

936,261.

Decrease in speed of motor.

Decrease of pressure due to opening gate.

To open gate.

To open gate.

INVENTOR.
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GOVERNOR FOR MOTORS.

936,261

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, HENRY E. WARREN, a citizen of the United States of America, residing at Ashland, in the county of Middlesex and Commonwealth of Massachusetts, have invented certain Improvements in Governors for Motors, of which the following is a specification.

The invention relates to governors for fluid pressure motors, and is especially applicable to turbine wheels operated by water which is conveyed to them through very long penstocks or feed pipes, as is frequently the case in modern water power plants; where the feed pipes may be several hundred or even thousand feet long. In connection with these long pipes the action of the usual governor in opening the water-gate in response to a sudden increase in load on the wheel, is temporarily nullified so far as bringing the speed back to normal, is concerned, for when the water outlet is enlarged by suddenly opening the gate, the pressure in the feed-pipe is reduced to a greater or less extent, first immediately at the gate; and if it is opened very quickly the pressure will be reduced substantially to zero, for a short interval, due to the inertia of the water in the pipe. This reduction of pressure will still further reduce the speed of the water-wheel and cause the usual governor to open the gate still farther to compensate for such reduction. As soon as the velocity of the water in the feed-pipe has increased sufficiently to bring the pressure upon the wheel back to normal, its output will be greatly in excess of that needed to meet the increased load which caused the reduction of speed, and consequently the speed will increase unduly and cause the governor to close the gate suddenly and in excess of the amount needed, thus increasing the pressure in the feed-pipe abnormally, frequently producing water-hammer to a dangerous degree, and always carrying the speed of the wheel much higher than would be the case, with a corresponding motion of the gate, if the water pressure remained constant.

The purpose of this invention is to overcome these objectionable features by placing the valve, which is normally operated by the governor to regulate the speed of the water-wheel, at all times under the independent influence of a device which is re-

sponsive to variations of the water pressure in the feed-pipe, so that the effect of the action of the governor upon said valve due to variations of speed will be modified through said pressure device by the temporary disturbances in the pressure of the water at the wheel, caused by the movements of the gate induced by the action of the speed-governor, and such modifications will be produced independently of the speed governor and of its valve-controlling movements.

In the drawings which illustrate a simple and desirable form of the mechanism applied to a governor for a water motor by which the action of the governor, due to changes in speed of the motor, is modified by the change of pressure of head of water in the feed-pipe induced by such action of the governor,—G is what is termed in French, a *servo-moteur* which in this instance is the gate operating mechanism controlled by the valve D, the movement of which is primarily regulated by its connection with the fly-ball governor F which is operatively connected with the shaft of the motor M by a belt *d*.

P is the penstock or feed-pipe for the motor.

Conveniently attached to the frame of the servo-motor G is a cylinder C, within which is a piston *e*, the rod *f* of which is pivoted to one end of a floating lever *b*; the opposite end of the lever *b* is pivoted to the rod *i* which extends down from the fly-balls F to the lever *b*, between the two ends of which the rod *k* of the valve D is pivoted. Within the cylinder C, a spring *s* is placed between the piston *e* and the head of the cylinder, and is so arranged as to tend constantly to press the piston toward the opposite end of the cylinder, and this end of the cylinder is connected by a pipe *a* with the feed-pipe P near to the water-wheel gate, not shown, but which is operated by a pulley *l*, through a belt *n* connecting with another pulley *l'*, driven by a pinion *o*, which engages a rack *q* attached to the rod *r* of a piston within the servo-motor G.

Under normal conditions the pressure of the water in the penstock P, through pipe *a*, raises the piston *e* so as to partially compress the spring *s*; then when a sudden increase in load on the turbine wheel M occurs, the de-

crease in speed is communicated to the fly-balls F, which acting through the rod *i* and lever *b*, which turns on its connection with the rod *f* as a fulcrum, moves the rod *k* and valve D upward so as to operate the servo-motor G in a direction indicated by arrow at rod *r*, to open the motor gate. This ultimately would increase the power of the motor, but in practice it is found that this increased opening of the water-gate will cause a sudden fall in the pressure of the water in the feed-pipe P and consequently, momentarily a decrease in speed and power of the motor, which through a decrease in speed of the fly-balls F would result in the secondary effect of further opening of the water-gate, that is, such would be the result except for the action of this improved attachment to the governing mechanism, the operation of which is as follows:—

Through the pipe *a* the reduced water pressure in the feed-pipe P is communicated to the cylinder C, and the spring *s* moves the piston *e* with its rod *f* downward, as indicated by an arrow, which action through the lever *b* turning on its connection with rod *i* as a fulcrum, depresses the rod *k* and moves the valve D so as to operate the servo-motor G in a direction to tend to close the water-gate, thus independently modifying the effect of the fly-balls F in their action to further open the gate. By this means the gate is held substantially stationary until the pressure in the feed-pipe becomes readjusted and returns to normal. Thus the governor becomes "dead-beat" instead of permitting racing in the motor.

When there is a sudden decrease in load on the wheel M, its increase in speed is communicated through the fly-balls F and valve D to the servo-motor G, which will tend to close the water gate and thereby increase the pressure of water in the pipe P. This increase will raise the piston *e* with its rod *f*

in the cylinder C, and through the lever *b* and rod *k* will independently of the fly-ball governor and without changing the position thereof, tend to modify or partially neutralize the effect of the fly-balls on the valve D, due to the increase of speed, and this modifying tendency will continue until the water pressure in the pipe P returns to normal.

I claim:

1. In governing mechanism for hydraulic motors, the combination of a valve which regulates the supply of motive liquid to the motor to be governed, a speed-responsive device driven by the motor, a pressure-responsive device subject to the pressure of the motive liquid near to the motor, and means to control the movement of said valve, which means are at all times subject to actuation by either of said devices independently of the other, and through which a movement of the valve produced by the speed-responsive device which causes a change of pressure in the motive liquid will be modified by a counter-acting movement caused by the action of the pressure device due to such pressure change, independently of the speed-responsive device and of its movement to control the valve.

2. In combination with the valve operating mechanism of a speed governor for a hydraulic motor, a valve to control the liquid supply to the motor, normally operated by the governor, a pressure device responsive to variations of liquid pressure in the motor supply pipe, and means connecting said device with the valve, which means at all times are adapted, in response to such variations, to actuate the valve independently of the governor and of its valve-controlling movements, to modify the effect of such movements.

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Witnesses:

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