G. A. BURNHAM.

AUTOMATIC VOLTAGE REGULATOR.

APPLICATION FILED AUG. 23, 1909.

985,109. **Patented Feb. 21, 1911.**

3 SHEETS—SHEET 1.

Fig. 1.

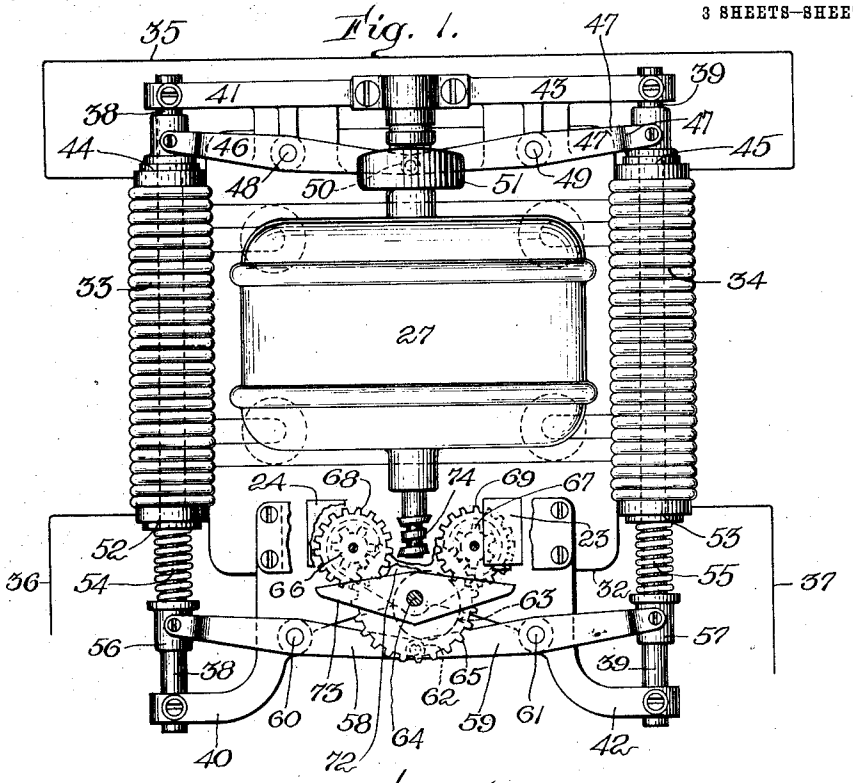
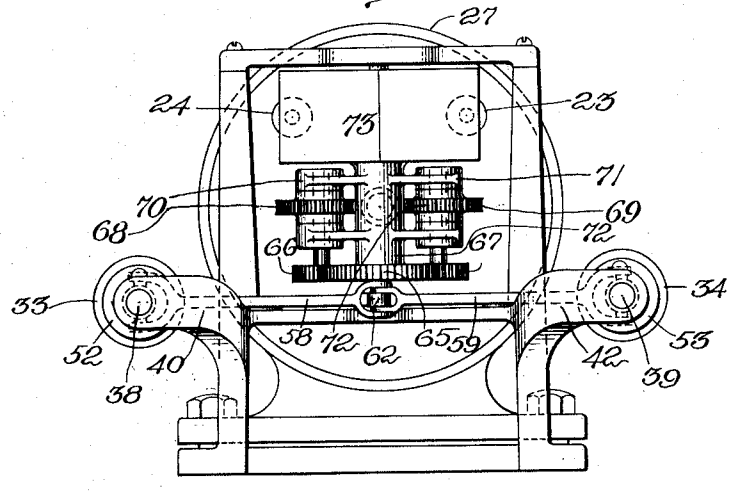


Fig. 5.



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3 SHEETS—SHEET 2.

Fig. 4.

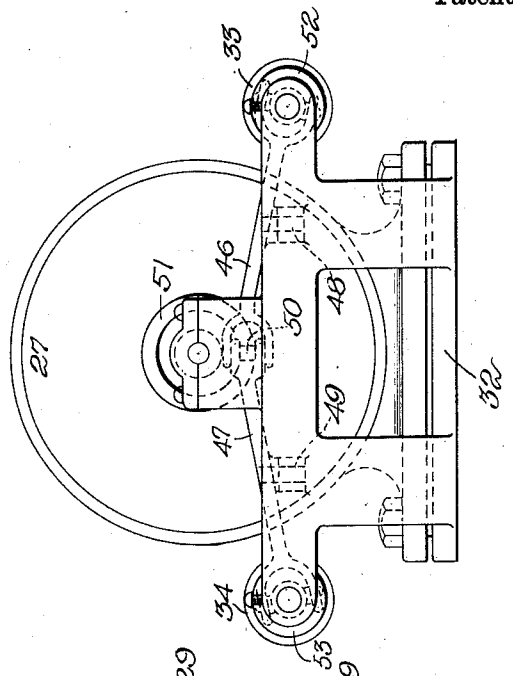
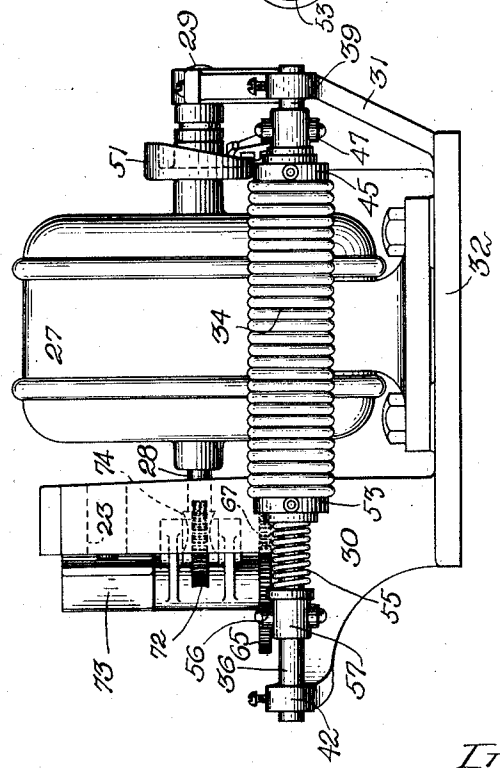


Fig. 2.



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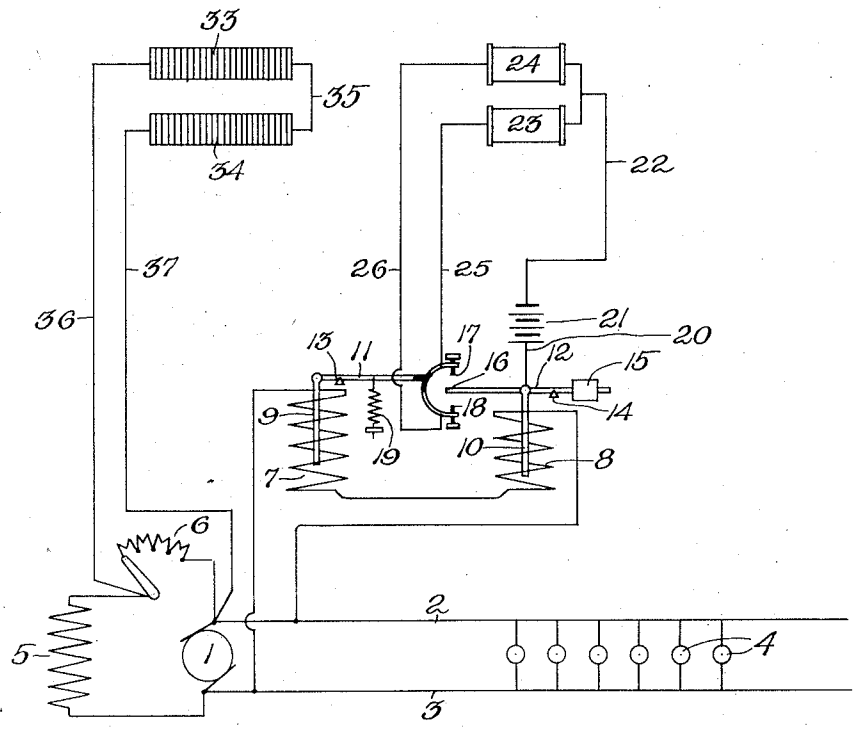
3 SHEETS—SHEET 3.

Fig. 5.



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UNITED STATES PATENT OFFICE.

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AUTOMATIC VOLTAGE-REGULATOR.

985,109. Specification of Letters Patent. Patented Feb. 21, 1911.

Application filed August 23, 1909. Serial No. 514,121.

To all whom it may concern:

Be it known that I, GEORGE A. BURNHAM, a citizen of the United States, and resident of Essex, in the county of Essex and State of Massachusetts, have invented an Improvement in Automatic Voltage-Regulators, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

The present voltage regulator aims to eliminate the disadvantages of those regulators in which the circuit is constantly made and broken.

A further important feature resides in having the resistance formed as an integral part of the regulator, so that the device can be shipped from the factory fully wired and adjusted ready simply to install without change.

In carrying out my invention, I provide a compressible resistance member, preferably in the form of a series or pile of resistance disks, whose resistance is rapidly changed by means of a constantly operating member, said resistance being further varied by an intermitting operating member in response to changes in the circuit whose voltage is being regulated. The object of the moving member is to change the value of the resistance to such an extent that it tends to produce a greater change in voltage than the regulation desired, so that one of the novel and important features of my invention resides in accomplishing this result through the agency of a resistance member whose value is changed by compression. I depend on the constantly operating compression member to give the overlapping or overstepping tendency to the voltage of the circuit, and upon the intermittingly operating compression changing member to so adjust the value of the resistance that it will produce the desired voltage changes, or in other words maintain the proper average.

Further advantages and the constructional details of my preferred apparatus will be pointed out in connection with the accompanying drawings, and thereafter further defined in the claims.

In the drawings, Figure 1 is a top plan view of the regulator; Fig. 2 shows the same in side elevation; Fig. 3 is a view thereof looking at the left hand end, Fig. 1; Fig. 4 is an opposite end view; and Fig. 5 is a diagrammatic view.

In order that the regulator may be better understood in its detailed embodiment, I have indicated diagrammatically in Fig. 5 a set of wiring arrangements with which it may be used. The generator 1 to be regulated is shown as supplying current to a circuit 2, 3 containing translating devices 4, said generator having the usual field 5 and resistance or rheostat 6. Across the circuit 2, 3 is connected a voltmeter, comprising electro-magnets 7, 8 in series to whose cores 9, 10 are pivoted levers 11, 12 fulcrumed respectively at 13, 14, the lever 12 being counterweighted at 15 and provided with a contact 16 at its opposite end to coöperate as a vibrating needle with adjustable contacts 17, 18 provided in the branched end of the lever 11, herein shown as held under normal tendency to move downward by a spring 19. The needle 12 connects by a wire 20 with any suitable source of current supply, as a battery 21 whose opposite end connects by a wire 22 with the actuating coils or electro-magnets 23, 24 of the regulator, which in turn are connected by wires 25, 26 with the contacts 17, 18 of the voltmeter.

A constantly rotating motor 27 Figs. 1–4 is journaled at 28, 29 in the uprights or ends 30, 31 of a frame on whose base 32 the motor is bolted. The compression resistance member before mentioned is herein shown in two parts, 33, 34, for better convenience of balanced construction and operation, one half of said resistance being mounted at one side of the motor and the other half at the other side, herein shown as connected in series at 35 and with wires 36, 37 Fig. 5, thereby constituting a variable shunt for varying the flux of the field 5, (although they may be connected in parallel instead of series when less resistance is required for a larger current, etc.). The wires 36, 37 are shown as connected around the rheostat 6, so that, provided the latter is used, they serve to place the compression resistance in shunt around the rheostat, and in any event, whether the rheostat is present or not, produce the desired fluctuating effect or influence on the field. It will be understood that the main function of the rapidly fluctuating resistance member is to cause a cor-

responding fluctuation in the field 5, and while I prefer that this should be accomplished by a shunt, and preferably a shunt around a rheostat, I do not restrict myself in either of these respects. These resistances preferably consist of carbon disks and are loosely mounted for longitudinal movement on rods 38, 39, the rod 38 being fast at its opposite ends in brackets 40, 41 of the machine, and the rod 39 in brackets 42, 43. At one end the carbon disks are engaged by slide blocks 44, 45, to whose adjacent collars are pivoted levers 46, 47 fulcrumed at 48, 49 and provided at their meeting ends with a cam roll 50 which engages a cam 51 fast on the motor shaft. At their opposite ends the carbon disks of the compression resistance member are engaged by blocks 52, 53 held forward by compression springs 54, 55 on the shafts 38, 39 respectively, said springs resting at their opposite ends against collars 56, 57 to which are pivoted levers 58, 59 fulcrumed at 60, 61 on the machine and provided at their meeting ends with an anti-friction roll 62 engaged by a cam or eccentric 63 fast on a vertical rock shaft 64 journaled in the frame of the machine and driven by a gear 65. Meshing with the gear 65 are opposite gears 66, 67 driven by worm wheels 68, 69 carried by brackets 70, 71 projecting from a frame 72 movable with a double ended armature 73 which is turned in one direction or in the other as the case may be by the electro-magnets 23, 24 before mentioned. The adjacent end of the armature shaft of the motor 27 is provided with a worm 74 in position to be engaged by said worm wheels 68, 69 whenever they are swung by their brackets to engage with said worm under the influence of the armature 73.

From the above description it will readily be understood that the motor 27, acting through its cam 51 and the adjacent levers 46, 49, maintains the compression resistance under constant heavy and light pressure alternately at each rotation of the motor cam, thereby causing a rapid succession of increase and decrease of resistance in the generator field circuit 36, 37. While the effect or influence of this rapid fluctuation of the current by the varying compression of the resistance member may be transmitted to the field 5 in various ways, I prefer to employ it in connection with a usual field rheostat, in which case the wires 36, 37, which otherwise would constitute the field circuit, now constitute a shunt around the rheostat. By this arrangement, in connection with the rheostat, the compression resistance member is not required to carry so much current and can therefore be smaller, besides other advantages, as a certain proportion of the field current passes through the resistance of the rheostat. The carbon disks are compressed tightly by this cam action, which is resisted by the springs 54, 55, and the latter are caused to hold up strongly or not as the case may be by the action of the voltmeter-controlled mechanism. This is as follows. Upon the occurrence of an abnormal change in the voltage in the translation circuit 2, 3, the electro-magnets 7, 9 and 8, 10 of the voltmeter are thereby actuated to shift the needle 12 in one direction or the other to close the battery circuit at 17 or 18 as the case may be, thereby energizing either the solenoid 23 or 24 of the regulator which attracts the adjacent end of the armature 73 and thereby swings the worm wheel 68 or 69 into driven engagement with the worm 74. This rotates the gear 66 or 67 as the case may be, and, through the gear 65, moves the eccentric 63 in one direction or the other and thereby correspondingly moves the levers 58, 59, causing their outer ends to move away from the resistances 33, 34 and thereby relieve the pressure of the springs 54, 55 on the compression resistance member, or to move in an opposite direction so as to increase the pressure on said compression resistance member and hence to increase the resistance of said member.

The particular arrangement of the needle 12 and contact-carrying lever 11 of the voltmeter aids in the sensitiveness and delicacy of results attained by my invention inasmuch as the location of the fulcrums of said parts with respect to the cores of the electromagnets causes their contact-making ends to move in opposite directions so as to approach each other, as distinguished from the movement being provided all in the needle as in the usual voltmeter. By having the contacts move toward the needle as well as the needle move toward the contacts, it will be evident that a much more responsive and delicate or sensitive action is secured, without any more delicate mechanism than usual.

As already intimated, I am aware that my invention may be embodied in a wide range of mechanical combinations and hence it will be understood that the invention is not limited to the preferred embodiment herein shown and described except as otherwise expressly stated in certain of the appended claims.

Having described my invention, what I claim as new, and desire to secure by Letters Patent is:

1. A voltage regulator, comprising non-circuit-breaking means for varying the resistance in a field circuit, means for continually changing the value of said resistance-varying means, and means for intermittingly changing the value of said resistance-varying means in response to the requirements of the circuit being regulated.

2. A voltage regulator, consisting of a unitary apparatus as an article of manufac-

ture, comprising a resistance member, two influencing means therefor, one of said influencing means continually operating to maintain a continual variation in said resistance, and the other influencing means intermittingly operating and being responsive to extraneous control.

3. The combination with a generator, the generator circuit supplied thereby, the generator field and its circuit, of a voltage regulator including a compression resistance member, means for rapidly increasing and decreasing the resistance of said member, and automatic means responsive to a change of voltage in said generator circuit for changing the compression of said compression member.

4. The combination with a field and its circuit, of means for continuously varying the flux of said field, including a compression resistance member, means for rapidly fluctuating the resistance thereof, and automatic means for intermittingly changing said resistance.

5. The combination with a field and its circuit, of a variable shunt for varying the flux of said field, including a compression resistance member, means for rapidly fluctuating the resistance thereof, and automatic means for intermittingly changing said resistance.

6. The combination with a field and its circuit, of a rheostat in said circuit, and means to shunt said rheostat, including a compression resistance member, means for rapidly fluctuating the resistance thereof, and automatic means for intermittingly changing said resistance.

7. A voltage regulator, including a compression resistance member, pressure-applying means for rapidly increasing and decreasing the compression of said member, a continuously moving actuator for said means, and electro-responsive means for intermittingly varying the compression of said member.

8. A voltage regulator, including a compression resistance member, pressure-applying means for rapidly increasing and decreasing the compression of said member, and means for varying said compression intermittingly, comprising electro-responsive means having two positions, one for increasing said compression and the other for decreasing said compression, responsive respectively to voltage extremes in opposite directions in the circuit being regulated.

9. A voltage regulator, including a compression resistance member, pressure-applying means for rapidly increasing and decreasing the compression of said member, a continuously moving actuator for said means, and means for following said compression intermittingly, comprising pressure-transmitting means, power driven mechanism for controlling the movement of said transmission means and providing the pressure therefor, and electro-responsive means for bringing said power driven mechanism into action.

10. A voltage regulator, including a compression resistance member, pressure-applying means for rapidly increasing and decreasing the compression of said member, a continuously moving actuator for said means, and means for following said compression intermittingly, comprising pressure-transmitting means, power driven mechanism for controlling the movement of said transmission means and providing the pressure therefor, and electro responsive means for bringing said power driven mechanism into action, said continuously moving actuator being provided with driving means for said controlling mechanism.

11. A voltage regulator, including a compression resistance member, pressure-applying means for rapidly increasing and decreasing the compression of said member, a continuously rotating member for operating said means, pressure-transmitting means for intermittingly varying the compression of said member, mechanism for controlling the movement of said transmitting means, said mechanism including opposite driving members, said rotating member having means for engaging and operating said driving members, and electro-responsive means for bringing one or the other of said driving members into engagement with said engaging and operating means as required.

12. A voltage regulator, including a compression resistance member, pressure-applying means for rapidly increasing and decreasing the compression of said member, a continuously rotating member for operating said means, pressure-transmitting means for intermittingly varying the compression of said member, mechanism for controlling the movement of said transmitting means, said mechanism including opposite driving members, said rotating member having means for engaging and operating said driving members, and electro-responsive means for bringing one or the other of said driving members into engagement with said engaging and operating means, including two electro-magnets and a pivoted armature operatively connected to said driving members and adapted to be moved in opposite directions under the attractive influence of said respective electro-magnets.

13. A voltage regulator, including a compression resistance member, pressure-applying means for rapidly increasing and decreasing the compression of said member, a continuously rotating member for operating said means, pressure-transmitting means for intermittingly varying the compression of said member, mechanism for controlling the

movement of said transmitting means, said mechanism including a cam for engaging said transmission means, opposite reciprocally movable worm wheels, intervening mechanism therefrom to said cam for driving the latter in opposite directions from one and the other respectively, said continuously rotating means being provided with a worm located between said worm wheels normally out of engagement with the latter, and electro-responsive means for moving one or the other of said worm wheels into engagement with said worm according as said compression is to be increased or decreased by said cam.

In testimony whereof, I have signed my name to this specification, in the presence of two subscribing witnesses.

GEORGE A. BURNHAM.

Witnesses:
C. C. BADEAU,
H. W. BOWDITCH.