No. 695,220. Patented Mar. 11, 1902.

L. LYNDON.

ELECTROMECHANICAL WATER WHEEL GOVERNOR.

(Application filed Sept. 13, 1900.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1.

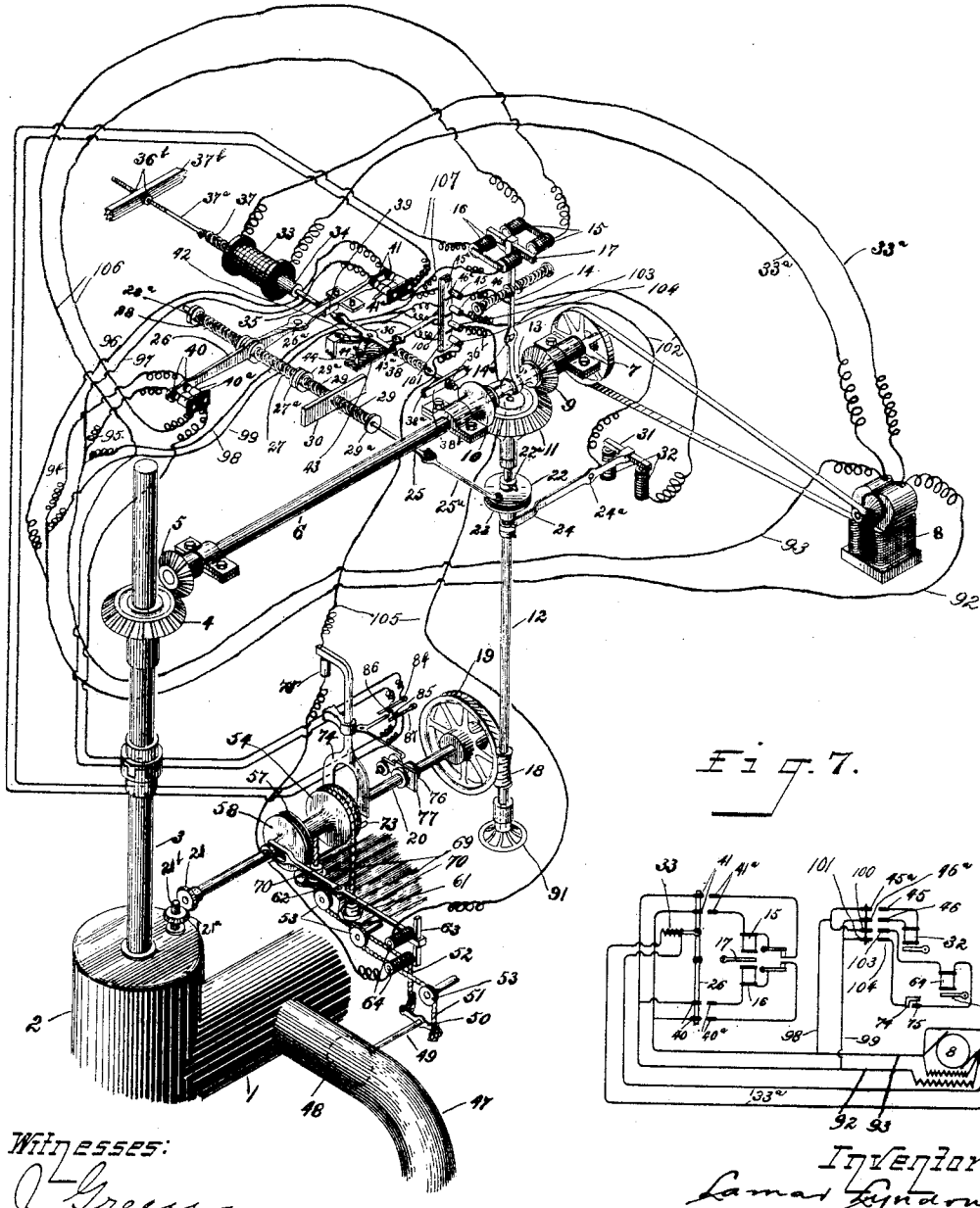


Fig. 7.

Witnesses:
J. Green
A. P. Knight

Inventor:
Lamar Lyndon
by Strong & Moo
Attys

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

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(No Model.) 4 Sheets—Sheet 2.

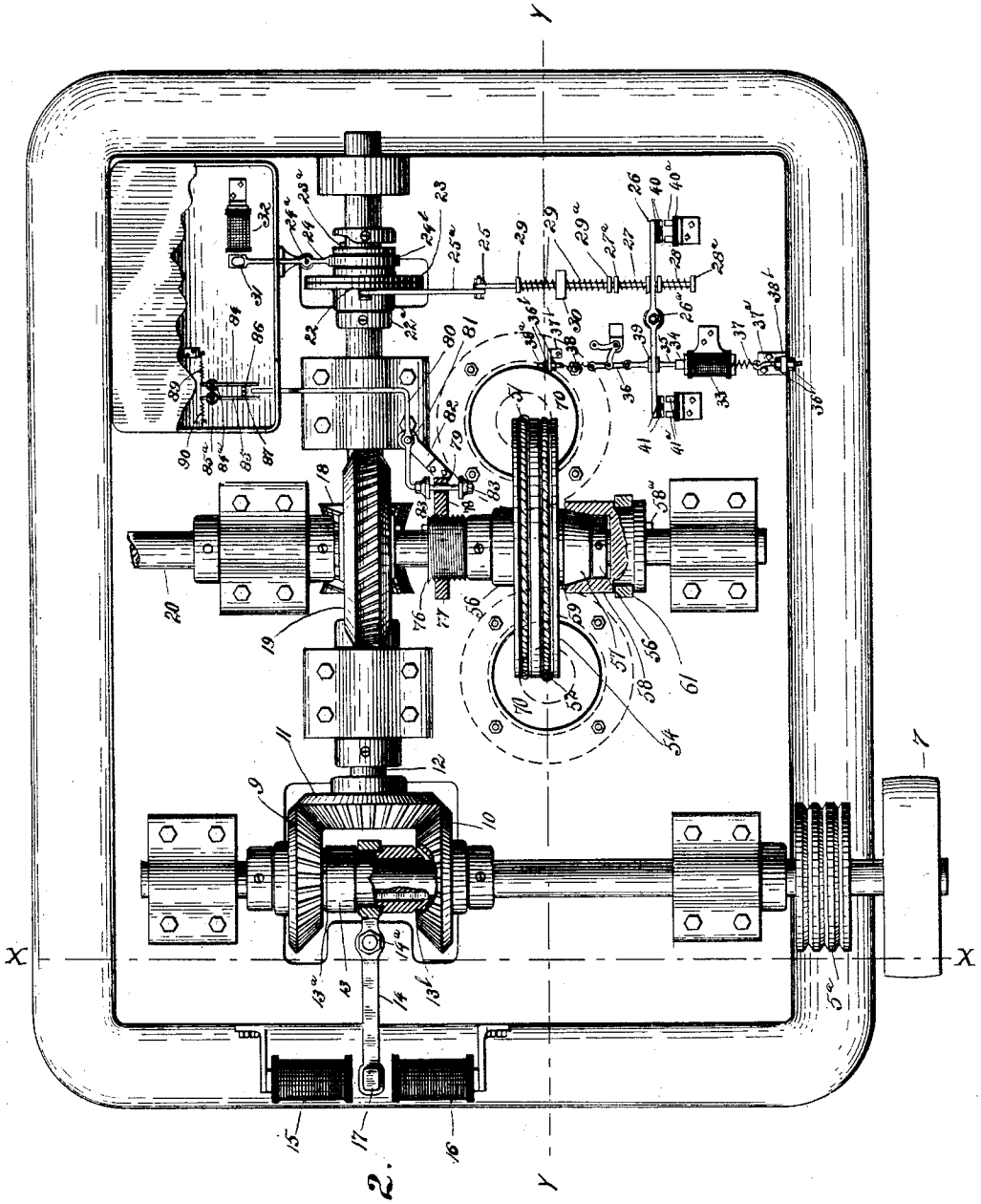


Fig. 2.

WITNESSES:

J. Green.

A. P. Knight

INVENTOR

Lemar Lyndon

BY

Knight Bros

ATTORNEYS

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

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L. LYNDON.

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(No Model.) 4 Sheets—Sheet 3.

Fig. 3.

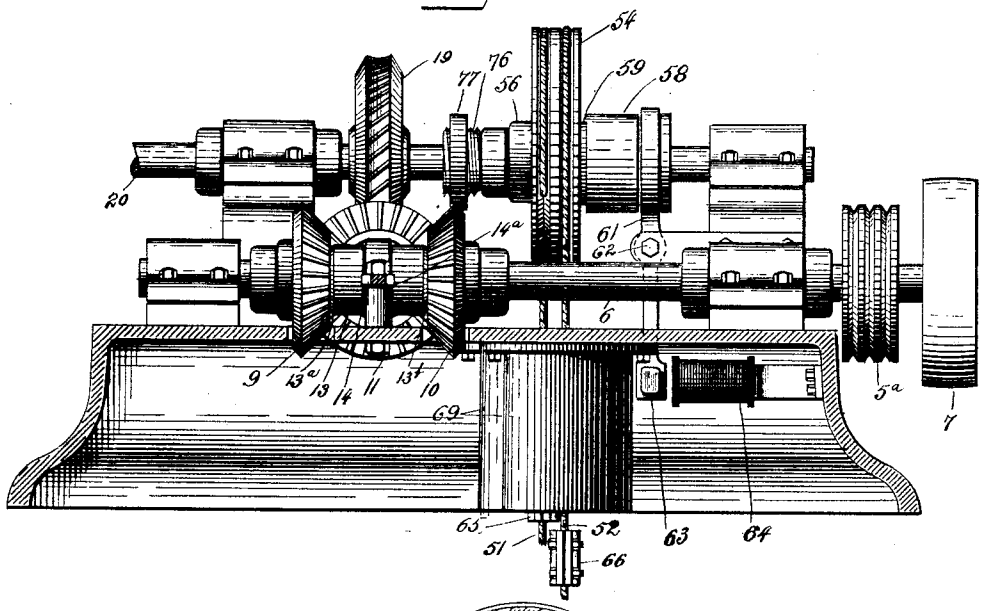
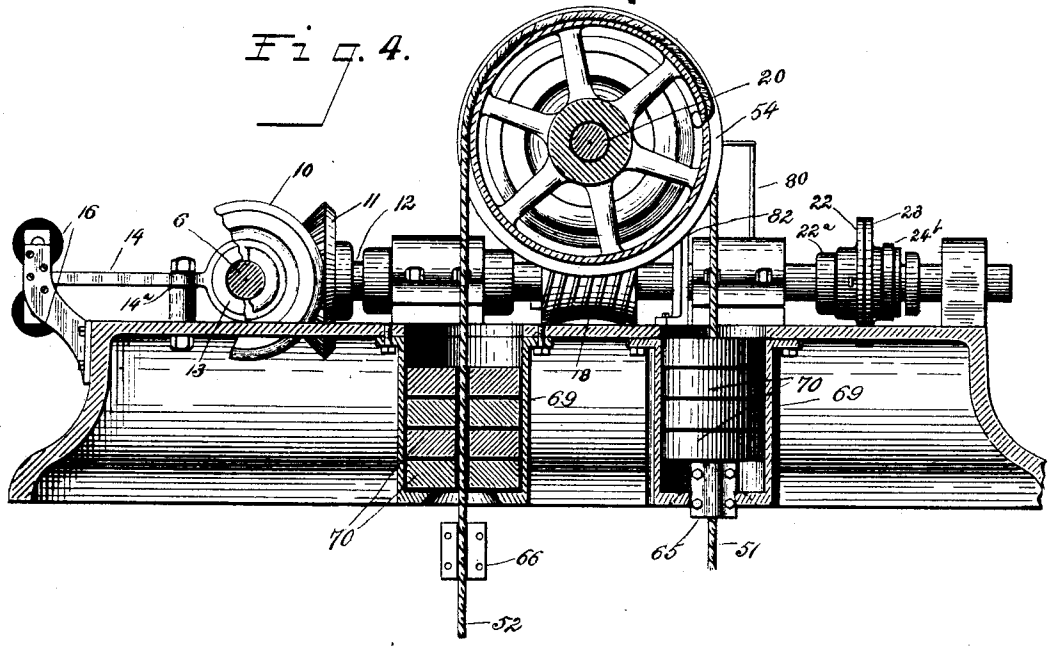


Fig. 4.



WITNESSES:

J. Green

A. P. Knight

INVENTOR

Lamar Lyndon

BY

ATTORNEYS.

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

No. 695,220. Patented Mar. 11, 1902.

L. LYNDON.

ELECTROMECHANICAL WATER WHEEL GOVERNOR.

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(No Model.) 4 Sheets—Sheet 4.

Fig. 5.

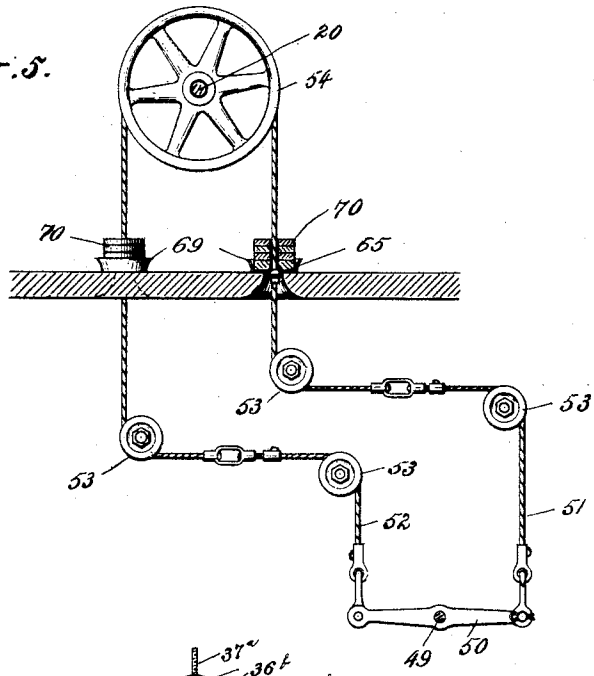
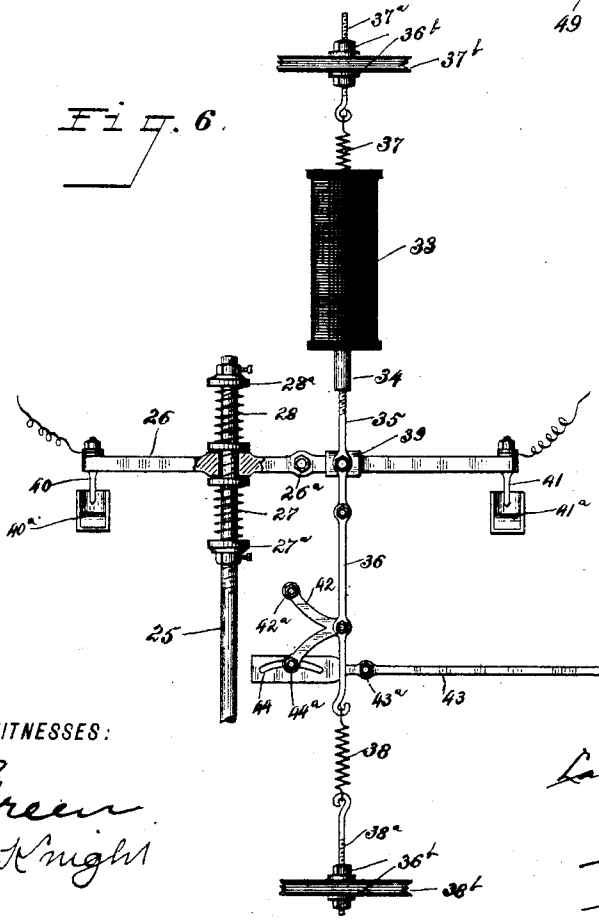


Fig. 6.



WITNESSES:

J. Green

A. P. Knight

INVENTOR

Lamar Lyndon

BY

Strong & Brock

ATTORNEYS.

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

UNITED STATES PATENT OFFICE.

LAMAR LYNDON, OF NEW YORK, N. Y.

ELECTROMECHANICAL WATER-WHEEL GOVERNOR.

SPECIFICATION forming part of Letters Patent No. 695,220, dated March 11, 1902.

Application filed September 13, 1900. Serial No. 29,880. (No model.)

To all whom it may concern:

Be it known that I, LAMAR LYNDON, of the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Electromechanical Water-Wheel Governors, of which the following is a specification.

The governors at present employed to regulate the water-supply to the water-wheel in general simply operate to open or close the water-wheel gate, thereby allowing of the admission of a greater or less supply of water. Now the first effect of such opening or closing of the gate, owing to the inertia of the water, is always the opposite to that which it is desired to bring about—*i. e.*, the opening of the gate operating to momentarily cause less velocity of water at the wheel, owing to the greater orifice the water has to flow through, and, vice versa, the closing of the gate operating to momentarily cause an increase of velocity, owing to the contraction of the orifice. Moreover, these contrary effects will last until the changed conditions can be imparted to the source of supply of water.

One object of my present invention is the overcoming of these opposite effects, and for this purpose I provide a by-pass inserted into the penstock or flume at a point near the water-gate and a gate in the said by-pass controlled by the same governing mechanism that controls the water-gate and operating to allow a greater or less flow through the by-pass, according as the water-gate is being closed or opened.

Other features of my invention relate to means for preventing excessive action of the governor in either direction, so that the governor is not allowed to pass beyond the proper point for regulation, by reason of the inertia of the parts or for other causes, thereby preventing the oscillation on either side of the regulating-point usual to such devices. Means are also provided for arresting the action of the governor when the water-gate is fully opened or closed.

Another feature of my invention relates to the control of the governor by a dynamo driven by the water-wheel and so wound that the electromotive force at the terminals is substantially independent of the load and varies with the speed, but at a rate greater than the speed variation, so as to obtain greater sensitiveness in regulation.

Other features of my invention relate to details of construction and arrangement, as hereinafter set forth.

Referring to the accompanying drawings, Figure 1 is a perspective and somewhat diagrammatic view of my improved water-wheel governor. Fig. 2 is a plan view showing in detail certain parts of same. Fig. 3 is a vertical section on the line X X of Fig. 2. Fig. 4 is a vertical section on the line Y Y of Fig. 2. Fig. 5 illustrates a part of my compensating device. Fig. 6 illustrates in detail a part of my controlling device. Fig. 7 is a diagram of the circuit connections.

In Fig. 1 I have shown the penstock 1 leading into the cylinder 2, the latter containing a turbine water-wheel. (Not shown.) 3 is the main shaft, connecting at one end with the water-wheel and carrying a bevel-gear 4, engaging with another bevel-gear 5 on a shaft 6, as shown in Fig. 1, or connected to drive such shaft 6 in any suitable manner by belt or rope connection to a sheave 5^a, (see Fig. 2,) this latter shaft being situated, preferably, at right angles to the main shaft 3. The shaft 6 carries a pulley 7, which is connected by belting to a dynamo 8. This shaft 6 also carries loosely-mounted bevel-gears 9 and 10. These bevel-gears are adapted to mesh with a third bevel-gear 11, mounted on a shaft 12, preferably at right angles to the shaft 6. Mounted on the shaft 6, so as to move longitudinally, but splined thereto, so as to rotate therewith, and located between the bevel-gears 9 and 10, is a sleeve 13, having friction-disks or chamfered ends 13^a 13^b or other form of clutch adapted to engage in holes in the bevel-gears 9 and 10, respectively. A lever 14, fulcrumed at 14^a, engages at one end in an annular groove in the sleeve 13, while the other end carries an armature 17, adapted to oscillate between the clutch-magnets 15 and 16.

On the shaft 12 is mounted a worm 18, meshing with a worm-wheel 19 on a shaft 20. The shaft 20 also carries a bevel or spur gear 21, which meshes with another bevel or spur gear 21^a, situated on the shaft 21^b, which operates the water-wheel gate, (the latter not shown.)

A disk 22 is mounted on shaft 12, so as to

be free to rotate, but is held from endwise movement by collars, one of which is shown at 22^a. On the same shaft is a disk 23, normally out of contact with disk 22, but movable endwise on said shaft into contact with said disk, the disk being caused to rotate with the shaft by a spline connection 23^a. A lever 24, fulcrumed at 24^a to a fixed frame part, has a yoke 24^b engaging in an annular groove in the hub of disk 23 and carries the armature 31 of a magnet 32, herein termed the "returning-magnet." A returning device consisting of a rod 25, connected by a pivoted link or connecting-rod 25^a with the disk 22, passes through a hole in the controller-lever 26, pivoted at 26^a to a fixed support, and through a fixed abutment or frame-piece 30. Springs 27 28 are arranged on the rod between lever 26 and respective collars 27^a 28^a on the rod, while springs 29 29 are placed between collars 29^a 29^a on the rod and the fixed abutting piece 30, these latter springs serving to restore the returning device 25 to normal position after it has been displaced in either direction by the operating-clutch means 22 23. The springs 27 28 enable the returning-rod 25 to exert pressure on the controller 26 to return it to normal position, while permitting displacement of such controller from normal position under the action of its electromagnetic operating means. Such means consist of the solenoid 33, with its soft-iron core 34, carrying a rod 35, springs 37 38 being connected to said core and to a link 36, connected to said rod, so as to act reversely thereon and maintain the core in normal position when the water-wheel is at normal speed, the energization of the solenoid being responsive to such speed. The springs 37 38 are supported by screw-rods 37^a 38^a, adjustably secured by nuts 36^b to fixed supports on frame-pieces 37^b 38^b. The rod 35 is pivotally or loosely connected at 39 to the lever 26, which acts as a circuit-controller for the magnets 15 16 of the clutch-reversing gear, said lever carrying contacts 40 41 at its respective ends adapted to engage with fixed contacts 40^a 41^a, connected to the respective magnets aforesaid. The solenoid 33 also serves to control the action of the compensator-magnets and returning-magnets through a secondary controlling-lever 43, pivoted at 43^a to a fixed support and having a widened portion with a slot 44, engaged by a pin or roll 44^a on one end of a bell-crank 42, which is pivoted to a fixed part at 42^a, and whose other end is connected by link 36 to the rod 35, the slot being curved reversely to the arc of movement of pin or roll 44^a on the bell-crank, so that when the lever 26 and rod 35 move in either direction the lever 43 will be moved in one given direction. In such movement of the lever 43 contacts 45^a 46^a 100 101, carried thereby, will connect with fixed contacts 45 46 103 104 to close the circuit of the returning-magnet and the compensator-magnet, respectively.

The compensating devices comprise a by-pass 47, connected around the wheel and leading from the feeder-pipe or penstock at a point near the wheel-gate, the latter, however, being between the by-pass and the wheel. This by-pass is of an area which is a small percentage of the area of the feed-gate. A valve 48 in this by-pass is operated by ropes 51 52, attached to opposite ends of a lever 50 on the stem 49 of said valve, these ropes passing over idlers 53 and around pulley 54, being secured at the ends to said pulley. The double sheave or pulley 54 is mounted on shaft 20, so as to be free to rotate thereon, being held from endwise movement by collars 56. A clutch consisting of corresponding disks or cones 57 58, respectively, on said sheave and on hub 59, mounted on the shaft 20, so as to move endwise, but compelled to rotate therewith by spline connection 58^a, enables the sheave to be clutched to the shaft, this operation being controlled by a lever 61, pivoted at 62 and having a fork engaging in an annular groove in said hub. The other end of this lever carries the armature 63 of the compensator-magnet 64. On the ropes 51 52 are lugs or clamps or stops 65 66, adapted to engage under and lift weights 70 70 when the sheave is turned either way from normal position, these weights being guided in casings 69 on a suitable fixed support. Means may be provided for easing off the descent of these weights, if desired. For example, the casings 69 may constitute dash-pots.

Upon one side of the sheave 54 are pins, one of which is shown at 73. These pins are adapted to alternately engage a slide-bar 74 to lift same from contact with a contact-piece 75. The said slide-bar is returned to its normal position (which is in engagement with said contact-piece) by any ordinary means, such as gravity or a spring.

76 is a screw-threaded sleeve mounted upon and firmly secured to the shaft 20. A collar or sleeve 77, having a female screw part, is adapted to engage the screw-threaded sleeve 76. This collar of sleeve 77 has upon one side a projecting part 78, having a hole 79, through which passes an end of a rod or lever 80. This collar will therefore be prevented from rotating and will be constrained to move longitudinally of the sleeve. This sleeve is fulcrumed at 81 to a fixed piece 82 and carries on either side of the part 78 tappets 83 83. The other end of the rod or lever 80 projects between contact-levers 84 85, pivoted at 84^a 85^a and caused to normally press against the contact-points 86 87 by springs 89 90.

A hand-wheel 91 is adapted to engage the end of the shaft 12. This hand-wheel is readily removable for reasons hereinafter described.

The dynamo which I employ is compound wound and in a manner to give constant potential at the terminals with constant speed independent of the variation of the current. Wires 92 93 lead out from opposite sides of the armature. To these wires are connected,

first, wires 94 95, leading to the contacts 40; second, the wires 96 97, leading to the contacts 41, and, third, the wires 98 99, leading to to contacts 45^a 46^a on the lever 43 and also to contacts 100 and 101, situated on the same lever. The contacts 45 46, which coöperate with contacts 45^a 46^a, are connected together by wire 102, leading through magnet 32. Contacts 103 104, which coöperate with lever-contacts 100 101, are connected together by wire 105, leading through compensating magnet 64 and circuit-breakers 74 75. From the respective sets of contacts 40^a and 41^a wires 106 107 lead through clutch-magnets 15 16, such wires including the circuit-breakers 84 86 and 85 87. Wire 33^a leads from the dynamo to solenoid 33.

The operation of the device is as follows: When the speed of the main shaft 3, owing to an increase or decrease of the load thereon, is caused to fluctuate, the speed of the shaft 6, and consequently that of the armature of the dynamo 8, will also fluctuate. The dynamo which I employ is of the direct-current type, preferably of between three hundred and five hundred watts capacity. It is compound wound, the field-magnet being made up of soft laminated iron. The series winding is to be sufficient only to compensate for drop due to the internal resistance of the machine and to give at any given speed practically a constant potential at its terminal without regard to the quantity of current delivered by it when operating within its capacity. The fields are so proportioned that the magnetic density when the dynamo is running at normal speed is low and below the "knee" of the magnetic curve, say, ten thousand to twelve thousand lines per square centimeter in soft laminated iron. It is evident that a slight increase in speed of the armature will give an increase in voltage, due, first, directly to the increase in speed, and, second, to the increase in magnetic density, which latter increases because of a greater current flowing through the shunt-windings caused by the slight increase of voltage. Therefore a variation in speed of the armature will give a variation in voltage which will change much more rapidly than directly as the first power of the speed variation. The variation in voltage will be approximately as the square of the variation in speed of the armature. As the controlling-solenoid 33 responds directly to the square of the variation of voltage it will be seen that its control will be more sensitive than a control due simply to direct effect of the speed.

We will now assume the main shaft to be revolving clockwise as we look down upon it and also that it revolves at normal speed. Under these circumstances the solenoid 33 is energized to such an extent as to hold the controlling-lever 26 in its mean position, not making contact at either end, and the valve 48 in the by-pass is half open. Suppose that the load in the shaft has been decreased. The speed of shaft 6, and consequently of the pulley 7, will be increased, which will cause an increase of speed of the armature of the dynamo, and consequently of the electromotive force thereof. This will cause a greater than usual energizing of the controlling-solenoid 33, which will cause the core 34 to be drawn farther within it against the tensile force of the spring 37^b. The operation of the solenoid-core causes the contacts 40 to come in touch with their opposing contact-piece 40^a, thereby causing an excitation of the clutch-magnet 15. The armature 17 will now be drawn toward the magnet 15, thereby causing the end 13^a of the sleeve 13 to clutch the gear-wheel 9. The gear 9 will now be constrained to rotate with the shaft 6, and this will cause the gear-wheel 11, and consequently the shaft 12, to also rotate. The shaft 20 will therefore, through the worm 18 and worm-wheel 19, be caused to rotate and the water-gate will be closed.

In order that the shafts 12 and 20 may not tend to continue to revolve in either direction after the complete opening or closing of the gate, means must be provided for interrupting the circuit controlling the clutch-magnets. To this end I provide the screw-threaded sleeve 76 and collar 77, herein described. A certain number of revolutions of the shaft 12 will completely pen or close the gate. The same number of revolutions will cause the collar 77 to travel the entire length of the sleeve 76. When the said collar arrives at a point near the end of the said sleeve, it will come in contact with one of the tappets 83, causing it, and consequently the rod or lever 80, to move with it. The other end of the rod, projecting, as it does, between the ends of the contact-levers 84 85, will cause one or the other of said levers (depending upon the direction of revolution of the shaft 12) to be lifted from contact with the contact-points 86 87, which operation will break the circuit of the corresponding clutch-magnet. This contact-lever will be kept out of contact until the shaft 12 is revolved in the opposite direction, when the collar 77 will travel away from it, thus allowing it to again come in contact with its contact-point. The rod 25, disks 22 and 23, and the controlling clutch-magnet 32 constitute a returning device for preventing the governor from overrunning—that is, moving the water-wheel gate a greater distance than is actually necessary for proper regulation—this necessitating a second movement of the gate in an opposite direction, which in turn may overtravel and require the gate to be moved back again. With an "overrunning" governor the gate movement is to a certain extent oscillatory, the amplitude of movement decreasing until the proper position of the gate is finally reached. When the governor-shaft 12 is set in operation in either direction by the controlling-solenoid 33, the rod 36 operates the lever 43 to close the circuit of the clutch-magnet 32, which causes engagement of disks 23 22 and causes

the disk 22 to be carried slightly around one way or the other, according to the direction of movement of the governor-shaft 12, thereby returning the lever 26 to normal position. This movement of the returning-rod 25 is resisted by spring 28 or 29, according to the direction of operation. As soon as the lever 26 is returned to normal position it operates directly through contacts 100 101 to deënergize the clutch-magnet which set the governor in operation and indirectly through lever 43 and contacts 46^a 46^b to deënergize the clutch-magnet for the returning device, the latter being thus released and returning to normal position under the influence of its spring. When the gate is operated, as above described, the lever 43 is moved to close the contacts 45^a 46^a 100 101, this closure being effected whatever the direction of movement of the controlling-lever 26 by reason of the pin and curved-slot connection between such levers. Current will therefore flow from the dynamo through wires 92 98, contacts 100 and 103, to wire 105, leading through the compensating magnet 32, and thence through contacts 74 75 and 104 101 to wires 99 93, back to the dynamo. Magnet 32 then engages clutch 58, and thus throws the by-pass valve into operative relation through the ropes 53, sheave 54, and clutch 58 with the gate-operating shaft 20. Consequently the by-pass valve will be turned toward open or shut position, according to whether the gate is closing or opening, for the purpose above stated. Normally the gate or valve in the by-pass will be half-way open, so that the amount of water flowing through the by-pass and around the wheel without doing work will be half the amount which the by-pass is capable of carrying. When the governor acts to close the main gate, the compensating device will open more widely the by-pass. The rapidity with which the valve in the by-pass opens is such that the increased volume of water which it allows to pass through is proportional to the decrease in area which the main gate effects by reason of its closing. Should the main gate open, a reverse action takes place. The object of this compensating device is to take care of the inertia effect of the column of water in the feed-pipe. As is well known, if a water-wheel gate be suddenly opened to increase the speed of the wheel the first effect will be to actually decrease the speed of the wheel, for the reason that the velocity of the water through the gate drops, because a larger area for the water to pass through is provided, and a larger volume of water is not immediately provided, because there is a time element required, which time element is the length of time required for gravity to accelerate the entire volume of water contained in the feed-pipe, which cannot be accomplished instantaneously. If the water-wheel gate be closed, a reverse effect will be noticed—that is, instead of decreasing the speed of the wheel the speed will actually rise, owing to increased velocity, through the water-wheel gate, due to a decreased area of opening, while the volume of water remains for the time constant, the volume decreasing only after a short time has elapsed, which length of time is required to arrest the column of water in the feed-pipe. It is obvious that the by-pass, arranged as described, opening or closing in a manner opposite to that in which the main gate opens or closes will, if properly adjusted, admit of the main gate being rapidly operated and the governing of the water-wheel quickly accomplished. After the governing takes place the by-pass gate is either open or closed, or nearly so, and in order to be useful for a second governing must return to its normal position. It, however, must return slowly in order that the effect of increased or decreased speed of water through both the by-pass gate and the water-wheel gate will not take place. It is here to be noted that all water-wheel governors as made to-day must accomplish their governing only at such a speed as the acceleration or retardation of the water in the column of the pipe can be accomplished, whereas in the case of the governor hereinbefore described, with the compensation-gate and actuating apparatus, the time element is removed from the main gate and the water-wheel and taken care of in the by-pass.

When the governing is completed, the controlling-solenoid allows the lever 26 to return to normal position, the circuit of the compensating magnet is broken by the return of rod 36 and lever 43, and the butterfly-valve returns slowly under the influence of its weight 70 to normal position.

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

1. In a governor for water-wheels, the combination with a water-gate-operating shaft and a driving-shaft, of a reversing clutch-gear, adapted to connect the water-gate-operating shaft to the driving-shaft in reverse driving relations, means for reversely controlling the operation of such clutch-gear, a dynamo connected to be driven from the water-wheel and wound to maintain constant potential for varying currents therein, but to vary the potential in a greater ratio than the speed, an electromagnetic device connected to such dynamo, and controlling the clutch-gear-controlling means, and means for resisting the action of said electromagnetic device in such manner, that at normal speed the clutch mechanism will be disengaged, but on increase or decrease from normal speed the clutch will be operated to govern the water-gate through its operating-shaft.

2. In a governor for water-wheels, the combination with a water-gate-operating shaft and a driving-shaft, of a reversing clutch-gear, adapted to connect said shafts in reverse driving relations, electromagnetic means controlling such clutch-gear, a dynamo connect-

ed to be driven by the water-wheel and wound so as to deliver an electromotive force varying in a greater ratio than the speed of the water-wheel, a solenoid connected to said dynamo and a device controlled by said solenoid and carrying a contact device, and energizing connections for the electromagnetic gear-controlling means, controlled by said contact device.

3. In a water-wheel governor, the combination with a water-gate-operating shaft, and means for operating same in either direction to govern the water-wheel, of a controller for said operating means, responsive to changes of speed of the water-wheel, a returning device for said controller provided with a clutch connection to said operating-shaft, and means, actuated by said controller on movement thereof from normal position to engage said clutch with the said shaft, so as to cause the return of the controller to normal position and interrupt the governing action before it has overrun the proper amount, substantially as and for the purpose set forth.

4. In a water-wheel governor, the combination with a water-gate-operating shaft, a driving-shaft and reversing clutch-gear, adapted to turn the water-gate-operating shaft in either direction, a controller, responsive to changes of speed of the water-wheel and controlling such reversing-gear, and a returning device for said controller provided with actuating means controlled by said controlling means to return the controller to inoperative position, so as to prevent excessive movement of the governor.

5. In a water-wheel governor, the combination with a water-gate-operating shaft, a driving-shaft and a reversing clutch-gear, adapted to connect said shafts so as to cause the water-gate-operating shaft to move in either direction, a dynamo operatively connected to produce an electromotive force responsive to the speed of the water-wheel, a solenoid device energized by said dynamo, a core for said solenoid and a circuit-controller actuated thereby, springs for holding the circuit-controller in normal position, two electromagnetic devices for reversely operating the reversing clutch-gear, a returning device adapted, when operated, to return the circuit-controller to normal position, a clutch adapted to bring said returning device into operative connection with the water-gate-operating shaft, a magnet controlling said clutch and a circuit for said magnet including a circuit-closer operatively connected with the aforesaid circuit-controller and adapted to energize said magnet on movement of the circuit-controller in either direction.

6. In a water-wheel governor, the combination with means for operating the water-gate in either direction, a by-pass for the water-wheel, and a valve controlling said by-pass, of means connected to the water-gate-operating means and operating the by-pass valve inversely to the operation of the water-gate.

7. In a water-wheel governor, the combination with means for operating the water-gate in either direction from normal position, a by-pass for the water-wheel, and a valve for such by-pass, of means connected to the water-gate-operating means and adapted to operate the by-pass valve from normal position in either direction, so as to control such valve inversely to the control of the water-gate, during the governing action of the water-gate, and means for returning the by-pass valve to normal position on completion of governing movement of the water-gate-operating means.

8. In a water-wheel governor, the combination with a shaft for operating the water-gate in either direction from normal position, a by-pass for the water-wheel and a valve for such by-pass normally held in partly-open position, of an operating device for said valve provided with means for returning the valve to normal position, a clutch, adapted to connect said operating device for the by-pass valve with the water-gate-operating shaft to control the by-pass valve inversely to the water-gate, reversing means for operating the water-gate-operating shaft in either direction, a controller, responsive to the speed of the water-wheel and controlling said reversing means, and means operated by said controller to bring the aforesaid clutch into operation and to release said clutch when the governing action is effected.

9. In a water-wheel governor, the combination with a shaft adapted to operate the water-gate in either direction from normal position, a by-pass for the water-wheel and a valve for such by-pass, normally held in partly-open position, of means adapted to operate said valve in either direction and provided with means for returning the valve to normal position, a clutch, adapted to connect such operating means with the water-gate-operating shaft, a driving-shaft, and a reversing-gear for turning the water-gate-operating shaft in either direction, a dynamo connected to the water-wheel, so as to be responsive to the speed thereof, an electromagnetic device connected to said dynamo, a controller operated by said electromagnetic device and controlling the said reversing-gear, a magnetic device controlling the aforesaid clutch for the by-pass-operating means, a circuit for said magnet and means operated by said controller in its movement in either direction to close such circuit.

LAMAR LYNDON.

Witnesses:
A. P. KNIGHT,
HARRY E. KNIGHT.