

No. 673,372.

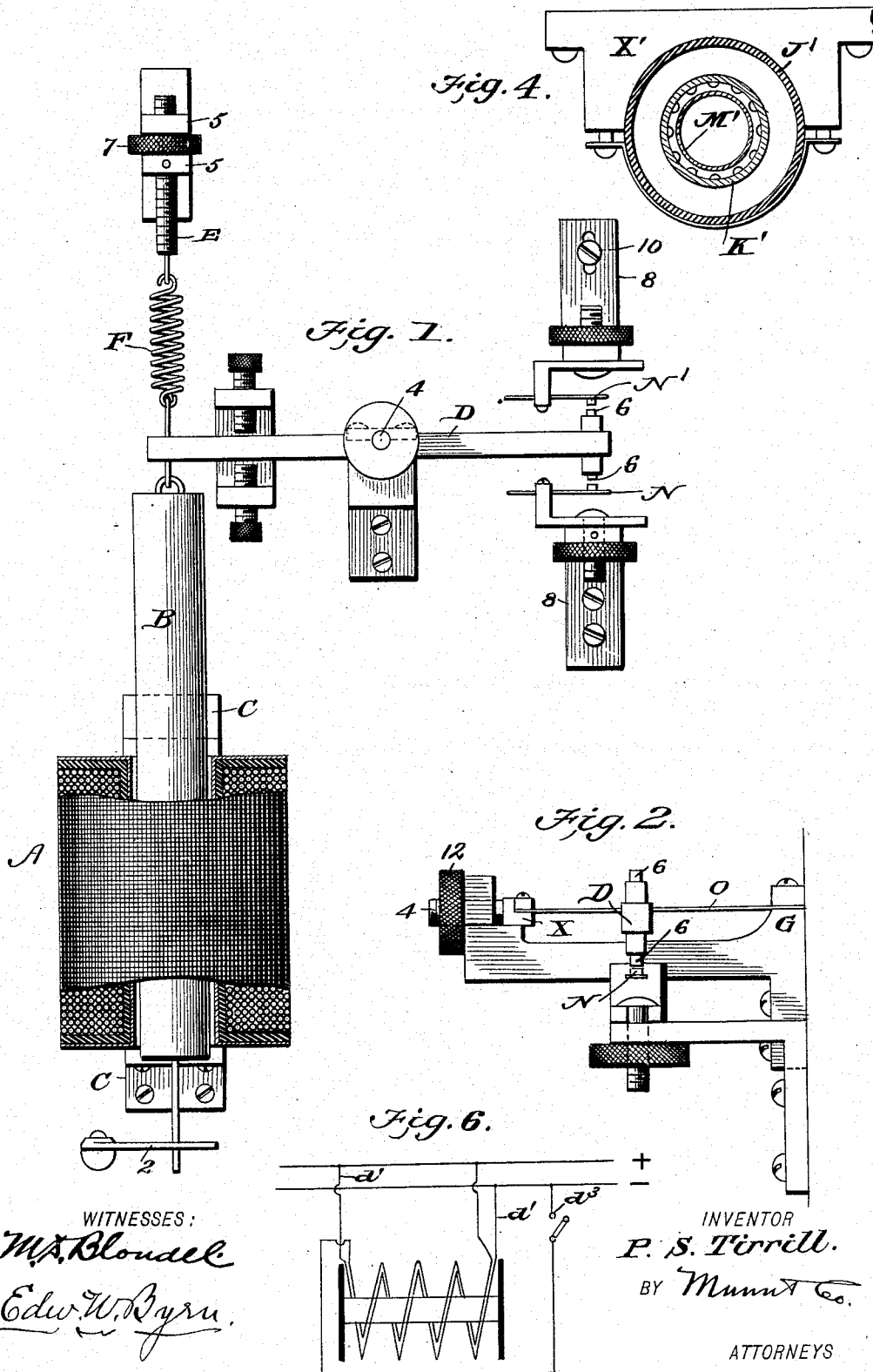
Patented Apr. 30, 1901.

P. S. TIRRILL.
VOLTAGE REGULATOR.

(Application filed June 27, 1900.)

(No Model.)

3 Sheets—Sheet 1.



WITNESSES:

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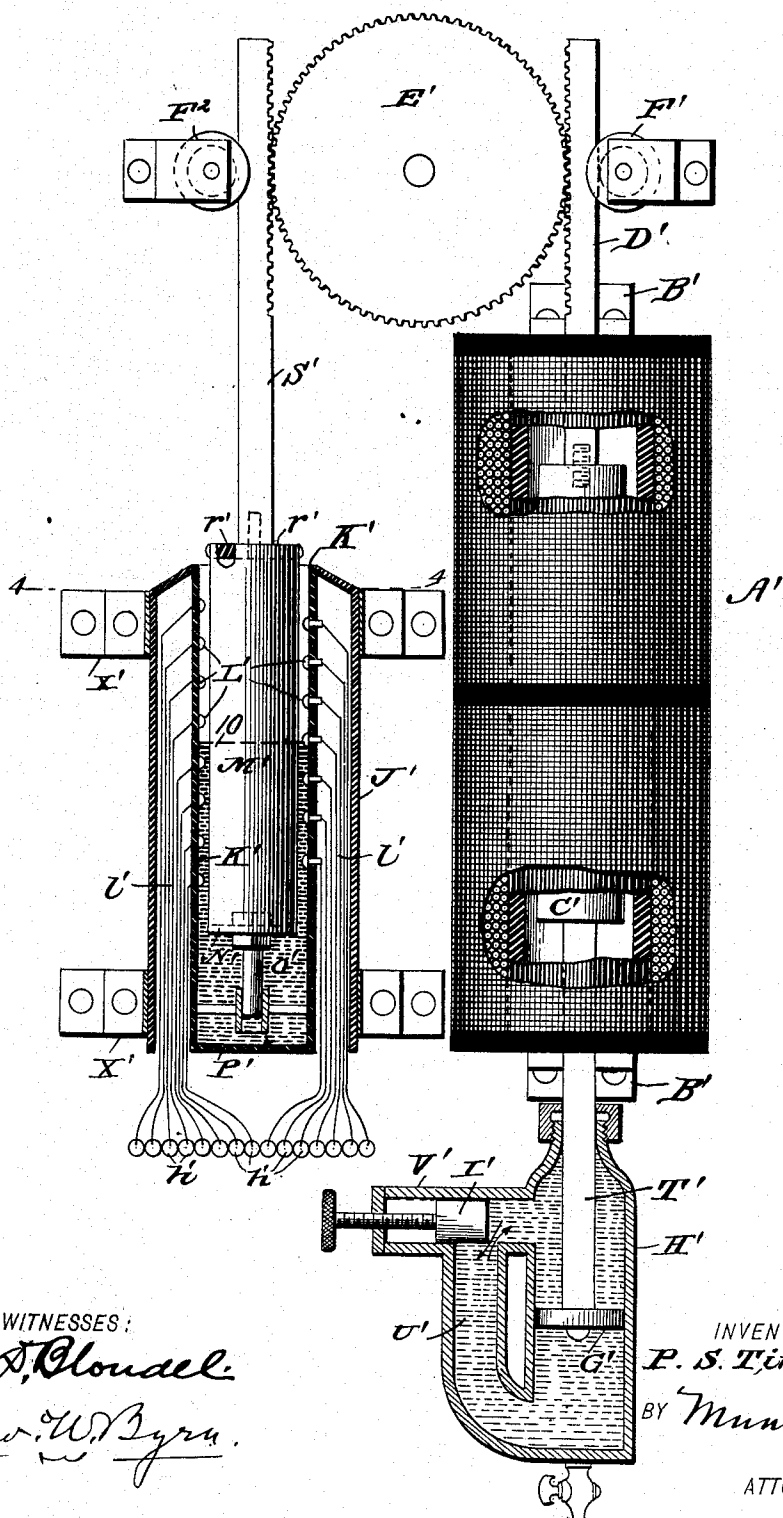
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3 Sheets—Sheet 2.

Fig. 3.



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UNITED STATES PATENT OFFICE.

PHILL SHERIDAN TIRRILL, OF GROVETON, NEW HAMPSHIRE, ASSIGNOR OF
ONE-HALF TO CHARLES E. BELLOWS, OF SAME PLACE.

VOLTAGE-REGULATOR.

SPECIFICATION forming part of Letters Patent No. 673,372, dated April 30, 1901.

Application filed June 27, 1900. Serial No. 21,833. (No model.)

To all whom it may concern:

Be it known that I, PHILL SHERIDAN TIRRILL, of Groveton, in the county of Coos and State of New Hampshire, have invented a new and useful Improvement in Voltage-Regulators, of which the following is a specification.

In a prior patent granted me in connection with Allen A. Tirrill as joint inventors January 4, 1898, No. 596,923, we showed and described an automatic potential regulator for dynamos whose object was to automatically regulate the potential or voltage on the supply-wires, so that an even potential shall always be maintained on said wires notwithstanding the varying tax or demand made upon said supply-wires by starting and stopping electric motors or the throwing of electric lights in and out of circuit. My present invention is an improvement upon that machine designed to overcome certain objections which experience has developed. If the magnets of a dynamo could be made so that they would respond to the changes of the current made in the coils of said magnets (by regulators) as quickly in practice as they do in theory, then the regulator shown in said prior patent would be practical to a certain extent. In theory the iron cores do respond instantaneously to the variations of the current made in the coils that surround the cores; but in practice they do not do so, owing to the reluctance and hysteresis of the iron. In the former patent it is intended to regulate by continuously breaking and making a part of the field-circuit, which is impractical from the fact that it takes time to raise the degree of saturation of the iron by increasing the ampere-turns and to lower the degree by decreasing the ampere-turns. For the above and other reasons it is superfluous to vary the exciting-current any faster than the iron cores will respond to the said changes. In consequence of the continuous make and break of the exciting-current in the patent referred to the regulator has to work just as hard when there is no change of load or speed as it does when there is a variation of load or speed. Therefore there is a continual waver in the voltage or lights. There are also other objections to a plan of this kind, which I will men-

tion later on. I would here say, however, that any multiplication of contact-points by relays only increases the trouble, for then there is the reluctance and hysteresis of the relay to contend with. The object of my invention is to automatically regulate the voltage and to respond to the sudden changes of load or speed just as quickly as in the patent referred to—i. e., as quickly as the iron will respond to the changes made in the field-circuit—and when the voltage is at its proper pressure to have the regulator do no work until there is some variation in the voltage. There are some automatic rheostats that are designed to do this; but they do not do so from the fact that the contact-piece of the moving part of the rheostat has so far to travel back and forward on the contacts of the resistance-coils that they work to extremes, or, in other words, if they are speeded up so that they will work and cover the rheostat on heavy changes of load they will work by on small changes, and vice versa, and the result called "seesaw" is obtained. I have so arranged my regulator that the whole range of the rheostat is covered with a very slight movement of the controlling-magnet and without using any multiplication of levers.

The principal object of my regulator is to be able to cover the range of the rheostat in such a way that its movement can be timed to act just as quickly as the iron of the magnets will respond to the changes made in the exciting-current by the regulator and no quicker.

Figure 1 is a side view of the contact-making devices. Fig. 2 is a side view of the torsion-fulcrum of the contact-making devices. Fig. 3 is an enlarged sectional view of the resistance-varying devices; Fig. 4, a sectional plan on line 44 of Fig. 3 of the mercury-cup. Fig. 5 is a diagram of the entire regulator system, and Fig. 6 is a detail of a differential coil.

Referring to Fig. 1, A shows a coil or spool of wire, and B a movable iron core passing through the solenoid, said solenoid being held rigidly in position by the brackets C C. D shows an arm or lever held in position by a middle bearing 4. On the left-hand end this lever

is fastened to the upper end of the iron core of the solenoid, and directly above this fastening is secured a spring F. These fasteners are so made that they offer no friction to the iron core in moving up and down. The top of the spring F is fastened to a screw-threaded piece of metal E, the threaded piece passing up through two lugs 5 5 about one-fourth of an inch apart. Between these lugs is a nut 7 to fit the threaded stem that passes up through it. At the bottom of the iron core is a small guide-wire, which passes down through a hole in the piece of metal 2. This is to prevent the core from swinging around. At the right-hand end of the lever D are two platinum points 6 6, arranged on opposite sides. 8 8 show brackets for holding two more platinum points. The lower one is held rigidly in place, and the top one is made to move up or down by loosening the screw 10 and is held in place by tightening the screw 10. This is done to regulate the distance between the contact-points. The contacts N N' are mounted on small pieces of metal and are held to the brackets 8 8 in such a way that they can be readily lined up with the contacts on the lever D.

The bearing 4 is an important feature of my invention and different from any bearing ever used on any instrument of this kind. Instead of using pivots or what is called "knife-edge bearings" I use what could be called a "torsion-spring fulcrum," which is shown in side view in Fig. 2. O is a strip of flat metal—like a piece of watch-spring, for instance—one end securely fastened at the end G, and the other end is fastened to the screw-threaded piece X, by which sufficient tension can be given to the torsion-bearing by the threaded nut 12. The lever D is fastened to and supported upon the middle of this piece of spring, as shown. The function and value of this torsion-fulcrum will be explained hereinafter.

Fig. 3 shows the secondary part of the instrument for varying the resistance. A' shows a large double solenoid held in place by the brackets B' B'. C' shows a movable iron core, to the top of which is attached and projects upwardly a square bar of metal D' with a rack cut in one side of it, which engages into the gear E' and is held up in place thereagainst by the roller F'. At the bottom of the iron core is a round piece of metal T', which projects downward and on the end of which is fastened the piston G'. H' shows a sectional view of a dash-pot in which piston G' works. This dash-pot has a side passage-way U' opening into the opposite ends of cylinder H', and the dash-pot is filled full of liquid, like oil, so that any movement of the iron core up or down would make the oil pass from the top of the piston G' through the place indicated by the arrows, whereby the velocity of the movement can be controlled by turning in or out the screw-valve I' in the casing V'. J'

shows an outside case of the instrument that contains the contacts of the resistance-coils. K' is the inside case or mercury-cup, through which the contacts L' pass and from which wires L' pass down through in the annular space to the holes h', and thence to the resistance-coils on the back side of the supporting-plate. The cylinder K' has to be made of some non-conducting material, such as vulcanized fiber or hard rubber, and after all the connections are made and wires run out at the bottom, as shown, the remaining space between cases J' and K' is run full of some insulating compound to prevent any danger of short-circuiting the wires and to prevent any mercury from leaking out around the contacts L'. M' is a plunger made of a piece of round tubing of hard rubber or steel. The bottom N' of this plunger is made perfectly tight, and in the center of this bottom is a piece of wire O', which runs down through a guide-sleeve P' to prevent the plunger from swinging sidewise and touching the contacts. In the top of the hollow plunger M' is fitted a piece of insulating material r', to which is fastened a square rod of metal S' running upward and having a rack cut in one side, which engages the gear E' just the same as D' does on the opposite side, and is held in place by a similar roller F'. After the connections are all made about the contacts L' and the whole is fastened in place by the supports X' X' the iron core C' of the solenoid A' is placed exactly in the center, as shown, and the plunger M' in its proper place, as shown. The cylinder K' is then filled with mercury up to the dotted line 10, and then the inside of the hollow plunger M' is filled with mercury until it exactly balances the weight of the iron core C'. The whole is then in perfect balance, with half the resistance in circuit and the other half cut out of circuit. The object of filling the plunger with mercury instead of making it of solid iron is to get it as near the same weight as possible as the metal it displaces. Now any movement of the plunger M' would very rapidly change the level of the quicksilver and cut in or out resistance by bringing the mercury into contact with more or less of the connections L'. When the mercury stands at the dotted line 10, the moving of the iron core up or down a distance of three-eighths of an inch would cut in or out all the resistance of a thirty-four-point rheostat without any multiplying-levers. This is due to the fact that the cross-sectional area of the plunger exceeds half of that of the mercury-cup, so that a definite movement of the plunger causes a greater extent of movement in the rise or fall of the mercury. Now this all means that a dash-pot, as shown, can be set so that the iron core will move just fast enough to cut in or out resistance by the plunger displacing the mercury as the fields of the dynamo will respond to the changes. A rheostat that can be made to act as quickly

as this will furnish the fields with current or diminish it as quickly as in our former patent, with the advantage that everything would be at rest except when changes of load or speed occurred.

It is to be understood that all parts coming in contact with the mercury are made of materials that the mercury has no destructive effect on, and the top of the mercury is covered with any of the well-known liquids to prevent its oxidation.

Referring now to Fig. 5, I will endeavor to show the connections and workings of the regulator system. 15 represents a dynamo, 18 18' represent the supply-wires where a constant voltage is to be maintained, and 20 20' the field-circuit. One of these, 20, connects with one end of the rheostat R' to R¹³ and the other, 20', to the mercury-cup and cut-out wires l'. Now should for any reason the voltage rise above the normal point the core B would be sucked or pulled down in the coil A owing to the increased induction, and contact 6 would connect with contact N' and would complete the circuit in the lower half of the coil A' over the following path: $a a' a^2 a^3 a^4$. This would cause the iron core C' to be pulled downward and the plunger M' upward, which would let the mercury fall to some point below the dotted line 10 until sufficient resistance was thrown in to bring the voltage down to the right pressure, then the contacts 6 and N' would open and break the circuit around the lower half of the coil A' and would so remain until another change of load or speed occurred. If the throwing on of more load should cause the voltage of the supply-wires 18 18' to fall below the normal point, the induction of the coil A would be diminished and the controlling-spring F would pull up the core B and cause the contact-points 6 and N to be closed. This would complete the circuit in the upper half of the coil A' over the path $a b b' b^2 a^4$. This would pull up the iron core C' and cause the plunger M' to be pushed down, which would raise the mercury above the dotted line 10 or to a point where sufficient resistance was cut out to allow the field-magnets of the dynamo to bring the voltage up to the normal point, and then contacts 6 and N would open and so remain until another change. As one of the wires, 20, leads to one terminal of the rheostat and the other, 20', to the mercury in the cylinder K', it will be seen that the pushing of the plunger down and raising the mercury to the contact 1 would cut out all the resistance and lifting up the plunger so the mercury would fall to 13 would throw in all the resistance. The coil A is of course placed in multiple across the supply-mains, and in arranging this part of the apparatus the precautions have to be observed that are used in making a good dead-beat voltmeter, and just here I may describe the function and value of the torsion-spring fulcrum 4. This bearing is so set that when the contacts are

both open there is no torsion strain on the spring. When either contact is closed, however, there is a tension on the fulcrum-spring, and instead of the bearing offering any resistance to the lever in bringing the points back to their normal place the torsion helps it back. In other words, the lever D in deviating from the normal intermediate or open position finds a constantly-increasing spring stress in the torsion bearing or fulcrum, which tends always to cause the contacts to quickly respond in the return to the normal open position. The adjustment of the instrument to the proper voltage is effected by varying the tension of the spring F.

The regulator may be made to compensate for line loss by putting a few turns of one of the supply-wires around coil A, so that the current will flow in an opposite direction from what the other current does, which neutralizes more or less of the inductive effect, the number of turns to be determined by the loss to be compensated for.

Instead of using a condenser to suppress the sparks at the contacts 6 N 6 N' the large double coil could be differentially wound in a manner already well known. One of the simplest ways is to wind the coils the same way that non-inductive resistances are wound—viz., take two wires and wind them side by side until a sufficient number of turns are wound, and then connect them as shown in Fig. 6. Suppose now that a current of one ampere was flowing through the closed circuit $d' d'$ and the other circuit at the contacts d^3 should be closed. Then one ampere would flow in the coil in opposite directions to what it does in the other coil and would completely neutralize the magnetic induction, and there would be no magnetism. Now if the circuit at contacts d^3 should be opened the core would at once become magnetized; but there would not be any spark at the contacts, for it would be making magnetism at opening such circuit instead of destroying it.

One of the controlling-magnets shown in Fig. 1 can be made to operate several of the rheostats shown in Fig. 3, as when more than one dynamo is to be controlled from the same apparatus.

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

1. In a voltage-regulator, the combination with a solenoid-coil connected in multiple are to the supply-wires, and a core, and a sustaining-spring; of a contact-lever connected to the same and a regulating-rheostat controlled by the contact-lever and connected to the coils of the dynamo field-magnets, the said contact-lever being mounted in equilibrium in the normal open position, and a mounting for the lever for opposing its deflection with an equally-increasing stress or mechanical resistance in both directions as it deviates from the normal open position to the closed position whereby its return to the normal

open position is aided mechanically with a maximum force on the initial part of its return substantially as described.

2. In a voltage-regulator, the combination
5 with a solenoid-coil connected in multiple are
to the supply-wires, and a core and sustain-
ing-spring; of a double-contact lever con-
nected to the same, a torsion-spring forming
a fulcrum-mount for the lever, an upper and
10 lower contact, a double solenoid-coil one por-
tion of which is connected to one of said con-
tacts and the other portion to the other con-
tact and each being thereby thrown alter-
nately into the circuit of the supply-wires and
15 an automatic rheostat connected to and
worked by the core of the double solenoid,
said rheostat being in the circuit of the dy-
namo field-magnet substantially as shown
and described.
- 20 3. In a voltage-regulator, the combination
with a solenoid-coil connected in multiple are
to the supply-wires, and a core and sustain-
ing-spring; of a double-contact lever con-
nected to said core and spring, an upper and
25 lower contact, the lever being mounted in
equilibrium between said contacts, a bearing
for said lever constructed to resist mechan-
ically the deflection of said lever in closing
to contact in either direction, a double solen-
oid-coil one portion of which is connected to
30 one of said contacts and the other portion to

the other contact and each being thereby
thrown alternately into the circuit of the sup-
ply-wires, a core for the double solenoid and
a rheostat connected to and worked by said 35
solenoid-core, said rheostat being in the cir-
cuit of the dynamo field-magnets substan-
tially as and for the purpose described.

4. In a voltage-regulator the combination
with a solenoid-coil connected in multiple are 40
to the supply-wires, and a core, and suspend-
ing-spring; of a contact-lever connected to
the same, a fulcrum-bearing constructed as a
torsion-spring and contacts coöperating with
the lever and controlling an automatic rheo- 45
stat substantially as shown and described.

5. In a voltage-regulator, the combination
with a solenoid-coil connected in multiple are 50
to the supply-wires, and a core and suspend-
ing-spring; of a contact-lever connected to
the same, a fulcrum-bearing constructed as a
torsion-spring, tension-regulating devices for
said torsion-spring, and contacts coöperating
with the lever and controlling an automatic
rheostat substantially as described. 55

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

PHILL SHERIDAN TIRRILL.

Witnesses:

S. W. CUSHING,
J. CLARE CURTIS.