No. 831,563. PATENTED SEPT. 25, 1906.

G. A. MOSHER & F. C. CURTIS.

SPEED REGULATOR.

APPLICATION FILED NOV. 22, 1902. RENEWED FEB. 6, 1906.

5 SHEETS—SHEET 1.

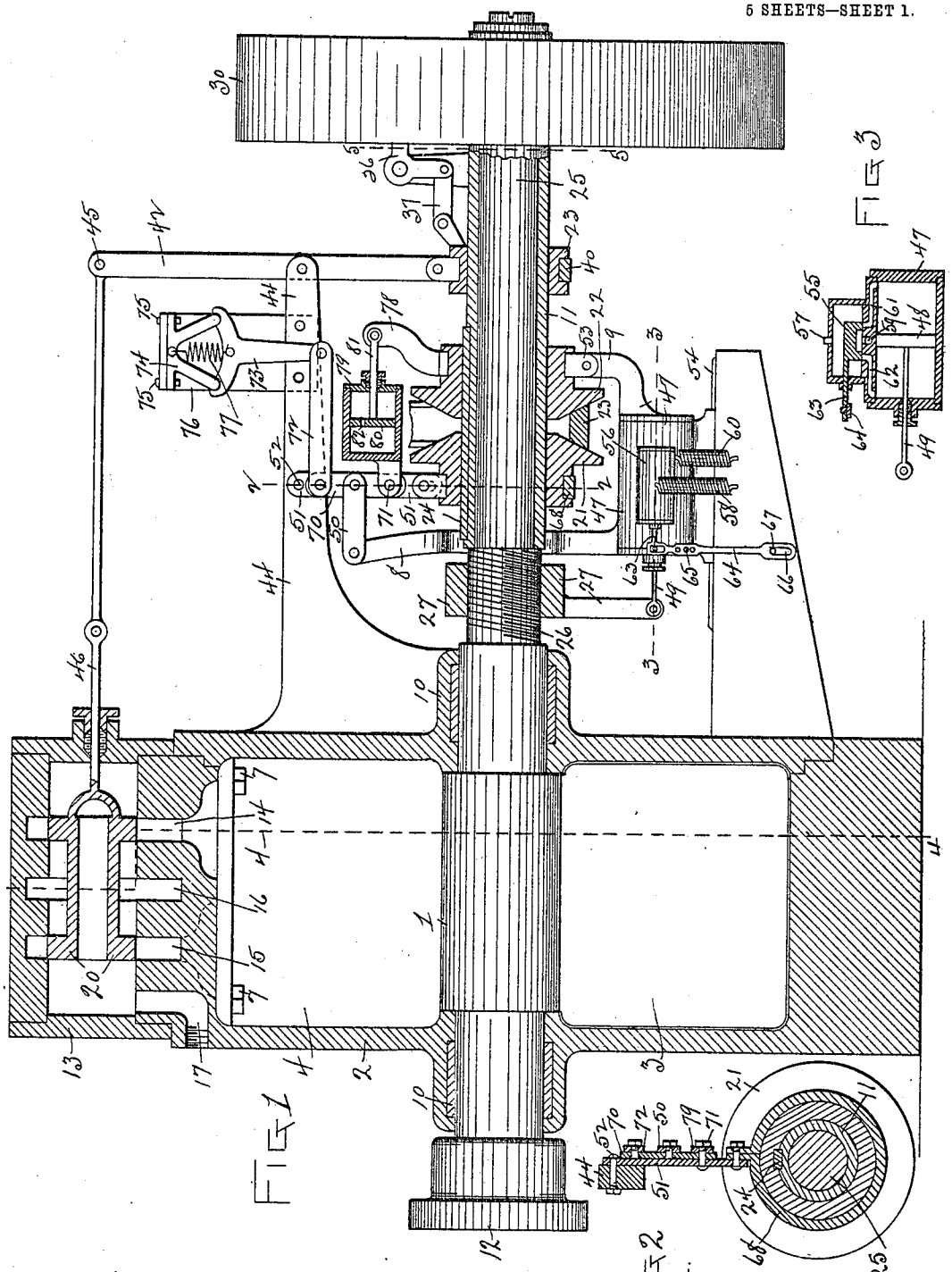


FIG 1

FIG 3

FIG 2

WITNESSES

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5 SHEETS—SHEET 2.

FIG 5

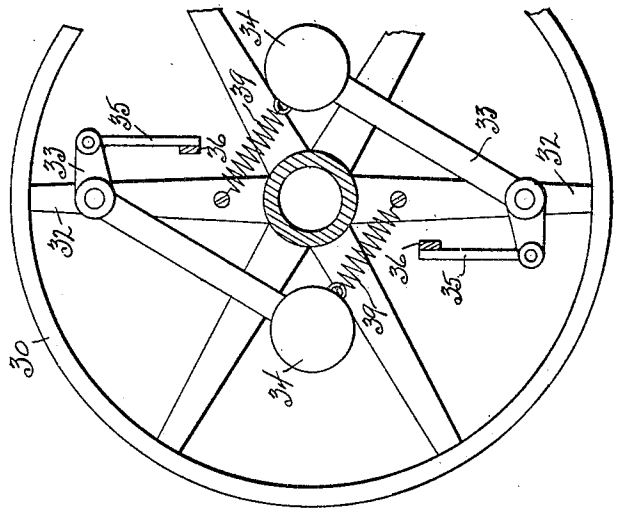
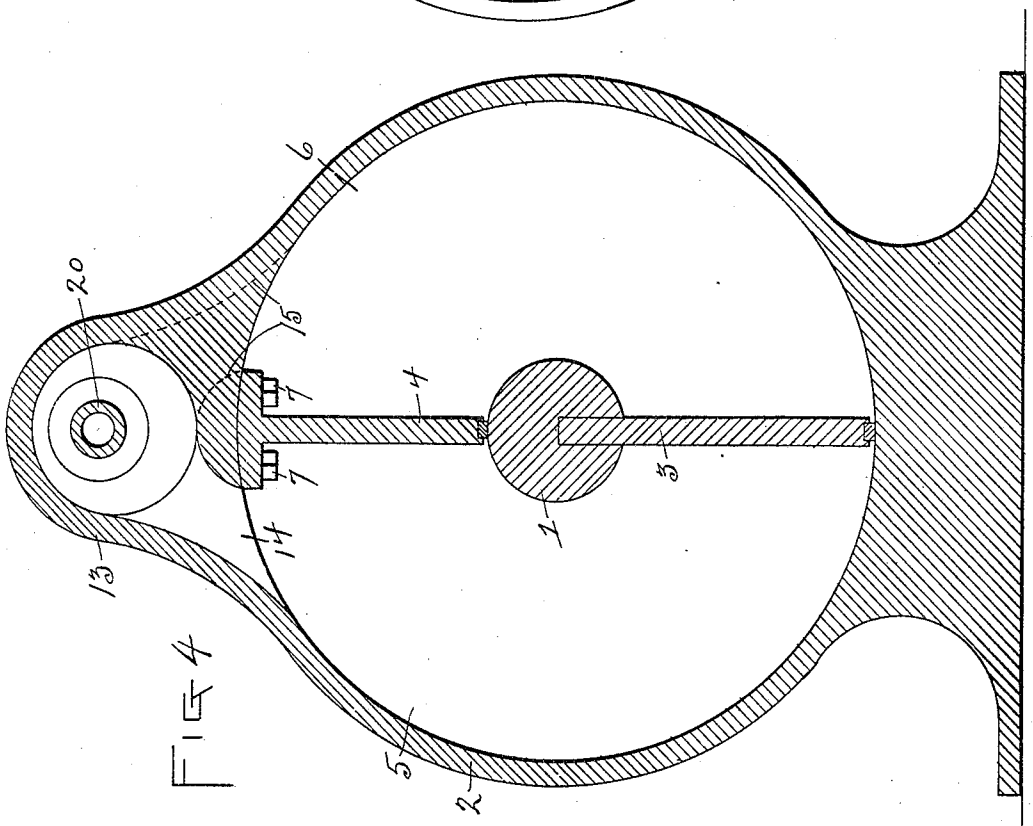


FIG 4



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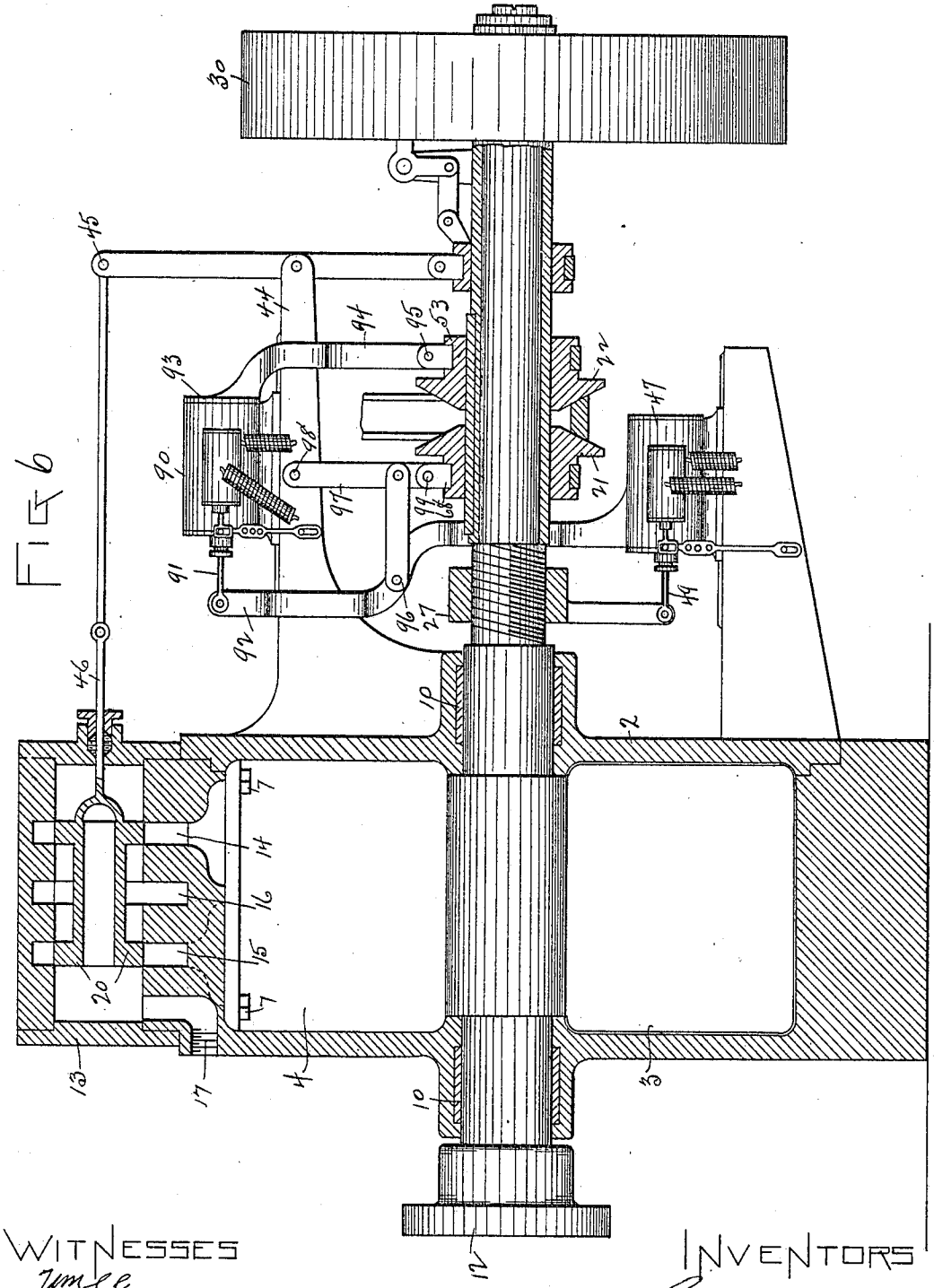
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5 SHEETS—SHEET 3.

FIG 6



WITNESSES

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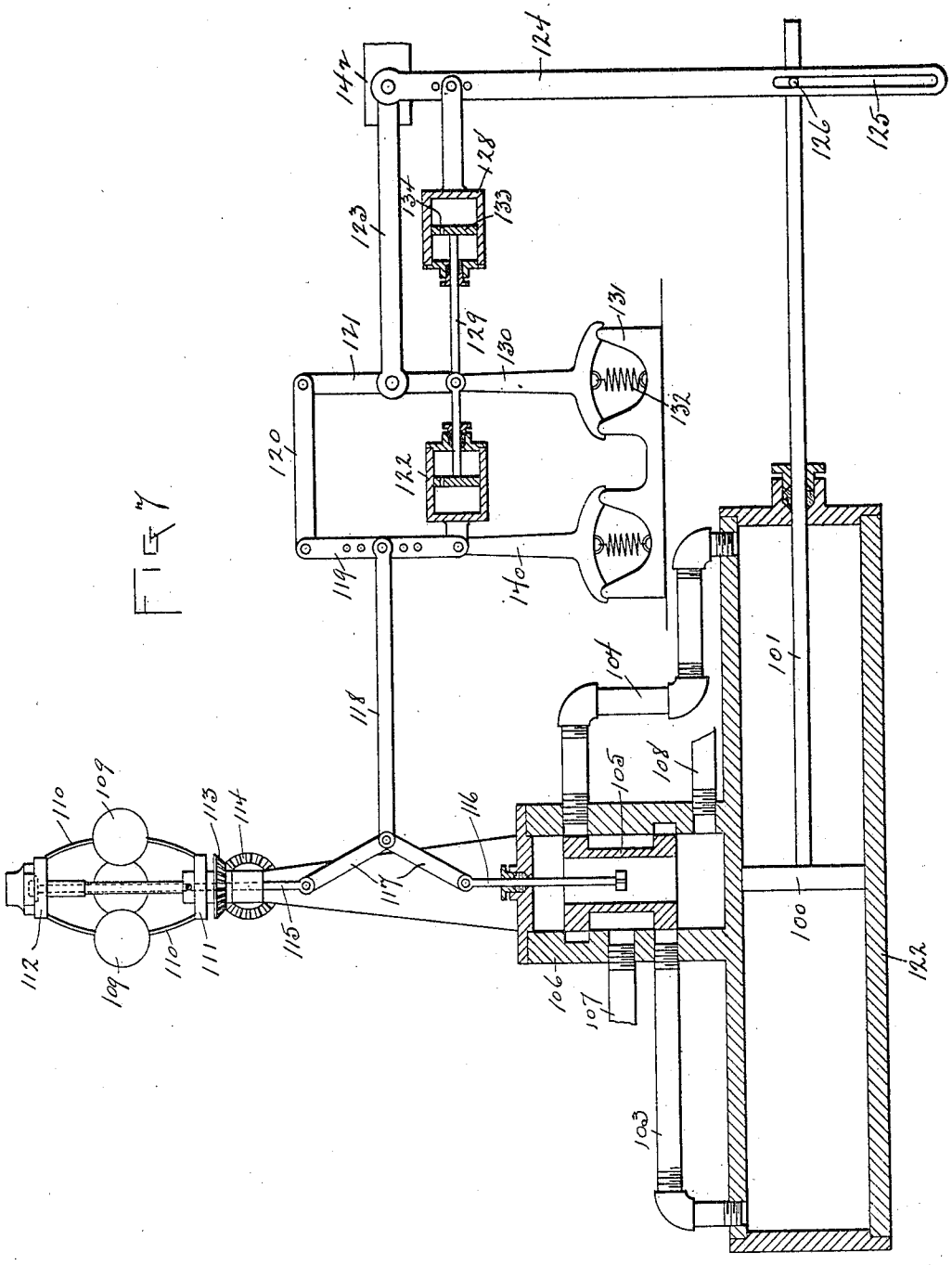


FIG. 4.

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5 SHEETS—SHEET 5.

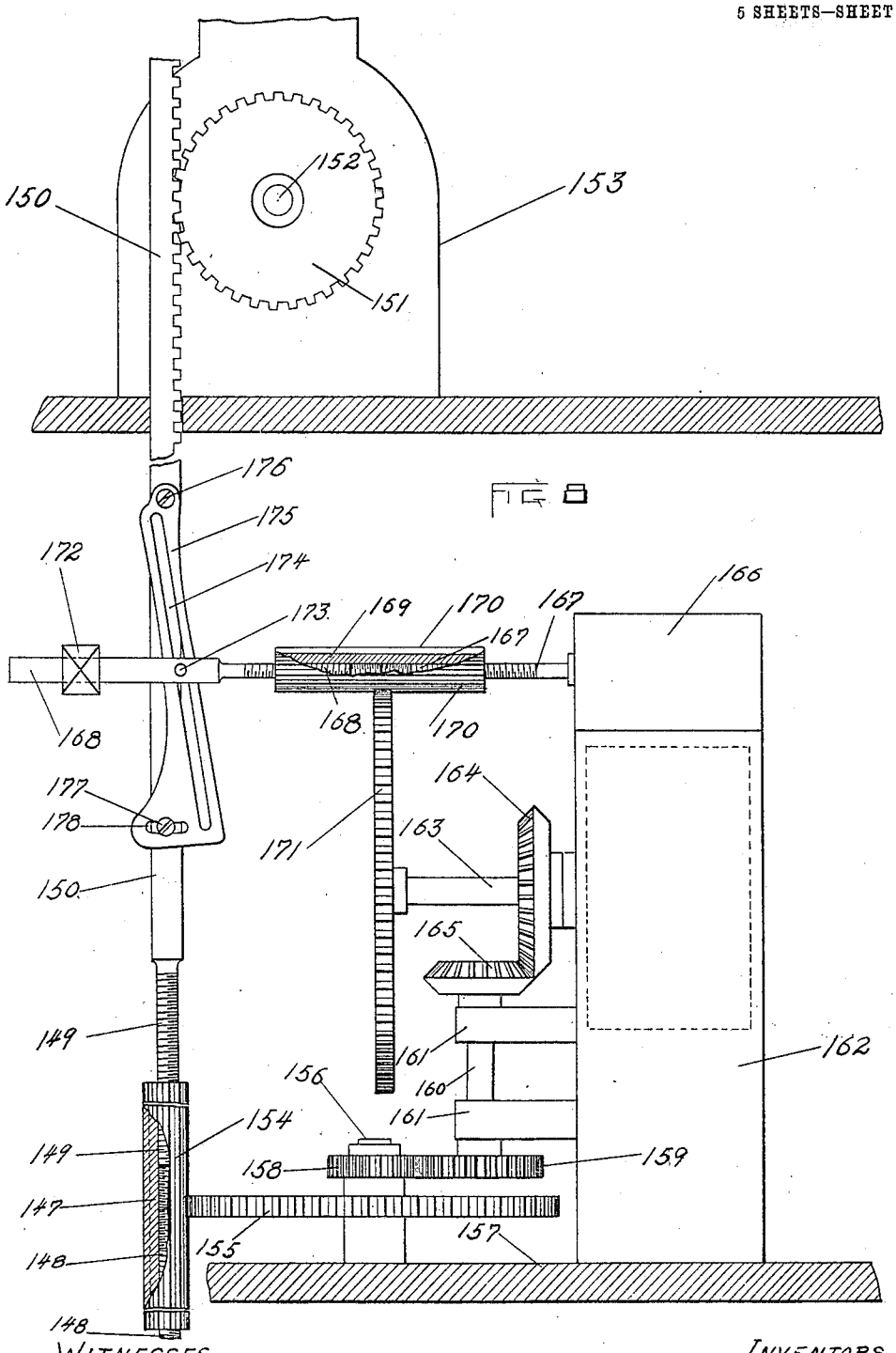


FIG 8

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UNITED STATES PATENT OFFICE.

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SPEED-REGULATOR.

No. 831,563. Specification of Letters Patent. Patented Sept. 25, 1906.

Application filed November 22, 1902. Renewed February 6, 1906. Serial No. 299,745.

To all whom it may concern:

Be it known that we, GEORGE A. MOSHER and FRANK C. CURTIS, citizens of the United States, residing at Troy, county of Rensselaer, and State of New York, have invented certain new and useful Improvements in Speed-Regulators, of which the following is a specification.

The invention relates to such improvements; and it consists of the novel construction and combination of parts hereinafter described and subsequently claimed.

Reference may be had to the accompanying drawings, and the reference characters marked thereon, which form a part of this specification.

Similar characters refer to similar parts in the several figures therein.

The invention is applicable to various kinds of fluid-operated motors or prime movers, and is more particularly adapted to hydraulic motors, such as water-wheels, the supply to which is regulated by a gate or the like.

For the purpose of correcting variations in speed of such motors due to variations in load and other causes various forms of mechanism have been employed to produce a variation in supply to the motor such as to eventually restore and maintain the normal speed. It is found, however, that such motors do not respond promptly to variations in their supply on account of the inertia of the fluid and the moving parts.

The object of our invention is to maintain in such a motor a more uniform rate of speed by more quickly correcting speed variations.

Figure 1 of the drawings is a central vertical longitudinal section of the gate-controller and connections with the motor-operated centrifugal governor. Fig. 2 is a vertical section taken on the broken line 2 2 in Fig. 1. Fig. 3 is a horizontal cross-section of the expansible and contractible link mechanism, taken on the broken line 3 3 in Fig. 1. Fig. 4 is a vertical cross-section of the controller and its valve mechanism, taken on the broken line 4 4 in Fig. 1. Fig. 5 is a cross-section taken on the broken line 5 5 in Fig. 1, showing the centrifugal governor in elevation. Fig. 6 is a view similar to that shown in Fig. 1, showing a modified form of construction. Fig. 7 is a view, partly in elevation and partly in central vertical section, illustrating the application of the invention to a different form of governor and gate-controller. Fig. 8 is a view, partly in side elevation and partly in section, of a modified form of our invention.

We have shown as one form of gate-operating mechanism a gate-controller comprising a rock-shaft 1, contained in a cylindrical inclosure 2, having its axial line coincident with the axial line of the cylindrical inclosure and provided with a radial leaf-piston 3, fixed thereon and extending from the shaft to the cylindrical wall of the inclosure. The inclosure is also provided with a fixed partition 4 radial to the shaft and extending from the shaft to the cylindrical wall of the inclosure, so that such partition, together with the leaf-piston and shaft, divides the inclosure into two chambers 5 and 6. The fixed partition is secured to the wall of the inclosure by means of the bolts 7. The shaft is provided with suitable bearings 10 in the end walls of the inclosure. One end of the shaft projects through the end wall beyond its bearings and is provided with a flange 12 for connecting the shaft with the gate of the water-wheel.

The water-wheel is not shown for the reason that the invention herein described and claimed is applicable to any known form of fluid-operated motor having means for controlling the fluid-supply to the motor.

Mounted upon the cylinder 2 is a cylindrical inclosure 12 for a hollow distributing-valve 20, the valve-inclosure being connected with chamber 5 through port 14, and with chamber 6 through a similar port 15, (indicated by dotted lines in Fig. 2,) and with an inlet-port 16, leading from a fluid-pressure supply (not shown) and extending around the valve 20, also with an exhaust-port 17.

When fluid under pressure is admitted through port 14 into chamber 5, the fluid-pressure upon the piston 3 causes the piston and rock-shaft to oscillate, the piston traveling in a direction toward the right hand as seen in Fig. 4, the fluid contained in chamber 6 being forced from such chamber through the other port 15 into the valve-inclosure and thence through the exhaust-port 17 outside of the inclosure, and when fluid under pressure is admitted through port 15 into chamber 6 the piston is caused to oscillate and travel in the opposite direction, the fluid in chamber 5 being forced back through port 14 into the valve-chamber and out through the hollow valve and the exhaust-port 17, thereby causing the piston to act as a rock-lever on the rock-shaft to impart to the shaft an oscillatory motion adapted to move the

gate of a water-wheel or the like in either of two opposite directions to open or close the same, and thereby increase or diminish the water-supply to the water-wheel.

The fluid under pressure can be supplied to the chambers 5 and 6 alternately by operating said valve in the usual manner.

The valve is automatically operated by a centrifugal governor 30, which may be of any known form and connected with the motor or turbine or machinery operated thereby, such connections being omitted from the drawings.

In the form of governor shown in Figs. 1 and 5 inside the rim of the governor and pivoted to the spokes 32 are levers 33, provided with weights 34 on one arm and links 35 on the other arm, connected, respectively, with one arm of the bell-crank lever 36, the other arm of the bell-crank lever being connected by link 37 with the sleeve 38, rotary with the governor. The outward throw of the weights 34 may be controlled by means of coiled springs 39. The sleeve 38, is provided with an annular channel adapted to receive a ring 40, upon which is pivoted one end of lever 42. The other end of lever 42 is pivotally connected at 45 with the valve-stem 46 or interposed mechanism, and the lever is fulcrumed upon bracket 44, projecting from the cylinder 2.

The centrifugal governor being connected so that the rotary movements of the motor will be transmitted thereto and the parts being so adjusted that when the governor is rotated at a predetermined normal speed, corresponding with the desired normal speed of the motor, a closed position of the valve 20 will be thereby induced, it will be apparent that any deviation of the governor from its normal speed will cause a movement of said valve which will admit fluid under pressure to one side or the other of the piston 3 to operate in the proper direction the gate-shaft and gate which controls the supply to the motor.

Any variation in the speed of the motor, due to a variation in load, will thus induce, through the governor, action of the gate-operating mechanism and gate to affect the supply, which would eventually cause the motor and governor to return to normal speed; but the abnormality of speed is not immediately corrected on account of inertia, as above stated.

It has heretofore been customary to provide mechanism for automatically arresting the movement of the gate after the same had reached a position such that the changed supply would eventually correct the variation in speed of the motor and to maintain the gate in such position as the motor gradually returned to normal speed.

An important object of this invention is to more quickly restore the motor to normal speed, and this is accomplished by causing a variation in the speed of the motor to induce a movement of the gate in excess of that required to restore the motor to normal speed and providing means for automatically inducing a reverse movement of the gate before the motor reaches such normal speed. We are thus able to subject the motor to a greater variation in supply than that required to restore and maintain its normal speed, so that the inertia is much more quickly overcome and the return to normal speed facilitated.

By inducing a reverse movement of the excessively-moved gate before the motor reaches normal speed and having the gate and motor returned to their normal conditions at the same time we are able to correct any variation in the speed of the motor in the shortest possible time and without causing an opposite variation in said speed. We have shown in Figs. 1, 2, and 3 mechanisms for accomplishing this result.

21 and 22 are a pair of disks having their adjacent sides beveled and adapted to receive between them a motor-driven belt 23, having its edges similarly beveled. Said disks are adapted to slide longitudinally of the sleeve 11, while being connected to rotate therewith by means of the feather 24. Rotary movements can thus be imparted through said beveled disks to the sleeve 11 and governor 30, said sleeve being rotatively mounted upon the spindle 25, forming an end projection of the controller-shaft 1. This shaft projection is provided with a screw-threaded portion 26, which receives and fits a nut 27, having differential connections with the respective beveled disks 21 and 22. Said nut is connected with the disks 21 and 22 by means of an expansible and contractible link 47 48 49, which link is movable as a rigid element in response to the movements of said nut when actuated by the rotation of the shaft of the gate-controller. This connection is such that the same degree of movement is imparted to the disk 22 as to the nut 27. The other beveled disk 21 is connected with the nut by the same expansible and contractible link through the link 50 and lever 51, said lever being pivotally connected at its lower end to a sleeve 68 on the hub of said disk and fulcrumed at its upper end at 52 upon the bracket 44. The connections are so arranged that a movement of the nut 27 in either direction will cause a greater movement of the disk 21. It will thus be seen that as the nut 27 is caused to move in either direction by the rotary or rocking movement of the controller-shaft a differential movement will be imparted to the disks 21 and 22, which will cause them to separate from or approach each other according to the direction of such movement and which will so vary the effective diameter of the belt-

pulley formed by said disks that the speed of the governor will be so changed as to restore the valve 20 to a closed position after the same had, by reason of abnormal speed of the governor, been opened, with a resultant movement of the gate-controller.

The expansible and contractible link comprises a fluid-filled cylinder 47, piston 48, and piston-rod 49, the piston-rod being connected with the nut 27 and the cylinder with the sleeves on the hubs of the beveled disks. This cylinder may be provided with a supporting-slideway 54.

The cylinder being filled with a comparatively non-compressible fluid, as water, the piston remains immovable therein so long as the contained fluid cannot pass from one side of the piston to the other, in which case the several parts act as a rigid connection between the nut 27 and the beveled disks. The mechanism shown, however, permits of the expansion and contraction of said link by fluid-pressure applied to one side or the other of said piston.

We have shown means for expanding and contracting said link consisting of a cut-off valve 55 reciprocatory in the chamber 56, which is connected, as by inlet 57 and coiled pipe 58, with a supply (not shown) of fluid under pressure. The chamber is also provided with an exhaust-port 59, connecting with the coiled exhaust-pipe 60.

The cylinder 47 is provided with fluid-passages 61 and 62, leading from the pressure-chamber 56 to the piston-chamber on opposite sides of the piston. The cut-off valve is connected by stem 63 with the upper end of lever 64, pivoted at 65 upon the cylinder and having a lower slotted end 66, adapted to receive a pin 67, projecting from a fixed support, whereby as the cylinder, piston, and rod are moved as a rigid element in either direction the movement thereby imparted to the lever 64 will cause the valve 55 to be operated to admit fluid under pressure to one side or the other of the piston 48 to expand or contract the link, such expansion or contraction being adapted in each case to return the cylinder and disk 22 to their normal positions and to restore the lever 64 to a vertical position and the valve 55 to a closed position. It will thus be seen that after operation of the gate-controller has been induced by an opening movement of the valve 20 in either direction, caused by a variation in the speed of the governor, and the movement of said controller has caused the nut 27 to move the disks 21 and 22 (the link 47 48 49 acting as a rigid member) until by the differential movement of said disks the effective diameter of the belt-pulley has been so changed as to vary the speed of the governor sufficiently to close the valve 20, and thereby arrest the movement of the controller, the resultant movement of expansion or contraction of said link will cause a reverse movement of the cylinder 47 and the rigid arms 8 and 9 erected from it and acting upon the disks through differential connections. One object to be accomplished by this reverse movement is to produce a variation in the effective diameter of the belt-pulley and a resultant similar variation in the speed of the governor in the same direction and, in addition to its last previous movement, to close valve 20, which will at once open said valve in the opposite direction, and thereby induce a return movement of the controller before the motor and motor-driven mechanism have reached normal speed.

Before considering further the reverse movement it will be necessary to understand more fully the construction and operation of the differential connections between the nut-27 and the beveled disks, consisting of an auxiliary lever 70, pivoted to the lever 51 at 71, pivotally connected intermediately of its ends with the upright 8 by the link 50. The oscillatory end of the auxiliary lever is pivotally connected by a link 72 with the bifurcate tilting post or arm 73, which bears upon the bifurcate support 74, secured, as by bolts 75, to the upper end of the upright 76, bolted to the arm 44. The post is held normally in the vertical position (shown in Fig. 1 of the drawings) by means of the spring 77. The arm 78 is erected from the sleeve on the hub of the disk 22 and pivotally connected with both levers 51 and 70 by means of the link comprising a closed fluid-filled cylinder 79, piston 80, and piston-rod 81. The pivot 71 serves to connect the cylinder 79 and the two levers together, so that a movement of lever 51 will be communicated to the disk 22, the piston-cylinder link forming a practically rigid connection between the lever and disk; but the piston 80 is provided with a small aperture 82 for the passage of the cylinder-inclosed fluid from one side of the piston to the other for the purpose of permitting at certain times a relative movement of the lever and disk.

The operation of the various parts of the apparatus is as follows: In case the motor and machinery attain a higher speed than the normal the weights of the governor force the sleeve 38 to the left, as seen in Fig. 1 of the drawings, which moves valve 20 to the right, admitting fluid under pressure to the gate-cylinder to oscillate the gate-shaft in a direction to cause the nut 27 to travel to the right, thereby forcing the expansible and contractible links in the same direction. The posts 8 and 9 being connected with the auxiliary lever 70 by practically rigid links, the auxiliary lever is moved to the right and maintained in an approximately vertical position, and the auxiliary lever being connected with the main lever 51 at 71 causes the disk 21 to travel faster than the nut 27 and the disk 22 with the same speed as the nut, thereby caus-

ing the two disks to approach each other and increase the effective size of the belt-pulley, which is driven by the belt 23, and thereby reduce the speed of the governor in advance of the reduction in speed of the motor-driven belt, closing the valve 20 before the motor-driven mechanism has been reduced to normal speed. The differential movements of the disks forming the members of the belt-pulley have given the gate-controller time to make an excessive movement in a direction to close the gate. It is therefore desirable to reverse the movement of the gate in a direction to open it again before the motor and motor-driven mechanism have been reduced to normal speed and to stop it again just as the speed of the motor reaches the normal and in a position approximating that required for normal speed. The expansible and contractible link 47 48 49 will always come back to the position shown in Fig. 1 after being forced in either direction by the nut 27, for the reason that the passages 61 and 62, Fig. 3, are both closed only when the lever 64 is in a vertical position. The lower end of that lever is held in a uniform position by the fixed pin 67 in slot 66. It is obvious, therefore, that after the governor has been brought to normal speed by the movements of the nut 27, the expansible and contractible link, and the disk the valve 20 will be closed and the nut 27 come to rest. The automatic movement of the expansible and contractible link then commences, resulting from its having been changed from its normal position. If the displacement from its normal position was to the right, its resultant movement would be to the left, which movement would be a comparatively slow one, due to the relatively small passages 61 and 62. While this resultant movement is taking place the spring 77, acting to restore the tilting post to its normal vertical position, has acted through the auxiliary lever 70 to contract the links 81 and 79 with a speed about equal to the movement of contraction of the link 47 48 49, so that the disk 22 has a greater actual movement to the left than the disk 21, causing the disks to approach and still further reduce the speed of the governor, thereby opening the valve 20 in the opposite direction, which reverses the movement of the gate-controller and the direction of travel of nut 27, so that the nut now travels to the left until it restores all the movable parts to normal position, the lever 64, the lever 51, and post 73 all occupying a vertical position and the two disks 21 and 22 being at the proper distance apart to impart normal speed to the governor just as the motor-driven belt has reached normal speed.

When the speed of the motor is normal, all the movable parts last above mentioned except the piston 48 and its rod 49 occupy their normal positions, which are those shown in Fig. 1 of the drawings; but the position of the gate-controller, nut 27, and piston 48 will vary according to the load. Should the gate be opened to an excessive degree to accommodate an excessive load, the piston 48 would simply occupy a position nearer one end of the cylinder 47, and if the gate was nearly closed for a light load the piston 48 would be nearer the other end of the cylinder. The parts are so adjusted that for normal loads the piston 48 will occupy a position equidistant from the ends of the cylinder.

Should the speed of the motor and machinery fall below the normal, it is obvious that the weights of the governor would force the sleeve 38 to the right, as seen in Fig. 1 of the drawings, which would cause the other movable parts to move and act in the opposite direction from that in which they would move and act when the speed is higher than the normal, as assumed in the foregoing statement of the operation of the various parts of the apparatus.

In Fig. 6 of the drawings is shown a modified form of construction wherein an expansible and contractible link 90 91 92, precisely like the expansible and contractible link 47 48 49, is substituted for the tilting post, cylinder, and piston shown in Fig. 1, the piston-rod 91, which corresponds with the rod 49, being connected with the post 92, which is an elongation of the post 8 in Fig. 1, and the cylinder 93, which corresponds with cylinder 47, being connected by the arm 94 with the disk 22 through the pivotal connection at 95 with the sleeve 53. The post 92 is pivotally connected by link 96 with the lever 97 intermediately of its ends, the upper end of the lever being pivotally connected at 98 with the bracket 44, and the lower end of the lever being pivotally connected at 99 with the sleeve 68 on the hub of disk 21. In the operation of this modified form of construction a movement of the nut 27 in either direction will cause the differential movement of the disks. For example, if moved to the right the two expansible and contractible links moving as rigid links force disk 22 to the right through the arm 94 with the same speed as the nut and disk 21 in the same direction with a greater speed due to the differential connection of post 92 with the disk 21 through the lever 97 and link 96, thereby reducing the speed of the governor sufficiently to close the valve 20 and bring the nut 27 to a state of rest. The resultant or return movement of the cylinder 47 carries with it at the same speed the piston 91, the arm 94, and the disk 22, but the disk 21 travels in the same direction—that is, to the left—at a greater speed due to the differential connection of link 96 and lever 97. However, the cylinder 73 has the same kind of resultant or return movement on its piston 91 at the same rate of speed as the movement of cylinder 47, so that the disk 22 has a double rate of move-

ment due to the movement of cylinder 47 and the additional movement of cylinder 93, which causes it to have a real movement to the left greater than the movement of disk 21, thereby increasing still further the effective size of the belt-pulley formed by disks 21 and 22, which results in causing the governor to open valve 20 again in the opposite direction, thereby opening the gate and imparting to nut 27 a movement to the left. This movement to the left of the nut 27 carries to the left both expansible and contractible links, and the parts are so adjusted that they all come to their normal positions just as the speed of the motor reaches normal, closing valve 20 and arresting the movement of nut 27.

In Fig. 7 the invention is shown applied to a reciprocatory gate-controller comprising a piston 100, fixed upon the piston-rod 101 and contained within the cylinder 102, to opposite sides of which piston fluid under pressure can be supplied through the pipes 103 and 104 by means of the hollow valve 105, located in the case or cylinder 106, having the inlet 107 leading from a fluid-pressure supply (not shown) and the exhaust 108. The governor-weights 109 are fixed upon the bowed springs 110, connected at their opposite ends to the sleeves 111 and 112, the sleeve 111 being secured against vertical movement and connected to rotate with the beveled gear 113, adapted to mesh with a similar beveled gear 114, to which rotary movements may be imparted by means of connections with the motor. (Not shown.) The sleeve 112 is free to reciprocate vertically in response to the movements induced by the centrifugal force of the weights and is connected with the sliding rod 115. This rod is connected with the valve-stem 116 by a toggle-joint 117, the hinge of which joint is connected by a link 118 with a lever 119, the upper end of which is pivotally connected by the rigid link 120 with the upper end of lever 121, the lower ends of the two levers being pivotally connected by the expansible and contractible link 122. The lever 121 is fulcrumed intermediately of its ends upon one end of the link 123, the other end of such link being pivoted upon a fixed support 142. Fulcrumed upon such fixed support is the lever 124, pivotally connected at its lower end with the piston-rod of the gate-controller, whereby said lever is operated by the reciprocating movements of the controller, the lever being provided with a slot 125 to receive the pin 126 on the piston-rod. The expansible and contractible link 127 connects pivotally the levers 124 and 121, as shown. The link 127 comprises a fluid-filled closed cylinder 128, piston 129, and rod 130, the same being movable as a rigid element in response to the movements of the lever 124, to which the cylinder is pivotally connected. The rod portion of the link 127 is connected pivotally with the lever 121, the link 122, and the upper end of the tilting post 130, which bears upon a fixed support 131, with which it is connected by the controlling-spring 132, which tends to maintain such post in a vertical position thereupon. The piston 133 is provided with a small aperture 134, adapted to permit the fluid contained in the cylinder to pass therethrough from one side of the piston to the other. The link 122 is like the link 127, and the tilting post 140, pivotally connected with the lever 119, is, with its support and spring, like the post 130 and its support and spring.

It will be seen that a variation in the speed of the governor will cause an opening movement of the valve 105 in one direction or the other, the toggle-joint 117 acting as a rigid element, and that the consequent movement of the gate-controller will cause the lever 124 to be operated, and thereby impart to the levers 119 and 121 a uniform movement, the expansible and contractible links acting as rigid elements, which opens or closes the toggle-joint to raise or lower the valve-stem until the valve has reached a closed position and the movement of the gate-controller has been arrested. As soon as the gate-controlling piston 101 comes to rest the tilting posts, which have both been tilted, automatically act under the influence of their controlling-springs to actuate the differential levers 119 and 121. The automatic movement of lever 121 is in the opposite direction to its last movement under the direct action of the gate-controller, but the automatic movement of lever 119 is in the same direction and at a greater speed than the movement of lever 121, so that the resultant movement of the toggle-joint is in the same direction it had been when it last closed the valve, and it therefore opens the valve in the opposite direction, energizing the gate-controller, which acts to restore the differential connections to their normal positions.

As in the constructions previously described, the several parts are so connected, arranged, and adjusted that the final closing movement of the valve will occur and the reverse movement of the gate-controller will be arrested just as the motor reaches normal speed and the gate reaches approximately the required position to maintain the motor at normal speed until the load again changes.

It should be observed that their controlling-springs will bring both of the tilting posts to their normal vertical position, which necessarily brings the two levers 119 and 121 and the toggle-joint to their normal position independently of the range of movement of the gate-controller.

The form and capacity of the fluid-passages and the construction and operation of the valves controlling such passages in the

expansible and contractible links can be varied, as desired, to regulate the flow of fluid therein, and thereby control and vary the speed of the automatically-moved parts.

The motor-driven belt 23 represents the motor, which may be of any known form of type of fluid-operated motors and is not for that reason more fully shown in the drawings.

In Fig. 8 we have shown a modified form of our invention, wherein compensatory movement of the gate is accomplished by a movement of expansion or contraction of the gate-stem independently of the main gate-operating motor, except that the amplitude of the return movement of the gate is determined by the amplitude of original movement thereof directly caused by said main gate-operating motor. In said Fig. 8 we have shown the upper end 150 of the gate-stem terminating in a gear-rack adapted to be engaged by the gear 151 of the shaft 152 of the main gate-operating motor 153, which may be of any known form adapted to respond with an excessive or overthrow movement of the gate to meet indicated variations from normal speed of the machinery operated by the gate-controlled water-wheel. As a means for compensating for such excessive or overthrow movement of the gate and returning the same to proper position to maintain the speed of the machinery substantially normal under the changed conditions we have shown an expansible and contractible construction of gate-stem comprising the upper portion 150 thereof, having its lower end screw-threaded at 149, and a lower portion having its upper end screw-threaded, as at 148, one of said parts having a right-hand thread and the other a left-hand thread. These screw-threaded parts of the gate-stem are connected together by means of a turnbuckle 147, having gear-teeth 154 extending longitudinally thereof adapted to mesh with a gear 155, by rotation of which gear 155 said turnbuckle can be rotated to produce an upward or downward movement of the lower portion 152 of the gate-stem, whereby the length of the gate-stem is diminished or increased, as the case may be. The gear 155 is rotatively mounted upon a stud 156, erected from the lower floor 157, and said gear has fixed thereto a pinion 158, meshing with a gear 159, fixed upon a vertical shaft 160, rotatively mounted in bearings in the brackets 161, which project from the case of a motor 162, which may be precisely the same in construction and operation as the main gate-operating motor contained within the case 2 and above described and shown in Figs. 1, 4, and 6 of the drawings herein. The shaft 163 of said motor 162 has fixed thereon a bevel-gear 164, adapted to mesh with a beveled gear or pinion 165 on the upper end of said vertical shaft 160. The motor 162 is controlled by means of a valve contained within the case 166, which valve is constructed and operates in substantially the same manner as the valve 20 contained within the case 13. (Shown in said Figs. 1, 4, and 6, above described.) The valve-stem of this valve 166 is composed of two parts 167 and 168, having their neighboring ends oppositely screw-threaded and connected by a turnbuckle 169, having extending longitudinally thereof gear-teeth 170, adapted to mesh with a gear 171, fixed upon the motor-shaft 163. When the turnbuckle is rotated by rotative movement of the gear 171, the valve-stem will be either lengthened or shortened in accordance with the direction of such movement. The outer part 168 of the valve-stem is adapted to reciprocate in a fixed slideway or bearing 172 and is provided with a pin or follower 173, which enters an inclined slot 174 in a plate 175, fixed upon the upper part 150 of the gate-stem. The upper end of the plate 175 is connected to the gate-stem by means of the screw 176, which forms a pivotal connection upon which said plate can be rotated to vary the inclination of the slot 174, said plate being secured in adjusted position by means of the screw 177, which passes through a curved slot 178 in the lower end of said plate 175, permitting the described adjustment thereof.

The parts are so arranged and proportioned that when the valve within the case 166 is displaced the motor 162 is set in operation and causes through its shaft 163, the gear 171, and turnbuckle 169 the valve-stem to expand or contract, as the case may be, to cause a return movement of the valve to a position to render the motor inactive. The valve in the case 166 is displaced by movement of its stem as a whole, due to the pin and inclined slot construction 173 and 174.

Whenever the gate-stem is moved as a whole, a downward movement of the gate-stem causes displacement of said valve to the left, with a resultant movement in one direction of the motor-shaft 163, while an upward movement of the gate-stem as a whole causes displacement of said valve to the right, with a resultant movement in the opposite direction of the motor-shaft 163. The degree of displacement of said valve can be varied by adjustment of the plate 175 to change the inclination of the slot 174, as above described, and said slot may be given other than a straight or regular form if it be desired to affect said valve differently in different positions of the gate.

The operation of the device is as follows: A certain movement of the gate having been indicated by the centrifugal governor and responded to by the main gate-operating motor 153 by an excessive or overthrow movement of the gate-stem as a whole such move-

ment is accompanied by a movement of displacement of the valve 166, which sets in operation the motor 162. After a partial rotation of the motor-shaft 163 the motor is rendered inactive by the closing of the valve 166 by expansion or contraction of the valve-stem through the turnbuckle connection operated by the gear 171. During the operation of the motor 162 it serves to operate, through the bevel-gear 164 and 165, shaft 160, and gears 159, 158, and 155 the turnbuckle 147 to expand or contract the gate-stem to cause an upward or downward movement of the gate, the direction of which movement is opposite to that caused by the main gate-operating motor 153 and the amplitude of which movement is substantially equal to the amplitude of the overthrow or excessive movement imparted to the gate in the first instance.

What we claim as new, and desire to secure by Letters Patent, is—

1. In a speed-regulator, the combination with a gate or the like controlling the supply to a fluid-operated motor; of means whereby a variation in speed of said motor is caused to induce a movement of said gate in excess of that required to restore the motor to normal speed; and means for automatically inducing a reverse movement of said gate before said motor reaches normal speed.

2. In a speed-regulator, the combination with a gate or the like controlling the supply to a fluid-operated motor; of means whereby a variation in speed of said motor is caused to induce a movement of said gate in excess of that required to restore the motor to normal speed; and means for afterward returning the gate to its required position simultaneously with the return of said motor to normal speed.

3. In a speed-regulator, the combination with a controller for a gate or the like adapted to regulate the supply to a fluid-operated motor; of a governor actuated by said motor; means for causing a motor-induced variation of said governor to induce a movement of said controller in excess of that required to restore the governor to normal; and means for automatically inducing a reverse movement of said controller before said motor reaches normal speed.

4. In a speed-regulator, the combination with a controller for a gate or the like adapted to regulate the supply to a fluid-operated motor; of differential mechanism adapted to induce action and inaction of said controller; a connection between a member of said differential mechanism and controller, whereby a movement of the controller in either direction is caused to induce inaction of the same; and mechanism connected with another member of said differential mechanism adapted to subsequently induce action of the controller in the opposite direction.

5. In a speed-regulator, the combination with a gate or the like adapted to regulate the supply to a fluid-operated motor; of differential mechanism adapted by differential movement of its members to induce action and inaction of said controller; said mechanism comprising in part an expansible and contractible link; mechanism for expanding and contracting said link; and means whereby a movement of the controller in either direction operates said differential mechanism to induce inaction of the controller and energizes the link expanding and contracting mechanism to expand or contract said link and thereby cause said differential mechanism to induce a reverse movement of the controller.

6. In a speed-regulator, the combination with a controller for a gate or the like adapted to regulate the supply to a fluid-operated motor; of differential mechanism connected with, and adapted by differential movement of its members to induce action and inaction of, said controller, one member of said mechanism comprising a fluid-filled cylinder, piston and rod connected with, and movable as a rigid element in response to the movements of, the controller; a connection between another member of said mechanism and said controller; a valve for distributing fluid under pressure to opposite sides of said piston to expand and contract said link; and connections whereby the movement of the link as a rigid element is caused to induce operation of said valve.

7. In a speed-regulator, the combination with a gate-controller comprising a cylinder and piston; a valve for distributing fluid under pressure to opposite sides of said piston; and a valve-operating governor; of differential mechanism adapted to operate said valve; a connection between a member of said mechanism and said controller whereby when the valve is opened in either direction the resultant movement of the controller is caused to close the valve; and mechanism connected with another member of said differential mechanism adapted to subsequently open the valve in the opposite direction.

8. In a speed-regulator, the combination with a controller for a gate or the like adapted to regulate the supply to a fluid-operated motor; of a governor for inducing action and inaction of said controller; a variable-gear connection between said governor and motor having two adjustable members; differential connections between said controller and said adjustable members whereby movement of the controller in either direction is caused to induce inaction of the controller by varying the speed of the governor; and

mechanism connected with one of said adjustable members for inducing action of the controller in the opposite direction by varying the speed of the governor.

9. In a speed-regulator, the combination with a controller for a gate or the like adapted to regulate the supply to a fluid-operated motor; of a governor for inducing action and inaction of said controller; a variable-gear connection between said governor and motor having two adjustable members; an expansible and contractible link connection between one of said adjustable members and said controller movable as a rigid element in response to the movements of said controller; means for expanding and contracting said link at certain times; and a differential connection between said controller and the other said adjustable member.

10. In a speed-regulator, the combination with a controller for a gate or the like adapted to regulate the supply to a fluid-operated motor; of a governor for inducing action and inaction of said controller; a variable-gear connection between said governor and motor; differential connections between said controller and an adjustable member of said variable gear, comprising in part an expansible and contractible link consisting of a fluid-filled cylinder, piston and rod, movable as a rigid element in response to the movements of said controller; a valve for distributing fluid under pressure to opposite sides of said piston; and connections whereby action of said valve is induced by the movement of the link as a rigid element.

11. In a speed-regulator, the combination with a controller for a gate or the like adapted to regulate the supply to a fluid-operated motor; of a governor for inducing action and inaction of said controller; a variable-gear connection between said governor and motor having two adjustable members; differential connections between said controller and said adjustable members whereby movement of the controller in either direction is caused to induce inaction of the controller by varying the speed of the governor; mechanism connected with one of said adjustable members for inducing action of the controller in the opposite direction by varying the speed of the governor; and means for subsequently and automatically restoring the adjustable members of the variable gear to their normal position, for normal speed, independently of the position of the gate-controller.

12. In a speed-regulator, the combination with a fluid-operated motor; and a gate-controller; of a governor; a variable-gear connection between said governor and motor having two adjustable members; differential connections between said controller and said adjustable members for changing the position, relatively to each other, of such members; means for automatically continuing such change at the end of a movement of the controller in one direction whereby a movement of the controller is induced in the opposite direction and the adjustable members restored to their normal positions at the end of the reverse movement of the controller.

13. In a speed-regulator, the combination with a fluid-operated motor; a governor and variable-gear connections between the motor and governor; of a gate-controller; means connected with the governor for moving the controller in one direction when the speed of the governor is above normal and in the opposite direction when the governor-speed is below normal; differential connections between the controller and members of the variable gear whereby the speed of the governor is changed to normal and the controller brought to rest before the motor reaches normal speed; means for automatically continuing the variation in governor-speed in the same direction until a reverse movement is imparted to the gate-controller before the motor reaches normal speed, and gradually restoring the movable parts and connections to normal speed and position, and at the same time bringing the gate-controller to a state of rest.

14. In a speed-regulator, the combination with a motor-actuated governor; of a gate-controller; means, actuated by the governor, for operating the controller in either direction; connections between the controller and governor for changing the speed of the governor to normal in advance of the motor; independently-actuated mechanism acting automatically upon the governor to continue such change of speed in the same direction until the controller is operated in a direction to reverse such change in governor-speed, whereby the controller is brought to rest and the various movable connections caused to assume their normal places and speed simultaneously with the return to normal speed of the motor.

15. In a speed-regulator, the combination with a fluid-operated motor; governor; and governor-influenced gate-controller; of differential and automatically-operative connections between such motor, controller and governor, whereby a departure of the motor from normal speed will induce a to-and-fro movement of the controller before the motor returns to normal speed.

16. That improvement in the art of regulating the speed of fluid-operated motors which consists in automatically producing a variation in the supply of operating fluid in excess of that required to restore the speed of the motor to normal, automatically reducing such variation before the motor reaches normal speed, and continuing such reduction until the speed of the motor becomes normal.

17. That improvement in the art of regulating the speed of fluid-operated motors which consists in automatically causing a variation in the supply of fluid to the motor in excess of that required to restore its speed to normal, and gradually eliminating such excess as the motor returns to normal speed.

In testimony whereof we have hereunto set our hands this 20th day of November, 1902.

GEO. A. MOSHER.
FRANK C. CURTIS.

Witnesses:
E. M. O'REILLY,
H. E. CURTIS.