

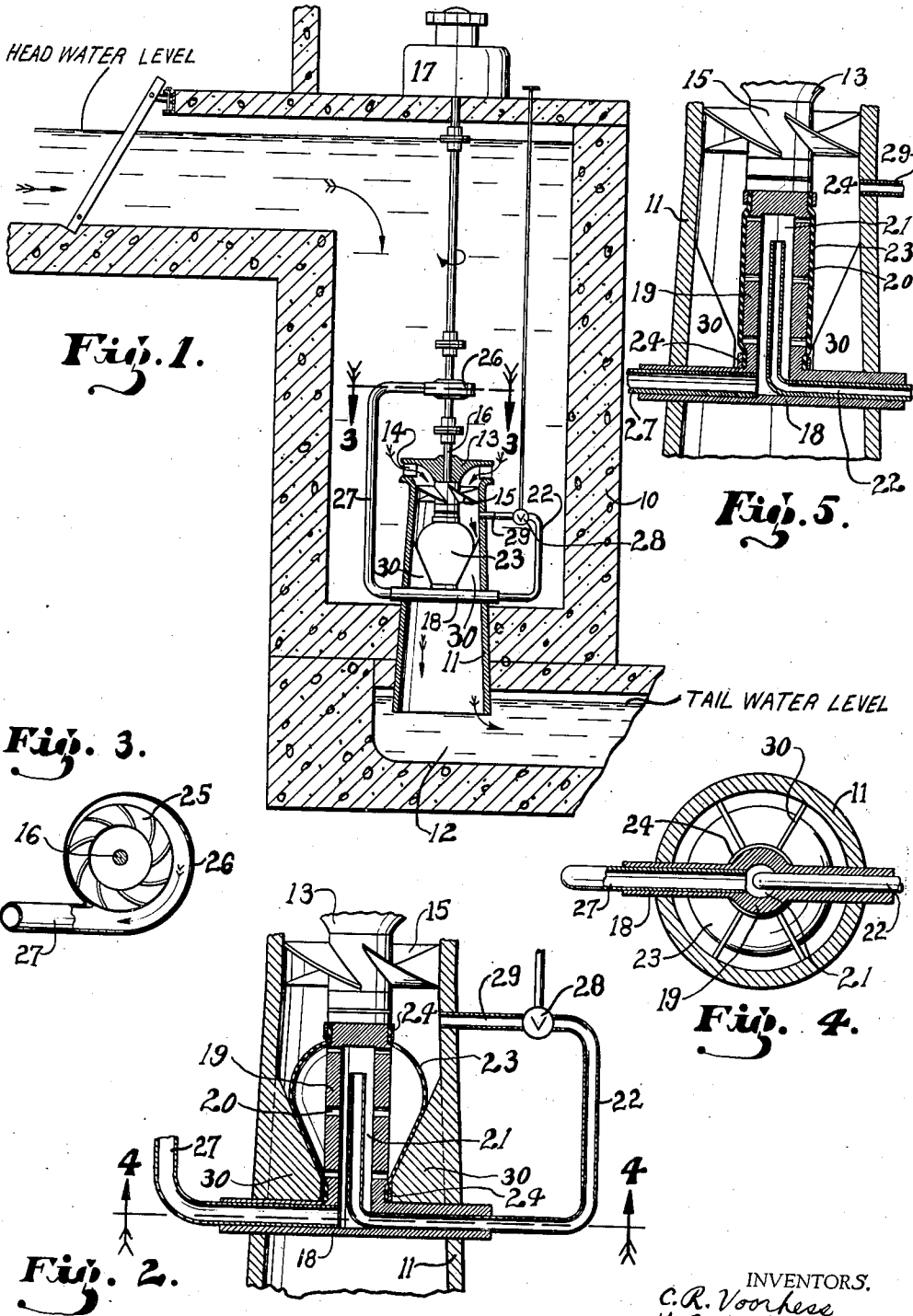
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TURBINE REGULATOR

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TURBINE REGULATOR

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The object of our invention is to provide a regulator for controlling the speed of water turbines, which regulator will be of simple, durable and inexpensive construction.

A further object of our invention is to provide a speed regulator for water turbines which will maintain a wheel speed within close limits during all normal fluctuations of the load which is being driven by the wheel.

Still a further object of our invention is to provide a speed regulator for turbine wheels which will operate without a conventional centrifugal governor and its associated operating mechanism, to thereby not only reduce the initial cost of the installation but provide more continuous operation due to the absence of these mechanical operating units.

Numerous types of turbine control devices have been used and, while some of these are exceedingly accurate in operation, the cost of such a regulator is prohibitive for the great majority of smaller power installations. The usual control consists of an annulus of small gates which are operated through links and a control ring through a hydraulic motor. The motor is controlled by a valve which in turn is usually controlled by some form of centrifugal governor. In most small installations, the cost of the governor, hydraulic pump, hydraulic motor and valve mechanism exceeds the cost of the rest of the turbine. Consequently, where capital investment is of major importance, manual operation or some makeshift type of control is usually provided. Our improved construction costs only a fraction of that of the associated turbine and functions to control the turbine speed within limits comparable to that of the most delicate hydraulic control.

Furthermore, our device, being free of mechanical parts, gives trouble-free operation for periods much longer than given by the more expensive mechanical regulators.

Still further, our device is distinguished from all other regulators known to the applicants in that no centrifugal governor in the generally accepted sense of the word is required, and because the water control valve, which replaces the complicated gate apparatus heretofore provided, is of simple, trouble-proof design and of relatively inexpensive construction.

With these and other objects in view, our invention consists in the arrangement, construction and combination of the various parts of our improved device, as described in this specification, claimed in our claims, and illustrated in the accompanying drawing, in which:

Figure 1 is a vertical, central, sectional view through a turbine installation having our improved control mechanism installed thereon, the control mechanism being in its closed position.

Figure 2 is a sectional view through the water control valve shown in Figure 1.

Figure 3 is a sectional view, taken on the line 3—3 of Figure 1.

Figure 4 is a sectional view, taken on the line 4—4 of Figure 2, and

Figure 5 is a sectional view, similar to Figure 2, but showing the control valve in an open position.

Referring to the accompanying drawing, we have used the reference numeral 10 to indicate a conventional penstock, the depth of which, of course, depends upon the head of water available to operate the turbine. A conventional draft tube 11 is mounted in the bottom of the penstock 10 and extends downwardly therethrough into a tail-race 12. The upper end of the draft tube 11 is provided with a bearing plate 13 having an annulus of downwardly projecting blades 14 formed thereon, which blades extend radially and rest upon the top of the draft tube so as to form an annulus of radially extending flues through which water from the penstock 10 enters the draft tube 11. A turbine wheel 15 is fixed upon a shaft 16 in position just beneath the plate 13 with the shaft 16 extending upwardly through the plate to position above the top of the penstock 10. The upper end of the shaft is connected to the device being driven, which in this case is a generator 17. The shaft 16 is shown with a number of couplings therein but this is only done for ease in assembly.

From the foregoing it will be understood that water enters the draft tube from the penstock through the above-mentioned flues and strikes the turbine wheel causing same to rotate. The water then drops down the draft tube generating subatmospheric pressure beneath the wheel in the usual manner. With our improved regulator the water is throttled in the draft tube to regulate the turbine speed, this regulation being accomplished by the novel valve which is about to be described.

Substantially midway in the draft tube we have provided a transversely extending tubular support 18 having an upwardly extending column 19 formed at the axis of the draft tube. The column 19 extends upwardly to position just below the wheel 15. The column 19 does not ordinarily resist the thrust of the wheel 15 but in case the wheel shaft breaks, then the column prevents

the wheel from falling down through the draft tube into the tailrace.

The column 19 is hollow with the center opening 21 being in communication with the left-hand tubular arm of the support 13. A plurality of perforations 20 is provided in the wall of the column. The other arm of the support 13 is provided with an air tube 22 which extends upwardly within the opening 21 to position, spaced beneath the upper end of the bore. A flexible rubber or other resilient sleeve 23 is fitted over the full length of the column 19, the top and bottom portions of which are clamped to the column by clamps 24.

From the foregoing, it will be noted that when pressure is applied to the left-hand arm of the support 13 the sleeve 23 will expand to egg shape, to thereby restrict the clear opening in the draft tube. In order to quickly collapse this sleeve, vacuum is supplied through the tube 22 to thereby quickly reduce the aforementioned obstruction in the draft tube. It is by expanding and contracting the sleeve 23 that the flow of water through the draft tube is restricted or increased to maintain a constant speed of the turbine wheel 15, within its load range.

Mounted upon the shaft 16 above the plate 13, we have provided a centrifugal pump impeller 25, around which is provided a conventional pump housing 26. A pipe 27 extends from the housing 26 downwardly to the support 18 so that the pressure developed by the impeller 25 in the housing 26 is conducted through the pipe 27 to proportionally expand the flexible sleeve 23.

The device, as so far described, functions in the following manner:

Water enters the draft tube and is forced downwardly against the turbine 15. This causes the turbine to rotate, thereby rotating the shaft 16 and impeller 28. As the speed of rotation of the turbine increases, the speed of the impeller 25 likewise increases to thereby develop a pressure in the pipe 27 in excess of that due to the normal head of the water in the penstock. The pressure in the housing 26 is conducted to the column 19 and gradually expands the flexible sleeve 23. As this sleeve expands, the space between the sleeve and the draft tube is gradually reduced so that it restricts the flow of water through the draft tube. At the regulated speed, the sleeve 23 has expanded enough to restrict the flow of water through the tube sufficiently to prevent further increase in the speed of rotation of the turbine.

If now a load is suddenly applied on the turbine, it is necessary to reduce or collapse the sleeve 23, thereby permitting more water to flow through the wheel, which prevents the load from slowing down the turbine. To regulate within small limits, it is necessary to immediately reduce the size of the sleeve 23 upon a slight reduction in speed of the wheel, which requires the exhausting of the water from within the tube. To rapidly accomplish this, we have provided the exhaust tube 22 which, as has been mentioned, extends from the upper part of the bore 21 out through one arm of the support 13 to a manually-operated valve 28. The valve 28 is connected to a suction tube 29 which extends into the draft tube 11 just beneath the wheel 15. In all turbines the pressure at the upper end of the draft tube is considerably beneath atmospheric, so that the tube 22 is impressed with subatmospheric pressure at all times that the valve 28 is open. Consequently, water within the sleeve 23 may be

exhausted through the tube 22 into the low-pressure zone of the draft tube.

The tube 22 also functions to draw out entrapped air from the resilient sleeve 23. When the valve 28 is open, the subatmospheric pressure within the draft tube draws air from within the sleeve, which would otherwise accumulate and make the governor less responsive to speed variations.

Six radial vanes 30 are equally spaced around the draft tube and extend from beneath the lower end of the column 19 upwardly toward the impeller where they merge into the walls of the tube. The purpose of the vanes 30 is to support the sleeve 23, when expanded, and to straighten out the flow of water through the upper end of the draft tube. This steadies the operation of the valve.

The speed of the wheel is controlled by the resistance to expansion of the sleeve 23 and, of course, by the pressure developed by the pump 26. This can readily be calculated within close limits by those familiar with hydraulic pumps and turbines so that a detailed explanation will not be given. Sensitivity adjustments may also be obtained by regulation of the air valve 28.

While we have shown the pump 26 as being directly connected to the turbine shaft, it will be apparent that the pump may be driven by the turbine through gearing or any of the numerous drives now available.

Among the many advantages arising from the use of our improved control, it may be well to mention that the cost of this control is only a fraction of that of the turbine installation, whereas the cost of other controls of equivalent accuracy is often more than the cost of the turbine.

Furthermore, the sleeve 23, being made of resilient rubber or other flexible material, will last almost indefinitely in the cold water associated with turbines.

Still further, the absence of mechanical gates and the complicated apparatus required to control such gates make this installation extremely reliable in operation.

We claim as our invention:

1. A device for controlling the speed of a turbine wheel, said wheel being rotatably mounted within a draft tube and said wheel and draft tube being supplied with water from a penstock, comprising an expansible valve disposed within said draft tube beneath said wheel, said valve being expansible by fluid pressure to increasingly obstruct the flow of water through said tube, and a centrifugal pump connected to rotate with said wheel, the outlet of said pump being conducted to said expansible valve so that said valve will be expanded upon an increase in the speed of rotation of said pump.

2. A device for controlling the speed of a turbine wheel, said wheel being rotatably mounted within a draft tube and said wheel and draft tube being supplied with water from a penstock, comprising an expansible rubber valve disposed within said draft tube, said valve being expansible by fluid pressure to proportionately obstruct the flow of water through said tube, and pump means connected to said wheel for supplying fluid at varying pressures to said valve, said pressures varying proportionately to the speed of said wheel.

3. In a device for controlling the speed of a turbine wheel, said wheel being rotatably mounted within a draft tube and said wheel and draft

tube being supplied with water from a penstock, comprising a flexible rubber sleeve axially mounted within said draft tube beyond said wheel, and pump means connected to said wheel for supplying fluid at varying pressures corresponding to the speed of said wheel to the interior of said sleeve, said fluid expanding said sleeve upon an increase in fluid pressure to proportionately restrict the flow of water through said tube.

4. In a device for controlling the speed of a turbine wheel, said wheel being rotatably mounted within a draft tube, and said wheel and draft tube being supplied with water from a penstock, comprising a hollow perforated column axially supported within said draft tube beyond said wheel, said column having a rubber sleeve forming a covering therefor, the ends of said sleeve being co-acting with said column to form fluid tight connections with the intermediate portion expansible by pressure from within said column to obstruct the flow of water through said tube, a centrifugal pump connected to rotate with said wheel, the outlet of said pump being conducted to said column so that said sleeve will be progressively expanded upon an increase in the speed of rotation of said pump.

5. In a device for controlling the speed of a turbine wheel, said wheel being rotatably mounted in the upper part of a draft tube and said wheel and draft tube being supplied with water from a penstock, comprising a hollow perforated column axially and fixedly supported within said draft tube beyond said wheel, said column having a rubber sleeve secured thereto and forming a covering therefor, the ends of said sleeve forming fluid-tight connections with said column with the intermediate portion expansible by pressure from within said column to increasingly obstruct the flow of water through said tube, a centrifugal pump driven from said wheel and having intake connection with said penstock, and means for conducting the fluid discharged by said pump to said column so that said sleeve will be progressively expanded upon an increase in the speed of rotation of said pump.

6. In a device for controlling the speed of a turbine wheel, said wheel being rotatably mounted within a draft tube and said wheel and draft tube being supplied with water from a penstock, comprising a valve controlling the flow of water through said draft tube, said valve being operated by fluid pressure, a means for supplying fluid under pressure to said valve so that said valve will be progressively operated upon an increase in the pressure of said fluid, and a tube extending from a point in said draft tube beyond said wheel to said valve, said tube exhausting the fluid from said valve to thereby reduce the effect of said fluid upon said valve, for the purpose described.

7. In a device for controlling the speed of a turbine wheel, said wheel being rotatably mounted in a draft tube, and said wheel and draft tube being supplied with water from a penstock, comprising a rubber sleeve axially mounted within said tube beneath said wheel, said sleeve being expansible by fluid pressure to increasingly obstruct the flow of water through said tube, a centrifugal pump connected to rotate with said wheel within said penstock, the outlet of said pump being connected to said sleeve so that said sleeve will be progressively expanded upon an increase in the speed of rotation of said pump, and a tube extending from a low pressure point in said draft tube to the interior of said sleeve, said tube exhausting fluid from said valve.

8. In a device for controlling the speed of a turbine wheel, said wheel being rotatably mounted in the upper part of a draft tube and said wheel and draft tube being supplied with water from a penstock, comprising a hollow perforated column axially supported within said draft tube beneath said wheel, said column having a rubber sleeve forming a covering therefor, the ends of said sleeve forming a fluid-tight seal with said column with the intermediate portion of the sleeve expansible by pressure within said column to obstruct the flow of water within said tube, a centrifugal pump connected to rotate with said wheel, the outlet of said pump being conducted to said column so that said sleeve will be expanded upon an increase in the speed of rotation of said pump, and a tube extending from a point in said draft tube just beneath said wheel to said column, said tube exhausting fluid from said valve.

9. In a device for controlling the speed of a turbine wheel, said wheel being rotatably mounted in the upper part of the draft tube and said wheel and draft tube being supplied with water from a penstock, comprising a valve controlling the flow of water from said penstock to said draft tube, said valve being operated by fluid pressure, a centrifugal pump connected to rotate with said wheel, the output of said pump being conducted to said valve so that said valve will be progressively closed upon an increase in the speed of rotation of said pump, a tube extending from a point of said draft tube just beneath said wheel to said valve, said tube exhausting air from said valve, and a control valve disposed in said tube, for the purpose described.

10. In a device for controlling the speed of rotation of a turbine wheel, said wheel being rotatably mounted in the upper part of a draft tube, and said wheel and draft tube being supplied with water from a penstock, comprising a rubber sleeve axially mounted within said draft tube in position beneath said wheel, said sleeve being expansible by fluid pressure to increasingly obstruct the flow of water through said tube, a centrifugal pump disposed within said penstock and connected to rotate with said wheel, the output of said pump being conducted to the interior of said sleeve so that said sleeve will be progressively expanded upon an increase in the speed of rotation of said pump, a tube extending from a low-pressure point within said draft tube to said sleeve, which exhausts the fluid supplied by said pump from said sleeve, and a control valve disposed in said tube, for the purpose described.

11. In a device for controlling the speed of rotation of a turbine wheel, said wheel being rotatably mounted in the upper part of a draft tube and said wheel and draft tube being supplied with water from a penstock, comprising a hollow perforated column axially supported within said draft tube beneath said wheel, said column having a rubber sleeve forming a covering therefor, the ends of which form a fluid tight connection with said column and the intermediate portion of which is expansible by pressure from within said column to obstruct the flow of water within said tube, a centrifugal pump disposed within said penstock and connected to rotate with said wheel, means for conducting the output of said pump to said column so that said sleeve will be progressively expanded upon an increase in the speed of rotation of said pump, a tube extending from a point in said draft tube just beneath said wheel to said column, the vacuum in said draft tube

beneath said wheel exhausting fluid from said column through said tube, and a manually operable valve in said tube which controls the amount of fluid exhausted by said tube.

12. In a device for controlling the speed of a turbine wheel by means of controlling the quantity of the motor fluid passing therethrough which comprises an expansible valve in a pipe in the fluid circuit of said wheel, expansion of said valve reducing the conduit of said motor fluid through said pipe, vanes in said pipe adjacent said valve to support said valve successively on expansion of said valve, a source of fluid pressure associated with said turbine and having the characteristic of exerting a continuous pressure proportional to the speed of said turbine, and conduit means from said source of fluid pressure to the interior of said expansible valve.

13. In a device for controlling the speed of a

5 turbine wheel, said wheel being rotatably mounted within a draft tube and said wheel and draft tube being supplied with water from a penstock, comprising a deformable valve member disposed within said draft tube beneath said wheel, said valve being deformable by fluid pressure to increasingly obstruct the flow of water through said tube, pump means connected to said wheel for supplying fluid at varying pressures to said valve to deform said valve, said pressures varying proportionately to the speed of said wheel.

14. The structure of claim 13 which is further characterized in that means are provided in said draft tube adjacent said deformable valve member to straighten out the flow of water passing said deformable valve member.

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