening and closing of said contacts, and a regulating resistance having one end thereof electrically connected with said movable contact and its other end connected with said regulator circuit at a point between said coil and said ballast resistance, said regulating resistance being connected in said regulator circuit in shunt relation to said ballast resistance for increasing the energization of said coil when said contacts are closed.

9. In combination with a generator having terminals and a field winding, a regulator comprising a magnet having a frame including a vibratory armature and a coil for energizing said frame to produce the vibratory movement of said armature, said regulator also having cooperating contacts including a first stationary contact electrically connected with one of the terminals of said generator and a movable contact means carried by said armature, circuit connections connecting said coil across said terminals to establish a regulator circuit for energizing said coil from said generator, a ballast resistance in said regulator circuit in series with said coil, said field winding having one end connected with the other of said terminals and its other end electrically connected with said movable contact means to provide a field circuit, a field resistance connected across said first stationary contact and said movable contact means to be intermittently connected into and shirt-circuited out of said field circuit by the opening and closing of said first stationary contact and said movable contact means, and a regulating resistance having one end thereof electrically connected with said movable contact means and its other end connected with said regulator circuit at a point between said coil and said ballast resistance, the contacts of said regulator also including a second stationary contact electrically connected with said other terminal, said regulating resistance being connected in said regulator circuit in shunt relation to said ballast resistance for increasing the energization of said coil when said movable contact means is in engagement with said first stationary contact and in shunt relation to said coil for decreasing the energization thereof when said movable contact means is in engagement with said second stationary contact.

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