A. HUGUENIN.

DEVICE FOR GOVERNING THE SPEED OF WATER TURBINES.

APPLICATION FILED JUNE 13, 1912.

1,041,289. Patented Oct. 15, 1912.

Fig. 1

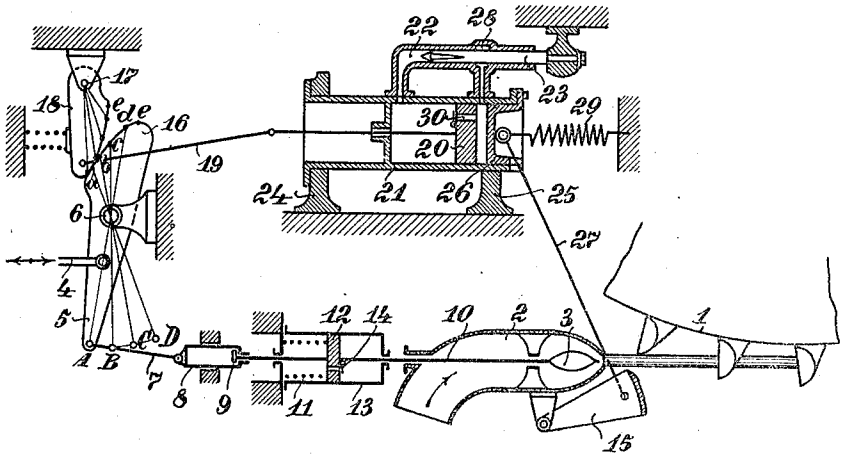


Fig. 2

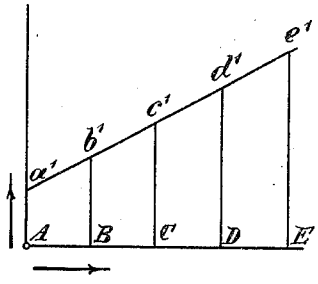


Fig. 3

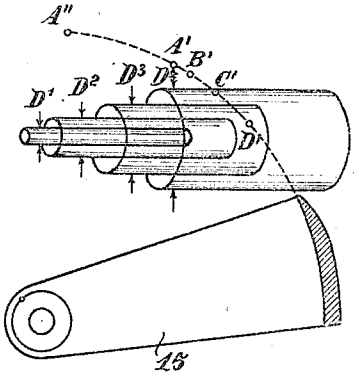
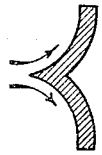


Fig. 4



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UNITED STATES PATENT OFFICE.

ALBERT HUGUENIN, OF ZÜRICH, SWITZERLAND.

DEVICE FOR GOVERNING THE SPEED OF WATER-TURBINES.

1,041,289. Specification of Letters Patent. Patented Oct. 15, 1912.

Application filed June 13, 1912. Serial No. 703,525.

To all whom it may concern:

Be it known that I, ALBERT HUGUENIN, a citizen of the Swiss Republic, residing at Zürich, in the Swiss Republic, have invented new and useful Improvements in Devices for Governing the Speed of Water-Turbines, of which the following is a specification.

The invention relates to improvements in devices for deflecting the nozzle of free jet water turbines when said turbines are suddenly unloaded. Such turbines are usually governed by causing the water jet to be quickly moved away from the turbine wheel, when said wheel is suddenly unloaded, by then gradually reducing the cross section of the nozzle and moving the jet thus reduced back to act on the wheel. The object of such devices is to prevent the turbine from racing and the water pipe from being closed too quickly, so that undesirable high pressures are avoided. In order to enable the water jet to act on the turbine wheel in a fully effective way for overcoming the full load, its middle axis must be at a certain distance from the axis of the wheel. If this distance is maintained not only for the full load but also for a lower load, that is to say, for water jets having a larger and smaller section, there is danger that on suddenly reducing an average load the water jet, in spite of the deviating device being put into action at once, will still act too long on the turbine wheel and produce an undesirably high speed of the same. If the turbine is coupled with a dynamo, for example, an electric current of excessively high tension will be produced. This drawback is to be avoided according to the present invention. For this purpose the jet deviating device is so operated as to be moved more quickly into the jet according as the load which is suddenly reduced or entirely removed is smaller. If the previous permanent load was also the normal one the deviating device is moved with a certain speed toward and beyond the middle of the jet. This speed of movement is quicker when, for example, the permanent load was equal to half of the normal load, and is still quicker when the turbine was working at about a quarter of the normal load, previous to being suddenly unloaded. How the deviating device is moved, and what mechanism is preferably used for obtaining this movement is explained below with reference to the examples shown in the accompanying drawing.

In Figure 1 a part of the wheel 1 of a Pelton-turbine is shown, 2 being the nozzle by which the water jet is directed against the turbine wheel 1. The pin 3 closes the section of said nozzle 2 more or less and regulates the water energy at disposal according to the power required by the turbine. For moving the pin 3 for normal loading and unloading conditions the following mechanism can be adopted: By any auxiliary engine which is under the influence of a governor the rod 4 is moved horizontally backward and forward so that the lever 5 is turned about the fixed axis 6. The lever 5 moves through the agency of the connecting rod 7 a frame 8, which, by means of the collar 9, pulls the rod 10 and therefore also the needle 3 toward the left. If the bottom end of the lever 5 is turned toward the right, and accordingly moves the frame 8 also toward the right through the agency of the connecting rod 7, said frame will release the collar 9, so that it will also be free to move in the same direction, and this movement is effected by the spring 11 acting on the piston 12 and thus also on the rod 10, to which the needle 3 is attached. The piston 12 moves in a fixed cylinder 13 filled with a retarding liquid, for example oil. Said piston has a comparatively large opening, which is so closed by a valve 14 that the movement of the piston 12 from the right toward the left requires comparatively little power even when it takes place quickly, because the oil on the left side of the piston 12 can pass with slight resistance past the valve 14 to the right side of the piston. When however the piston 12 is moved from the left toward the right the valve 14 will close the opening partly or entirely, so that the oil on the right side of the piston 12 can only pass through smaller openings which may be provided in the piston or between the small space left between the circumference of the piston 12 and the cylinder 13. Under the influence of the spring 11, the piston 12 and accordingly also the pin 3 can only be slowly moved toward the right, while a movement toward the left, as above mentioned, can take place without any essential resistance. This device affords security

against a too quick closing of the nozzle 2 by the pin 3, and therefore avoids a sudden and dangerous increase of the pressure due to throttling of the water.

The device above described can be used alone when the loading and particularly the unloading of the turbine takes place but comparatively slowly. If, on the other hand, the unloading takes place suddenly a device must be used to deflect the water jet away from the turbine wheel as quickly as possible and to allow it to gradually return to the wheel, the section of the nozzle 2 being in the meantime slowly reduced by the needle 3 moving slowly toward the right. In Fig. 1 a deviating device 15 is shown by way of example which when the turbine is suddenly unloaded cuts off a part or all of the water jet. In its position of rest the device 15 always occupies the same position, in which it nearly touches the jet of largest diameter. If this maximum load is suddenly reduced a small movement of the device 15 suffices to cut off a part of the water jet and thus to restrict the supply of water to the wheel 1. If however the unloading of the turbine takes place when it is working against a smaller load, for example, about one fourth of the maximum load, so that the water jet only has half its maximum diameter, the front edge of the deviating device 15 must pass through a certain distance before it touches the jet and begins to cut off the supply of water to the wheel. Before this takes place the jet has the opportunity to accelerate the speed of the unloaded wheel 1 to an extent which may be dangerous for the turbine itself or for the machines or other apparatus driven thereby. This difficulty however is overcome by the present invention. In all cases in which a turbine is working at less than the full load when unloaded, so that the water jet has a smaller diameter than its normal one, the deviating device 15 is caused to be moved with a much higher speed than when the water jet has its full normal diameter. Consequently the distance between the front edge of the device 15 and the water jet is moved through in less time. The smaller water jet is therefore deflected so quickly that it has no opportunity to accelerate the speed of the turbine wheel beyond an allowable point. The device preferably used for this purpose is described below with reference to Fig. 1, it being understood that other constructions may be employed within the scope of my invention. To the lever 5, which turns about the pivot 6, is secured a second arm 16 which extends upward. This arm has a cam-shape and rolls against the lever 18 adapted to turn about the fixed axis 17. If the lever 16 is moved about the axis 6 in the opposite direction to the hands of a clock, the lever 18 will be turned in the same direction as the hands of a clock. Said lever 18 moves, through the agency of the connecting rod 19, the piston 20 toward the left in the cylinder 21. This cylinder 21 is filled on both sides of the piston 20 with a retarding liquid, for example oil. If the piston 20 is moved toward the left sufficiently slowly the liquid on the left side of the piston can pass through a pipe 22 toward the right end of the cylinder. The throttling action exercised by the fixed spindle 22 is comparatively small and is only increased when the lever 16, by means of the lever 18 and connecting rod 19, produces a quick movement of the piston 20 toward the left. At the same time the piston 20 exercises, through the agency of the retarding liquid on the left side thereof, such a pressure on the left wall of the cylinder 21, that this cylinder is moved toward the left, being guided on the fixed supports 24, 25. The cylinder 21 is closed toward the right by a cover 26, to which the connecting rod 27 is attached, which, when the cylinder 21 is moved as just explained, moves the deviating device 15 in the opposite direction to the hand of a clock. According to the position of the cam-lever 16 in regard to the cam-lever 18 the purchase between the two levers is altered. If, for example, the lever 16 is supposed to be uniformly turned, the lever 18 will move with an increasing angular velocity, that is, it will move at the lowest angular velocity, when it touches the lever 16 at the point a and at the highest velocity when it touches said lever at e. The contact between the levers at b, c and d produces angular velocities of the lever 18 which lie between the two extremes. The contact of the levers at the points a, b, c, d and e corresponds with the positions A, B, C, D and E of the lever 5, or, for example, with the full load, $\frac{3}{4}$, $\frac{1}{2}$, $\frac{1}{4}$ thereof, or with a completely unloaded condition.

Fig. 2 shows a diagram showing the dependence of the angular velocity of the lever 18 from the momentary position of the lever 5, supposing that the latter turns at a uniform angular velocity in the opposite direction to the hands of a clock. If the lever 5 or its lower end is in the position A or B, C or D, represented by the abscissæ, then the angular speed transferred by it to the lever 18 is A—a', B—b', C—c' or D—d' (ordinates). If the turbine is suddenly unloaded while working at a full load (the lever 5 being at A) the lever 18 will firstly be moved with the angular speed A—a', which increases up to and beyond D—d'. If the momentary permanent load is only half of the normal load (the lever 5 being at C) then the angular speed with which the lever 18, on being suddenly unloaded, will be moved, is firstly equal to C—c' and increase gradually up to and beyond D—d'. For

such sudden unloading of the turbine the lever 18 is therefore moved with a greater angular velocity when the permanent load was only ¾ or ½ or even less of the normal load. If now the lever 18 were rigidly connected with the deviating device 15 this device would be moved too far into the jet when the turbine is unloaded from the full load, supposing that the proportions of the lever and deviating device are so chosen that a sufficient movement of said device is also obtained when the turbine is unloaded while working with a lower output. In order to avoid the deviating device being moved too far when the full load is reduced the following arrangement is adopted: It is assumed that the lower end of the lever 5 is moved by the rod 4 out of the position A toward the right and the levers 16 and 18 touch each other along the points *a*, *b*, *c*, *d*. The piston 20 then moved from the right toward the left moves the cylinder 21 at first at its own increasing speed. At the same time the sleeve 22 attached to the cylinder 21 is moved in regard to the fixed spindle 23, and when the sleeve 22 has been moved far enough toward the left the annular recess 28 provided in the sleeve 22 will move over the pointed end of the spindle 23. By this means a larger outlet section is afforded for the oil on the left side of the piston 20 and said piston 20 is then not able to exercise pressure toward the left on the cylinder 21. The latter reduces its speed, although the speed of the piston 20 continuously increases, and the device 15 connected with said cylinder 21 will not be moved so far toward the left, as if the spindle 23 in the sleeve 22 were to exercise the same throttling action throughout. A spring 29 opposes the movement of the cylinder 21 toward the left and this spring will acquire an overbalance as soon as the throttling action of the spindle 23 in the sleeve 22 is reduced and the tension of said spring 29 has increased sufficiently. It can therefore occur that the cylinder 21 stops its movement although the piston 20 is moved farther toward the left. Consequently the path of the device 15 is restricted. If the lower pivot of the lever 5 is moved toward the right into the end position E, for example, or if it comes to rest previously, then the lever 18 and consequently the piston 20 will also stop. The spring 29 pulls the cylinder 21 over the momentary fixed piston 20 toward the right and the retarding liquid will pass through the opening 30 and the valve over said opening from the right side toward the left side of the piston without meeting any considerable resistance. In this manner the deviating device 15 arrives in its starting position. In the meantime the piston 12 will have had opportunity to move slowly toward the right and the nozzle 2 will therefore be closed by the pin 3 to such an extent that the reduced water jet will be suitable for the new load acting on the turbine wheel 1. Said turbine will therefore properly utilize the energy contained in the water. The spindle 23 or the sleeve 22 can be provided with grooves and enlargements, which will produce a definite displacement between the piston 20 and cylinder 21. Further, the piston 12 and fixed cylinder 13 can be so constructed as to provide any desired degree of throttling of the retarding liquid.

For the sake of clearness Fig. 3 shows on a larger scale which highest position the front edge of the deviating device 15 occupies when the turbine is unloaded while working at various permanent loads. If the turbine is suddenly entirely unloaded while working at its highest output the front edge of the device 15 would be moved into the position A″, if the parts 20—28 were not in operation. These parts cause the front edge to arrive into the position A′, and it is only moved into the position A′, B′, C′ or D′ when the turbine is suddenly unloaded, while working at ¾, ½ or ¼ of the full load, the water jet having the diameters D^4, D^3, D^2 and D′ respectively.

The device 15 has preferably a form resembling a snow-plow, so that the excess water is not only deflected downward but also toward both sides (Fig. 4).

What I claim and desire to secure by Letters Patent of the United States is:—

1. A device for deflecting the water jet of a turbine when suddenly unloaded, comprising in combination, a deflector adapted to be moved into the path of the water jet, and means to automatically move said deflector into the path of the water jet at a higher speed according as the turbine is working against a lower load when suddenly unloaded, substantially as, and for the purpose, set forth.

2. A device for deflecting the water jet of a turbine when suddenly unloaded, comprising in combination, a deflector adapted to be moved into the path of the water jet, a sliding cylinder connected with said deflector, a piston adapted to move in said cylinder and having a valve controlled opening therein, liquid in said cylinder on both sides of said piston, a cam-lever connected with said piston, a second cam-lever adapted to move said first cam-lever, and means to permit said liquid to pass from one side of said piston to the other, substantially as, and for the purpose, set forth.

3. A device for deflecting the water jet of a turbine when suddenly unloaded, comprising in combination, a deflector adapted to be moved into the path of the water jet, a sliding cylinder, means to connect said deflector with said sliding cylinder, a piston adapted to move in said cylinder and hav-

ing a valve controlled opening therein, liquid in said cylinder on both sides of said piston, a sleeve connecting the ends of said cylinder, a fixed spindle fitting said sleeve, a cam-lever connected with said piston, and a second cam-lever working against said first cam-lever with increasing purchase according as said second cam-lever is turned, substantially as, and for the purpose, set forth.

4. A device for deflecting the water jet of a turbine when suddenly unloaded, comprising in combination, a deflector adapted to be moved into the path of the water jet, a sliding cylinder, means to connect said deflector with said sliding cylinder, a piston adapted to move in said cylinder and having a valve controlled opening therein, liquid in said cylinder on both sides of said piston, a sleeve connecting the ends of said cylinder, a fixed spindle fitting said sleeve, a cam-lever connected with said piston, a second cam-lever working against said first cam-lever with increasing purchase according as said second cam-lever is turned, a needle adapted to reduce the section of the water jet, and means to automatically slowly move said needle when said second cam-lever is turned, substantially as, and for the purpose, set forth.

5. A device for deflecting the water jet of a turbine when suddenly unloaded, comprising in combination, a deflector of a snow-plow like form adapted to be moved into the path of the water jet, a sliding cylinder, means to connect said deflector with said sliding cylinder, a piston adapted to move in said cylinder and having a valve controlled opening therein, liquid in said cylinder on both sides of said piston, a sleeve connecting the ends of said cylinder, a fixed spindle fitting said sleeve, a cam-lever connected with said piston, and a second cam-lever bearing against said first cam-lever with increasing purchase according as said second cam-lever is turned, substantially as, and for the purpose, set forth.

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

ALBERT HUGUENIN.

Witnesses:
F. HULDREICH KELLER,
AUGUST RÜEGG.