This invention relates to hydraulic apparatus and more particularly to improved means for reducing or preventing leakage past the gates or other parts of a hydraulic turbine or pump when the gates are in closed position.

In certain hydraulic turbine installations it is very desirable to conserve the water supply as fully as possible and one manner of accomplishing this is to prevent or reduce to a minimum leakage through the turbine when the same is shut down. Therefore leakage has been controlled only by the provision of small clearances between and around the wicket gates, or by mechanical sealing arrangements embodied in the turbine structure and disposed between the relatively movable surfaces of the turbine parts such as the gates and speed rings; or by the provision of expensive gates or valves at entrance to the turbine, with their inconvenience of operation.

An object of my invention is to provide an improved apparatus for sealing the turbine against leakage when the same is shut down. A further object is to provide improved leakage reducing means which eliminates the need for mechanical packing elements between the turbine parts thereby eliminating the necessity for costly machine work and labor costs in the construction of the turbine. Leakage is objectionable on account of loss of stored water and power, often justifying expensive means for reducing it, which is obviated by this invention.

A further and more specific object is to perform the sealing action, as it can generally be referred to, by creating on the inside of the turbine a pressure head counter to the headwater. This counter-head is created preferably by compressed air admitted into the draft tube. To prevent discharge of the compressed air through the tailwater the lower portion of the draft tube is used as a liquid seal. The degree of effectiveness of the sealing is of course dependent upon the relative proportion of the head above the wicket gates to the tailwater head above the lower portion of the draft tube. This proportion is sufficient in a great many installations so that my improved system may be used therein with a high degree of effectiveness and at the same time it can be applied at a very low cost to either a new or existing installation irrespective of whether the installation is of the Francis type or high specific propeller type or whether the turbine is equipped with wicket, plunger or cylinder gates. While the invention is illustrated herein in connection with a hydraulic turbine having wicket gates it will of course be understood that the other forms of gates can be used which is also true of various other types of draft tubes other than the two forms herein shown.

Other objects and advantages will be readily apparent to those skilled in the art from the following description of the accompanying drawing in which:

Fig. 1 is a vertical sectional view of a turbine installation having a Francis turbine and an elbow draft tube, and

Fig. 2 is a vertical sectional view showing a high specific speed propeller type runner and a spreading draft tube.

In the illustrated embodiment of my invention I have shown a turbine intake 1 of any usual form from which the fluid flows radially inwardly past adjustable wicket gates 2 and thence through a Francis runner 3 into an elbow draft tube 4 which discharges to the tailrace level 5. The wicket gates are of the usual type wherein the pivotal vanes are in overlapping engagement with each other when in closed position and the flow of water through the turbine is controlled by varying the degree of opening between the vanes. In Fig. 2 a high specific speed type of propeller runner 6 is shown in a setting also having adjustable wicket gates 7 disposed inside of usual stay vanes 8. A spreading type of draft tube 9 discharges from its flaring end 10 into the tailrace whose level is at 11. The headwater level is shown generally at 12 and the head above the wicket gates is indicated by the line h1 while the tailwater head above the lower edge 10 of the draft tube is indicated by the line h2.

With the foregoing types of turbine installations I utilize the draft tube or discharge passage leading from the turbine runner as an element in which to create a sealing pressure head which counterbalances the head h1 of the headwater. To create this counterhead I introduce into the draft tube preferably compressed air through any suitable valve controlled inlet 13, Fig. 2 or 14, Fig. 1. The compressed air is admitted until the level 15 of the water in the draft tube is forced downwardly to just above the lower edge 10 of the draft tube Fig. 2 or the surface 16 Fig. 1. The edge 10 and surface 16 thereby constitute an inverted crest so as to provide a liquid seal for the compressed air. If the head h2 of the tailwater is substantially equal to or greater than the head h1 of the headwater 10 it is seen that the headwater head can be entirely counterbalanced by the compressed air thereby materially eliminating leakage.
through the gates even though the gates are not mechanically leakproof this being subject to the influence of the gate height in accordance with the disclosure hereinafter. In most installations the head $h_2$ of the tailwater level is less than the headwater head, and it is also necessary to allow for a slight height of water $h_2$ providing a seal above the crest 16 or 10 to prevent the escape of air; and hence elimination of the leakage in such cases cannot be as fully accomplished otherwise although it will in general be materially reduced. Since this reduction of leakage can be accomplished at slight expense and without inconvenience it will usually be well worth applying; and will be particularly valuable and effective in the usual low or moderate head plant. When the turbine is placed in operation the air in the draft tube would of course be discharged.

It should be understood that when the height B of the guide vanes is considerable, as in large units, it is not possible to balance perfectly the pressure difference tending to produce flow through the vane clearances. Thus if the pressure difference is reduced to zero at the centerline of the entrance space, as would be the case when $h_1 = h_2 - h_s$, then at the upper end of the guide vanes there will be a tendency for air to leak outward into the casing, and at the lower end for water to leak inward into the draft tube. This leakage will in general be unimportant, in comparison with the great reduction in leakage effected by the provisions of the invention.

While I have shown two forms which my invention may assume in practice it will of course be understood that various other forms may be employed without departing from the spirit of the invention as set forth in the appended claims.

I claim:

1. A sealing arrangement for a hydraulic machine having a rotor, passages leading to and from the same and flow control mechanism for the rotor, means whereby one of said passages is connected with a liquid having one level, means whereby the other passage is connected with liquid having a lower level than said other level, said passage leading to the lower level having provision whereby it may be sealed by liquid from the lower level, and means for introducing and maintaining compressed air in the passage leading to the lower level whereby the flow control mechanism is materially sealed against leakage of the fluid from the higher level.

2. A turbine installation comprising, in combination, an intake connected to a headwater level, a turbine having gate mechanism, and a draft tube leading to a tailwater level and having a lower inverted crest whereby the draft tube may be sealed by tailwater liquid, and means for introducing compressed air into said draft tube when the gate mechanism is in substantially closed position thereby creating a counterhead against the headwater and thus reducing leakage of headwater through said gate mechanism.

3. A hydraulic installation comprising, in combination, means providing a headwater and tailwater, a passage leading from one to the other and having provision for effecting a liquid seal, a hydraulic machine disposed in said passage having gate mechanism for controlling flow of fluid to said machine, and means for introducing elastic fluid pressure within said passage on the inner side of said gate mechanism thereby to effect a sealing action of said gate mechanism in cooperation with said liquid seal so as to reduce leakage of water from the headwater through said gate mechanism to the tailwater.

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