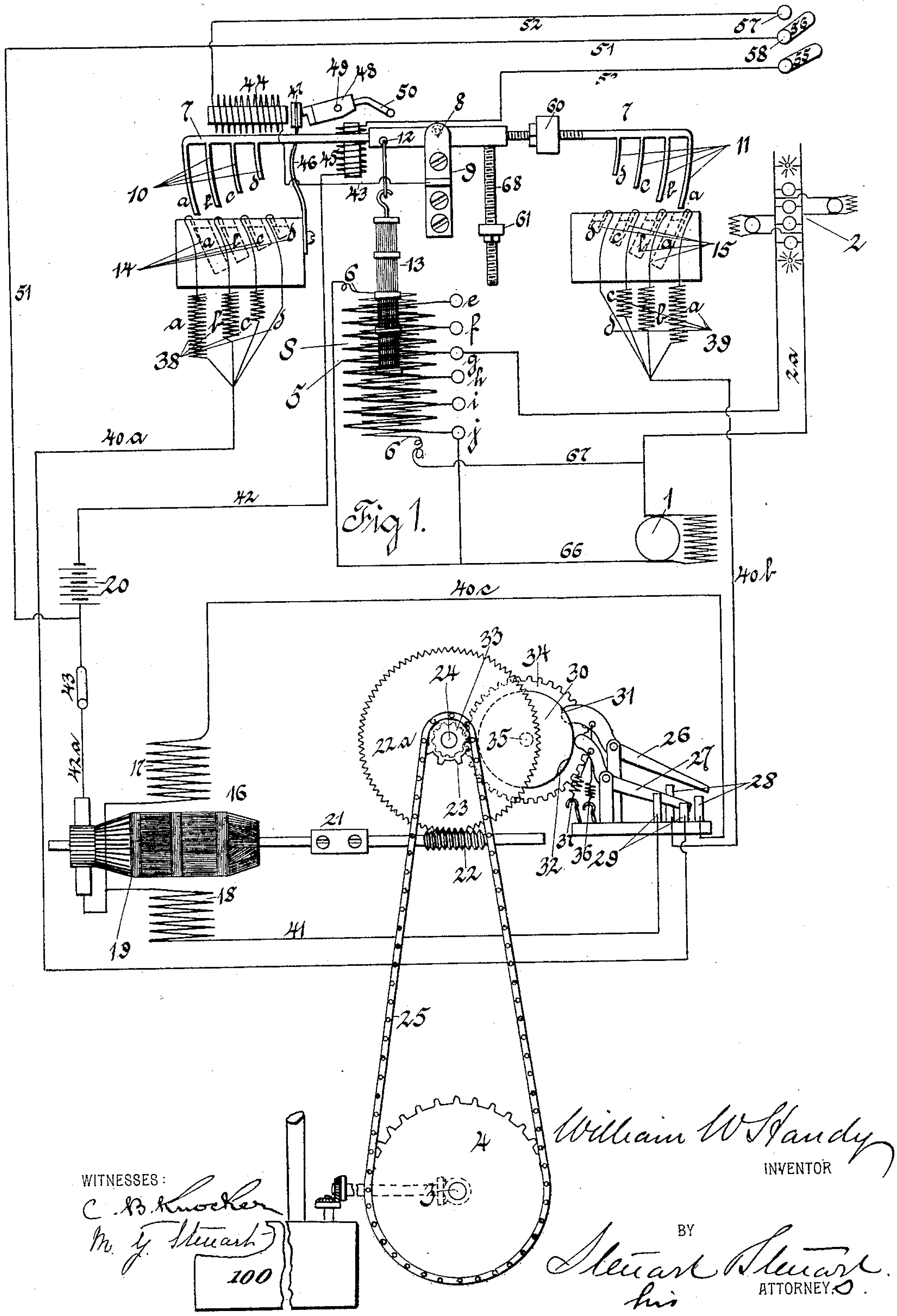
(No Model.) 3 Sheets—Sheet 1.

W. W. HANDY.

ELECTRIC GOVERNOR FOR WATER WHEELS.

No. 571,363. Patented Nov. 17, 1896.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.)

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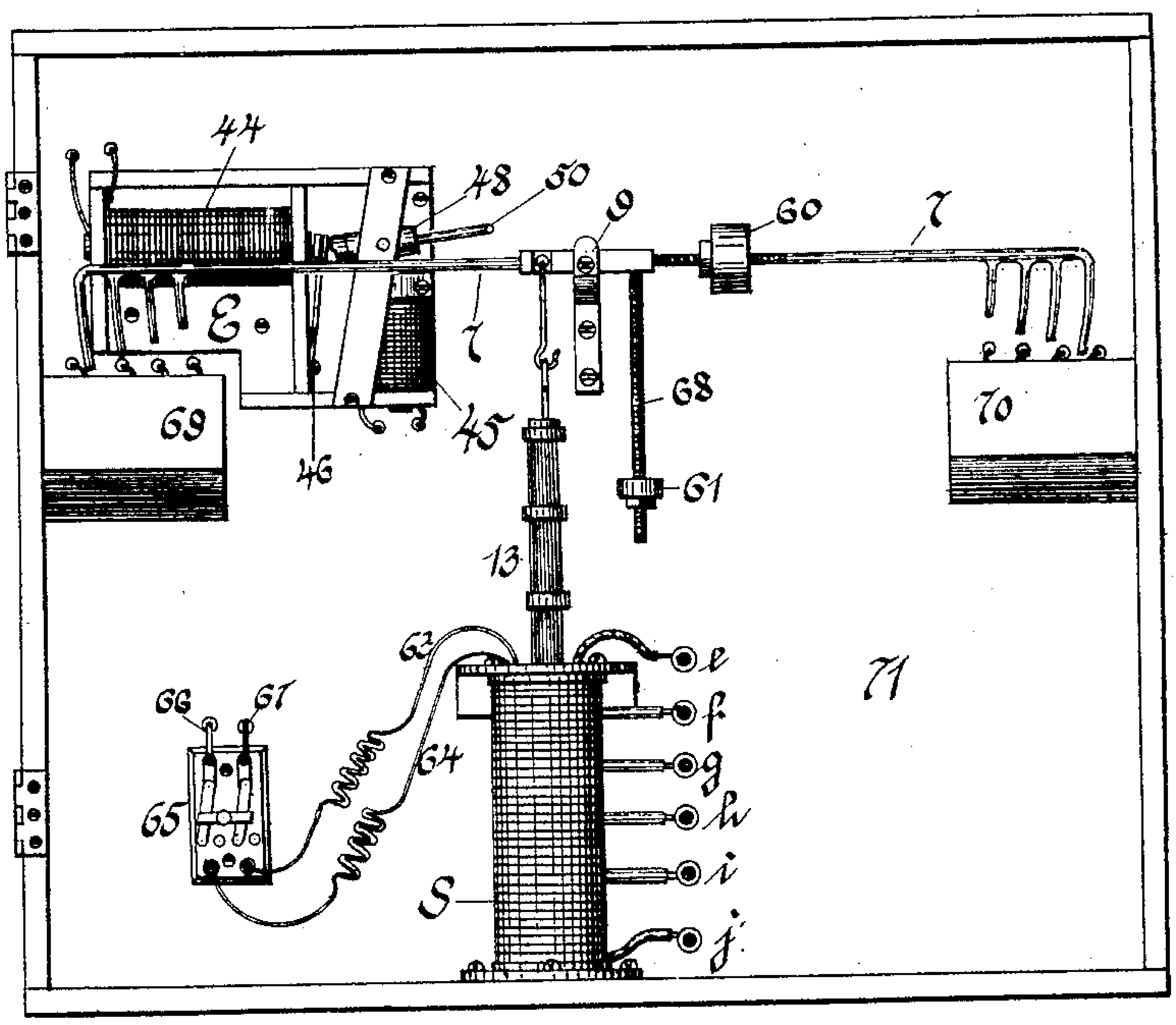
Fig. 2.



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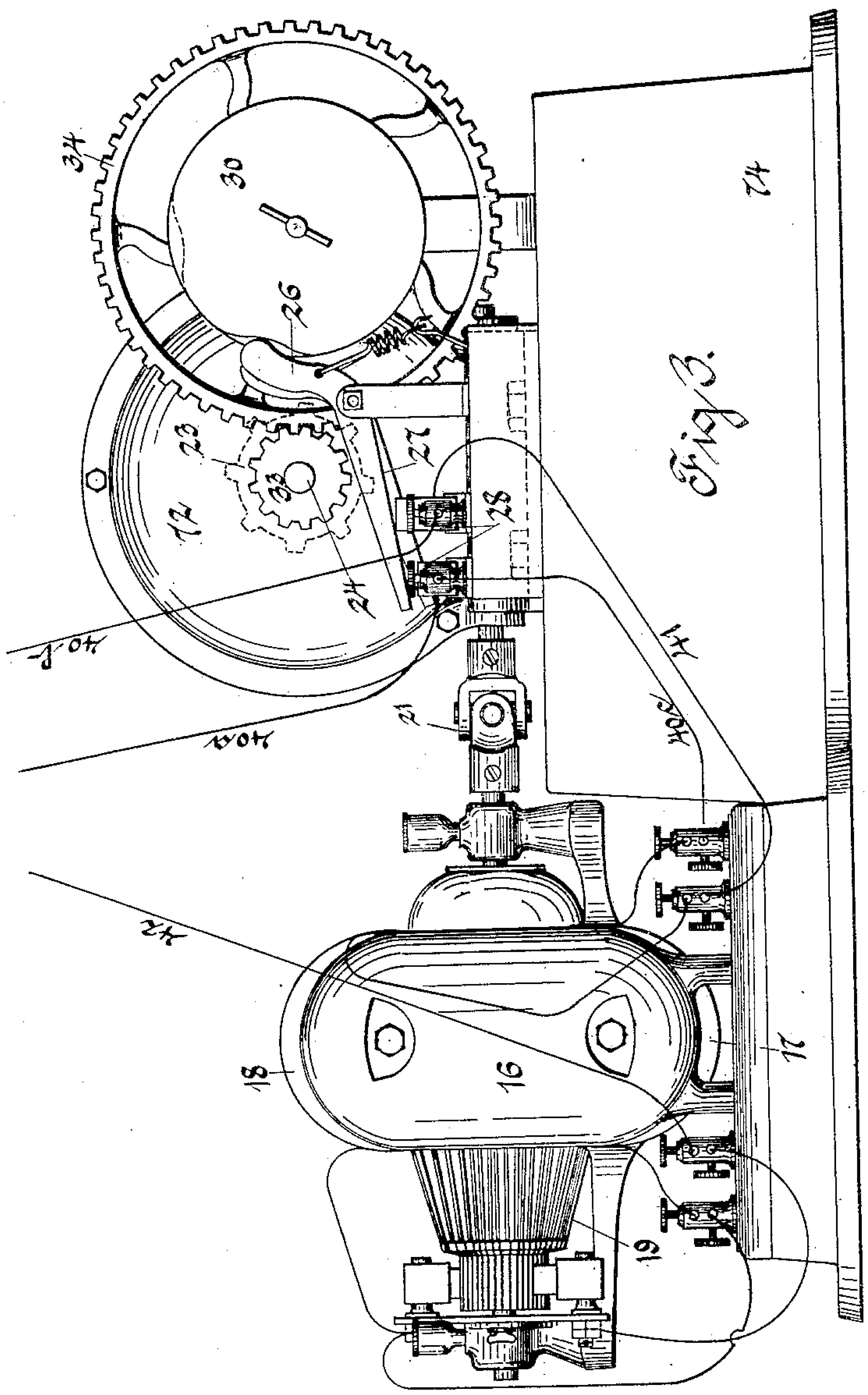

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UNITED STATES PATENT OFFICE.

WILLIAM W. HANDY, OF BALTIMORE, MARYLAND.

ELECTRIC GOVERNOR FOR WATER-WHEELS.

SPECIFICATION forming part of Letters Patent No. 571,363, dated November 17, 1896.

Application filed June 19, 1896. Serial No. 596,134. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM W. HANDY, a citizen of the United States, and a resident of Baltimore, in the State of Maryland, have invented certain new and useful Improvements in Electric Governors for Water-Wheels, of which the following is a specification.

The object of my invention is to provide means for governing the speed of a turbine or other type of water-wheel when the load on the wheel varies.

In electric plants run by water-power great trouble has heretofore been encountered in governing the water-wheels. The ordinary types of governors used are constructed to work on mechanical principles and do not respond to changes in load as quickly as they should.

My invention consists in an electric governor constructed on purely electrical principles. It is primarily intended for use on electric plants run by water-power, but may be used with equally good results on water-power plants connected directly to mill and other machinery.

This governor is an improvement on that shown in Letters Patent of the United States No. 542,640, granted to me on July 16, 1895.

The construction and operation of the governor are fully explained in the following specification, reference being had to the accompanying drawings.

Figure 1 is a diagrammatic view of the governor; Fig. 2, a detail view of the switchboard part, and Fig. 3 a detail view of the part which moves the water-wheel gates.

Referring to Fig. 1, 1 is the dynamo, which is driven by the water-wheel 100.

2 is the load on the dynamo, consisting of arc and incandescent lights and motors.

3 is the gate-shaft of the water-wheel, and 4 a sprocket-wheel on said shaft.

5 is a coil in series with the main dynamo-current, which may or may not be arranged in section, as shown, the said coil 5 being connected with the binding-posts *e f g h*, &c.

6 is a shunt-coil connected by means of wires 66 and 67 to the terminals of the dynamo.

7 is a double lever balanced on a knife-edge at 8 and supported on the stationary piece 9. The lever 7 is provided on each end with projections 10^a 10^b, &c., and 11^a 11^b, &c., the shortest being nearest the point of suspension 8. Suspended on the lever 7 at 12 is a plunger 13, preferably made of soft-iron wire, said plunger entering the solenoid S, formed by the series and shunt coils 5 and 6. The adjustable weights 60 and 61 are used to balance the pull of the solenoid S. By moving weight 61 higher or lower on rod 68 the lever may be made more or less sensitive to changes of pull exerted by the solenoid S.

14^a 14^b, &c., and 15^a 15^b, &c., are cups containing mercury and arranged in such positions with respect to the projections 10^a and 11^a, &c., that if the lever is caused to move the said projections will enter the cups, the one on the extreme end, such as 10^a or 11^a, entering first and the others in order after it.

16 is a series electric motor with two separate field-windings 17 and 18.

The motor is connected directly to the gate-stem 3 of the water-wheel by means of worm-gearing 22 and 22^a, the sprocket-wheels 23 and 4, and the sprocket-chain 25.

26 and 27 are strap-switches in circuit with the motor. The rear ends of these switches are held in contact with the circular block 30 by means of springs 36 and 37. This block, which is made of wood or other suitable insulating material, is rigidly connected to shaft 35, to which is keyed the gear 34. Gear 34 in turn engages with pinion 33 on the shaft 24. As the armature 19 revolves it turns with it the gates of the water-wheel by means of shaft 3, and at the same time it also turns the block 30. There are recesses 31 and 32 in the surface of the block into which the rear ends of the switches 26 and 27 are forced by the springs 36 and 37. It is arranged that one of the recesses, say 31, shall come opposite the rear end of switch 26 just at the time that the motor has opened the water-wheel gates to their full extent. It is shown this way on Fig. 1 with the lever raised up from the switch-tongues 28. Under these conditions the current through the motor is broken and the wheel can be opened no farther. The other recess 32 is arranged to make the switch 27 stop the motor when the wheel is fully closed.

The field-windings 17 and 18 of the motor are connected in such a way that when current flows through the armature 19 and field 17 by way of switch 26 the armature revolves in the direction necessary to open the water-wheel gates, and when current flows through the armature 19 and the other field 18 by way of switch 27 the armature turns in the opposite direction and closes the gates.

20 is a storage battery which provides the necessary current for running the motor.

Tracing the different circuits from the battery we have the following: When the motor is opening the wheel the current flows by wire 42^a, through the armature 19, field 17, wire 40^c, switch 26. When it is closed, through tongues 28 28, wire 40^b, resistances 39, cups 15, projections 11^a *b c d*, lever 7, wire 43, and wire 42 to the other terminal of the battery 20. When the motor is closing the wheel, the current flows by wire 42^a through the armature 19, field 18, wire 41, switch 27. When it is closed, through tongues 29 29, wire 40^a, resistance 38, cups 14, projections 10^a *b c d*, lever 7, wire 43, and wire 42 to the other terminal of the battery.

43 is a switch by means of which the battery may be cut in or out of circuit.

In Fig. 1 above the lever 7 is shown a device by means of which the water-wheel may be started or stopped. The construction and operation of this will be explained later in the specification.

Fig. 2 shows in detail that part of the governor which may be placed upon the switchboard or any other place suitable for a sensitive instrument. It consists of a box 71 containing the solenoid S, plunger 13, lever 7 with its attachments, and the starting and stopping device E. 69 and 70 are pieces of wood, nto which holes are bored opposite the projections on lever 7. These holes, or so-called "cups," are filled with mercury. The wires leading from the cups pass out the back of the box to the resistances 38^a, &c., and 39^a, &c. These resistances are not shown on this drawing, but in Fig. 1, and are fastened directly to the back of the box, taking up very little space. The shunt-coil of solenoid S is connected by means of wires 63 and 64 with a switch 65, and thence by means of wires 66 and 67 to the terminals of the dynamo. Binding-posts *e f g h*, &c., extend through the back of the box, and these and all other connections are made from the rear.

In Fig. 3 is shown in detail the gate-moving mechanism. Fastened to the bed-plate 74 is the motor 16 and gearing attached thereto. The worm-gearing is inclosed in the oil-tight case 72. The sprocket-wheel 23 is back of this case, and is shown in dotted lines. The rest of the devices will be understood from Fig. 1. The switch 27 is directly back of switch 26, and is arranged this way in order to occupy as small a space as possible. This motor is connected to the worm by means of a universal coupling 21.

In operation the governor works in the following manner: Suppose the line 2^a is many miles in length, as is the case with many modern plants for the transmission of power by means of electricity. The loss of potential at full load on line 2^a under these conditions would be considerable, this loss, of course, varying with the amount of current passing over the line. In ordinary plants governed by mechanical governors the speed should be kept constant, and if the generator is a compound or composite wound machine designed to overcome the drop on the line the voltage at the end of the line should remain constant. This result, however, is rarely attained, due principally to the inefficiency of the water-wheel governors, and hand-regulation has in many cases been resorted to. Even when it has been possible to maintain a constant speed the generators have in many cases been simply shunt-wound, and often when compounded they are not enough so to overcome the drop on the line. Hence although a fairly constant water-wheel speed might have been maintained it would have been impossible to keep the voltage constant at the center of distribution. Now my governor when used on electric transmission-plants of the above type, with long transmission-lines, governs the water wheel or wheels in such a way as to keep the voltage constant at the center of distribution. Where the generator is compounded to overcome the line-drop, the governor will keep the water-wheel at a constant speed, and where the generator is a simple shunt-wound machine it will vary the speed of the wheel in a certain proportion to the load, so that the voltage will be kept constant at the center of dis tribution.

The above result is attained in the following manner: Suppose the dynamo is running at the proper voltage with all the load off at the center of distribution. Then the voltage is the same at 2 as it is at the dynamo, and there will be no current through series coil 5. Also suppose the dynamo is a simple shunt-wound machine. Adjust weight 60 to such a position that the pull of the shunt-coil 6 is exactly balanced and both of the end projections 10^a and 11^a of the lever out of contact with the cups 14^a and 15^a. The coils 5 and 6 are wound on the solenoid S in such a way as to tend to demagnetize each other. As the load is thrown on at 2 the speed, and therefore voltage, will decrease; also current flows through coil 5. Hence the combined pull of both on plunger 13 will be less than at no load, due both to decrease in speed and voltage and increase in demagnetizing effect of 5. The plunger will be drawn a certain distance out of the solenoid by the weights 60 and 61, allowing 11^a to make contact in 15^a. This will cause current to flow through the motor 16 in such a way as to open the water-wheel gates, which has previously been explained in this specification. The gates will continue to open until the speed, and consequently the voltage, of coil 6 has increased sufficiently to make the pull on the plunger

13 the same as it was for no load. By the time this pull has reached this value contact will be broken between 11^a and 15^a, and the gates will cease to open. Now if the proper number of sections of coil 5 are in circuit this increased dynamo-voltage will be such that the voltage at 2 will be the same as for no load. If it is not, it is simply necessary to adjust the strength of the series coils by changing the number of section in circuit. Suppose now that the load be increased to full load. The shunt-coil 6 must exert a very much greater force in order to keep the combined pull of solenoid S on plunger 13 the same, and the lever consequently will not break contact between 11^a and 15^a until the dynamo-voltage is considerably higher. The contact, however, will be broken at the instant that the voltage at 2 is normal again. In other words, the governor acts not only as a regulator for the water-wheel, but also as a booster to the line, increasing the station-voltage in proportion to the load. In the following equation, where $e=E-CR$, e is kept constant, e being the voltage at 2, E the voltage at 1, and C R the loss of voltage on the line, (C being the line-current and R its resistance.) If the load should be increased to a value greater than the wheel could run, the motor would open the gates full, and switch 26 break contact before the lever 7, thus preventing straining of the wheel-gates. Now as the load at 2 is thrown off the combined force exerted by solenoid S will increase, due both to the decrease of pull exerted by coil 5, but principally due to the increase of voltage caused by increase of speed; the plunger 13 will be drawn down and contact made between 10^a and 14^a, current will flow through the motor in such a way as to close the water-wheel gates, which has heretofore been explained in this specification. This action will continue until the speed, and therefore voltage, has decreased sufficiently to allow the plunger 13 to be drawn back from solenoid S, and contact broken between 10^a and 14^a. At the instant contact is broken the voltage at 2 must be again normal.

In water-wheel governing it is well known that if the gates are moved too rapidly the wheel will hunt, that is, the speed will seesaw up and down. It is very desirable, however, in cases of extreme variation in load, say, when the whole load is thrown off, that the governor should close the gates rapidly, in order that the speed should not become dangerously high or low. This last result is attained and the first avoided by my governor in the following manner: When the load-changes are small, the increase or decrease in speed, and therefore voltage, is only sufficient to make the end projections 10^a or 11^a make contact in the end cups 14^a or 15^a. This permits current to flow through the motor by way of the resistances 38^a or 39^a, and since these resistances are quite high the voltage applied to the motor-terminals is quite low, say one-sixth of the voltage of battery 20. The motor will consequently run at one-sixth its maximum speed, and the gates will open or close at the rate of full gate in, say, one and one-half minutes. This rate of governing is slow enough to prevent any seesawing of lever 7 when contact is broken at the cups 14^a or 15^a. Now if the change in load is sufficient to cause contact to be made in the second cup also, namely, 14^b or 15^b, the current will flow through the motor by way of the two resistances 38^a and 38^b in parallel or 39^a and 39^b in parallel, and the motor will run and gates move at, say, one-fourth of the maximum speed (depending, of course, on the value of the resistance b with respect to a) until contact is broken in the cups 14^b or 15^b, when the gates will move at one-sixth maximum speed, which is sufficiently low to prevent seesawing when contact is again broken in either of the end cups, as has been explained. Also if the load changes sufficiently to cause contact to be made in either of the third cups the motor will move the gates at a still higher speed, decreasing step by step as the lever comes out of the cups. Also if the whole load is thrown on or off and contact made in the fourth cups 14^d or 15^d the gates will be moved at the maximum speed, say of full gate in fifteen seconds, this speed also decreasing step by step until contact is broken at 14^a or 15^a, with the gates moving at one-sixth maximum speed. In other words, the rate of governing varies in proportion to the changes in load. Where there is little or no drop of voltage on the transmission-line there is no object in using a solenoid composed of both a series and shunt coil, and for plants of this character a shunt-solenoid alone is all that is necessary. In plants where constant-current dynamos are employed a series solenoid alone is used, and the current instead of the voltage is kept constant.

This governor may be used with equally good results on continuous or alternating circuit plants. When used in connection with the latter, converters are placed between the coils 5 and 6 and the generators. It is, however, not absolutely necessary to use a series converter for the series coil 5, for the main-line current may be run directly through it without any bad results. In either continuous or alternating plants, when the main current is very large, it may be shunted across the terminals of the series coil 5.

This governor may be used with equally good results on water-wheel plants connected directly to mill and other machinery, such as is the case in many cotton, flour, and other mills. Many of these mills have their own dynamos for lighting, and it is only necessary to connect the shunt-coil 6 with the said dynamo. There would be no object in using the series coil. In cases where the mill did not have a dynamo a small one could be installed, one giving sufficient current for coil 6 and the governor-motor being all that would be necessary. Coil 6 consumes only about sixty watts, or a little over the power used for a sixteen-candle-power incandescent lamp, and for the largest plants the governor-motor would probably never take over 1 kilowatt.

Referring now to the starting and stopping device mentioned previously in this specification and shown in Figs. 1 and 2, in some cases it has been desirable to provide means for starting and stopping an electric plant from any point on the premises and even from a distance, and this object is attained by the device E. (Shown in Figs. 1 and 2.)

In Fig. 1, 44 and 45 are magnets, the windings of which are connected by means of the wires 51, 52, and 53 with the switch-levers 55 and 56, which are supposed to be at the point from which it is desired to operate the starting and stopping device. Pivoted at 49 is an armature 48, having a rod 50 projecting over the lever 7. The rear end of this armature is heavier than the end carrying the rod 50 and normally rests in the position shown in the drawings and at a distance above the lever 7 sufficient to allow contact to be made in cup 15^d without the said lever striking against arm 50. 46 is a spring having on its end an armature 47 in position to be attracted by magnet 44. The spring normally presses the armature 47 firmly against the rear end of armature 48, in which is a notch with which the armature 47 engages when the front end of armature 48 is drawn down by the magnet 45.

In operation the device works as follows: Suppose the plant running and the lever 7 balanced. To shut down the plant, join the circuit for an instant between 58 and 55, current flows from the battery 20 through the coil of magnet 45 by way of the wires 51, 53, and 42. The armature 48 is drawn down by the magnet 45, armature 47 catches in the notch in armature 48 and holds 48 in this position, the arm 50 presses the lever 7 down so that one or all of its projections enter the mercury-cups 14^a *b*, &c., and the moter 16 will close the gates of the wheel. This action will continue until recess 32 on periphery of block 30 comes opposite the rear end of lever 27, which will cause said lever to break contact between the tongues 29, and the motor will stop, and the gates will now be fully closed and the plant shut down. To start the plant, join the circuit for an instant between 58 and 57; current flows from the battery 20 through the coil of magnet 44 by way of the wires 51, 52, and 42, the magnet 44 attracts the armature 47, drawing it out of the notch in armature 48, the rear end of 48 drops by gravity, 50 rises from contact with the lever 7, the right-hand arm of which drops by means of the balance-weights 60 and 61, contact is made in the cups 15^a *b*, &c., and the motor opens the water-wheel. This action continues until the voltage rises sufficiently to attract plunger 13 and balance-weights 60 and 61, or until the switch 27 breaks the motor-circuit, (which would mean that the gates were full open.)

In large plants where the power required to actuate the gates is quite large it is necessary to use a one or possibly two horse-power motor, and the power to run the said motor should be taken from the station or an auxiliary generator. Under these conditions the starting and stopping device heretofore described would not be used. A coupling would be inserted between the worm-wheel shaft 24 (see Fig. 1) and the gate-shaft 3. To start and stop the plant, it would then be necessary to unlock the coupling and open the gates by hand. Under these conditions it would be best to have the block 30, actuating the switches 26 and 27, connected directly to the gate-shaft.

In plants using a number of wheels and generators and where the generators are connected in parallel with the transmission-line one of the boxes 71, containing the devices shown in Fig. 2, would regulate the whole plant. Each water-wheel or pairs of wheels would have one of the governors shown in Fig. 3. There would be one small generator, say five or six kilowatts. This generator would be subsituted in place of the battery 20 shown in Fig. 1. All of the governors would be connected with this generator and with the lever 7 in the same way as shown in Fig. 1, and a switch 43 would be in the wire 42^a connecting with each governor.

Having now fully described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In an electric governor, the combination of a dynamo, a prime motor and mechanism for regulating the force applied to the prime motor, a solenoid, a reciprocating core in said solenoid, a double lever from which said core is suspended having a number of projections on each end, and contacts with which the projections of the lever may engage, said contacts being connected with a source of current and said electrically-operated regulating mechanism.

2. In an electric governor, the combination of a dynamo, a prime motor and mechanism for regulating the force applied to the prime motor, a solenoid composed of a series and shunt coil in the same circuit, a reciprocating core in the said solenoid, a double lever from which said core is suspended, having a number of projections on each end, and mercury contacts into which the projections of the lever may dip, said contacts being connected with a source of current and said electrically-operated regulating mechanism.

3. In an electric governor, the combination of a solenoid composed of a series and shunt coil, a reciprocating core suspended in said solenoid, a double lever (from which the core is suspended) having a number of projections on each end, two adjustable weights connected to the lever used for balancing the pull of the solenoid and also for varying the

sensitiveness of the lever, mercury contacts into which the projections of the lever may dip step by step, resistances connected to the mercury contacts, a source of current, a gate-moving mechanism, and connections whereby the said mechanism will move at speeds proportional to the changes in load.

4. In a gate or valve moving mechanism, the combination of an electric motor connected to the gate or valve by means of worm and other gearing, switches which break the current through the motor when the gate or valve is closed or fully open, and connections between the motor and a source of current whereby the motor may be caused to run in opposite directions.

5. In a gate or valve moving mechanism, the combination of an electric motor connected to the gate or valve by means of worm and other gearing, switches which break the current through the motor when the gate or valve is closed or fully open, and connections between the motor and a source of current whereby the motor may be caused to run in opposite directions, and at speeds proportional to the changes in load.

6. In a starting and stopping device, the combination of the magnets 44 and 45, armatures 47 and 48, spring 46 and arm 50.

Signed at Baltimore, in the State of Maryland, this 17th day of June, A. D. 1896.

WILLIAM W. HANDY.

Witnesses:

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