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2 Sheets-Sheet 1

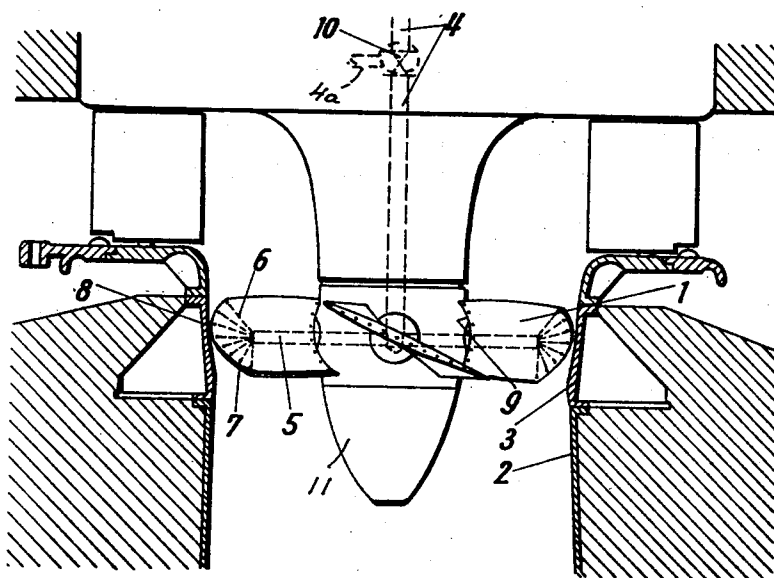


FIG. 1

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METHOD OF AND ARRANGEMENT FOR REDUCING CLEARANCE
LOSSES IN AXIAL AND SEMI-AXIAL FLOW MACHINES

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FIG. 2
AIR REGULATION

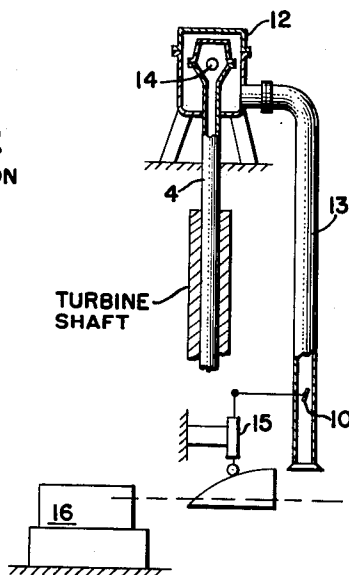
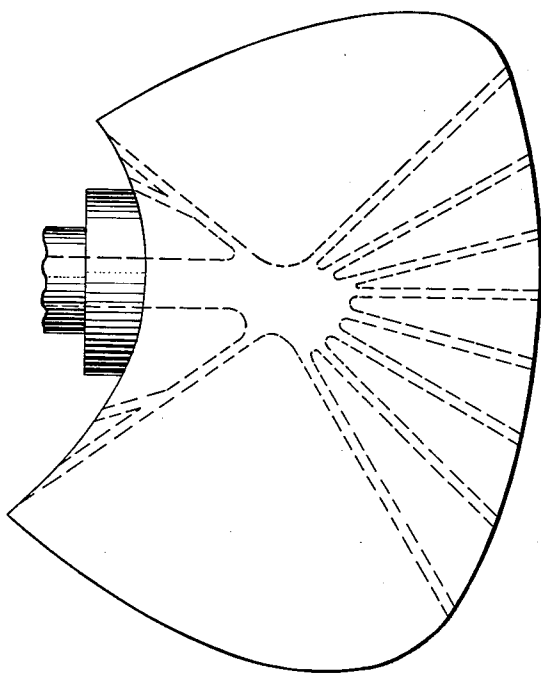


FIG. 3

RUNNER VANE
WITH PASSAGES



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METHOD OF AND ARRANGEMENT FOR REDUCING CLEARANCE LOSSES IN AXIAL AND SEMI-AXIAL FLOW MACHINES

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The present invention relates to a method of and an arrangement for reducing clearance losses in axial and semi-axial flow machines.

With runners of axial and semi-axial flow machines of this type, there is necessarily provided a clearance between the outer periphery of the blades of the rotating blade wheel and the encasement of the runner. In view of the pressure drop between the pressure side and the suction side of the blades, operating medium passes through the clearance thereby causing the so-called clearance flow.

This clearance flow has many drawbacks one of which is that the energy of the operating medium passing through said clearance cannot be converted into useful energy and thus presents a loss in the valuable operating medium. Moreover, the clearance flow has other important disadvantages inherent thereto. Thus, the clearance flow will for instance in hydraulic machines cause cavitation on the outer contour of the blades on the suction side thereof. Due to the pressure balance occurring at the periphery of the blades, because of said clearance, an unfavorable effect is obtained upon the pressure distribution on the blade surface at the pressure as well as on the suction side. More specifically, the higher pressure on the pressure side will drop, and the low pressure on the suction side will rise, toward the periphery of the blades. However, inasmuch as the force resulting from the mutual effect between the runner blades and flow depends on the pressure and the speed distribution on the blade surface, the clearance flow will unfavorably affect the output power of the runner thus causing a relatively high drop in the overall efficiency of the machine.

It is for this reason that numerous efforts have been made to reduce or eliminate the various disadvantageous effects of the clearance flow. The natural thing to do would, of course, be to reduce the clearance as far as possible. Such efforts, however, have not brought any satisfactory success inasmuch as for constructional reasons the clearance cannot be reduced below certain limits.

It is, therefore, an object of the present invention to provide a new method of and arrangement for reducing the clearance losses inherent to the clearance flow of axial and semi-axial flow machines. As a result of this invention, apart from an improved mode of operation, namely elimination or minimising of vibration being effected, an improvement in the efficiency of the machine will be achieved.

It is another object of this invention to provide axial and semi-axial flow machines with means which will considerably reduce the harmful effect caused by the clearance flow upon the pressure distribution on the surface of the blading thereby improving again the overall efficiency of the machine.

A further object of this invention consists in the provision of a new medium in hydraulic machines of the above mentioned type, which will reduce the harmful effect of cavitation on the blading thereby allowing the

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machine to operate under more severe conditions of running.

It is still another object of this invention to provide an arrangement for improving the aeration method heretofore known in connection with the aeration of river water by axial turbines as the Wagner method thereby improving the aeration of river waters.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawing diagrammatically showing the present invention in connection with a Kaplan turbine.

It has been found according to the present invention that it is possible in an advantageous manner considerably to reduce or practically even to avoid the drawbacks and losses caused by the clearance flow by introducing air or another gas or aerated water—an air or gas water mixture—through the runner blades into and/or below and/or above the clearance between the runner blade outer periphery and the surrounding wall for the runner and the inner clearance between the runner blade inner circumference and the hub. The air or gas or air water or gas water mixture may be introduced directly and/or indirectly into the said clearances, namely within the range of the axial length of the clearances or gaps and also in the direct neighborhood of the suction side or pressure side of said clearances or gaps. When introducing the medium, i.e. air or gas or an air water or gas water mixture, at the pressure side of the clearance, the introduction of the medium must always be effected under pressure. When introducing the medium into the clearance itself or into the direct neighborhood of the suction side of the clearance, it may suffice when the medium has atmospheric pressure. Of course, if desired, it may also at this point be introduced under pressure. At any rate, the medium is advantageously introduced at a plurality of points which are possibly uniformly distributed over the length of the individual clearances inasmuch as such an arrangement will assure a more uniform distribution of the medium over the entire length of the clearance or gap and will thus assure a uniform effect on all points of the respective clearance or gap.

According to a preferred embodiment of the present invention, the air or gas or air or gas water mixture is conveyed to the clearances or gaps through a plurality of bores, nozzles or the like distributed over the range of the outer and inner marginal portions of the blade wheels and arranged in the blades. These bores, nozzles or the like are connected through distributing passages to branch lines arranged in each blade and passing through the blade studs. These branch lines may through the turbine shaft, for instance through a bore in the latter or through pipes or the like mounted therein, communicate with the atmosphere or may be connected to a source of compressed air. If desired, the arrangement may be such that selectively a connection may be established with the atmosphere or with a source of compressed air. To this end, in order to control the amount of the new medium going into the clearances or gaps, a three-way valve may be provided. Such valve may, if desired, itself be automatically controlled according to the load on the turbine. Naturally, if desired, such three-way valve could also be operated manually.

FIG. 1 is a side elevation, partly in section of a Kaplan turbine embodying the invention.

FIG. 2 is a diagrammatic view of an alternative means for gas regulation applicable to the turbine of FIG. 1.

FIG. 3 is a plan view of a runner vane according to the present invention.

Referring now to the drawings in detail, the arrangement shown in FIG. 1 comprises a Kaplan turbine with runner blades 1 which blades are bored or cut to provide the required passages 6 for the air or gas or air- or gas-water mixture to be conveyed into the clearance between the periphery of the blades and the wall 3 surrounding same. These passages 6 communicate with feeder passages 5 which in their turn communicate with a common main line 4 in the main turbine shaft. The distributing lines or passages 6 end in openings or jets 7 at different points around the blade contour, as clearly shown in the drawing, in order to discharge and distribute the respective medium in and/or above and/or under the outer clearance or gap 8 between the runner blades 1 and the outer wall 3 and also the inner gap or clearance 9 between the runner blades 1 and the hub 11. The air or gas leaving the clearances or gaps 8, 9 will then pass in form of minute bubbles into the suction tube of turbine 2. If desired, a control valve 10 may be interposed in line 4 which may furthermore be provided with a connection 4a. In this instance, the connection 4a may be connected to a source of compressed air or compressed gas, while the free end of line 4 may lead into the atmosphere. The said control valve 10 may for instance be a three-way valve so that selectively atmospheric air or compressed gas may be conveyed to the clearances or gaps 8, 9. While the said valve 10 may be controlled manually, it is also possible to control valve 10 automatically in conformity with various conditions of operation of the fluid flow machine, for instance in conformity with the load, the circumferential speed on the periphery of the blades, etc.

FIG. 2 shows diagrammatically one of the many possible ways to automatically control valve 10 in conformity with one factor of operation of the machine, namely the governor.

As FIG. 2 shows this time valve 10 is not directly built in line 4 as previously mentioned. Here line 4 ends in an air box 12 with a built-in non-return floating valve 14 in order to stop the water from flowing back into the air system when this one is out of function. The air box is further connected to the atmosphere and/or compressed air through a passage 13 in which the regulating valve 10 is built. This valve is being regulated as shown by a cam and a roller 15 connected to the governor 16 of the machine. This arrangement will regulate the amount of the new medium flowing into the clearances and the gaps according to the gate openings, i.e. the load on the machine.

FIG. 3 shows a possible solution for connecting the different passages of the new medium. While the invention has been described in connection with the reduction or elimination of the clearance losses, it should also be noted that the present invention may also be used in connection with the enrichment of water with oxygen for biological purposes and for aiding in the self-purification of rivers and the like where axial turbines are employed. While for purposes of purifying or aerating river water, a method has been developed which consists in introducing air into the suction tube of a Kaplan turbine, with this method the air is, as mentioned above, introduced through the suction tube wall of the turbine and directly under the runner. In contrast thereto, the introduction of air through the blades into the clearances or gaps in conformity with the present invention will assure a still higher efficiency of aeration of river waters and the like than the above mentioned method in view of the fact that the air or gas comes out at said clearances or gaps between the runner blades and the surrounding walls in form of minute air bubbles due to the turbulence and the effect of rotation where the air or gas comes out. Such small air bubbles are considerably more efficient

for aerating purposes and in addition thereto will also cause less resistance to the flow.

As will be evident from the above, the present invention brings about a considerable improvement in the overall efficiency of machines of the type involved primarily due to a considerable reduction in or a complete elimination of the leakage losses. Furthermore, the influence of the leakage losses on the pressure distribution along the blade profiles is considerably reduced. Also a considerable reduction in the cavitation and the harmful effects thereof has been realized by the present invention.

It is, of course to be understood that the present invention is, by no means, limited to the particular construction shown in the drawing and method described above but also comprises any modifications within the scope of the appended claims. Thus, instead of air there could also be used nitrogen, oxygen, or any other gas or fluid.

What I claim is:

1. A method of reducing clearance losses in axial and semi-axial flow machines, especially Kaplan turbines, which includes the step of at least temporarily during the operation of the flow machine supplying at least one gas containing medium under pressure into the blades of the runner of the machine, distributing the medium in the blades, and discharging the medium from the edges of the blades into the clearance spaces of said flow machine and in the plane of the respective blade where the clearance losses to be reduced normally occur.

2. In a method of reducing clearance losses in axial and semi-axial flow machines, which comprise runner blades forming a first clearance with an encasement surrounding the outer periphery of said runner blades and also having a second clearance between the inner periphery of said runner blades and a hub, the step of: at least temporarily during the operation of the flow machine supplying at least one gas containing medium under pressure into the runner blades, distributing the medium in the blades, and discharging the medium from points distributed along the edges of the blades into said first and second clearances and in the plane of the respective blade.

3. A method according to claim 1, in which the medium being blown into the clearances is atmospheric air.

4. A method according to claim 1, in which the medium being blown into the clearances is compressed air.

5. A method according to claim 1, in which the medium being blown into the clearances is an air water mixture.

6. In an axial and semi-axial flow machine, a rotatable hub, a plurality of blades having studs on said blades inserted into and supported by said hub for rotation therewith, said blades having an inner and outer periphery, said inner periphery forming a clearance with said hub so as to confine therewith first gap means adapted to allow the passage of fluid therethrough, means surrounding said outer periphery of said blades with clearance so as to confine therewith second gap means adapted to allow the passage of fluid therethrough, main supply conduit means leading from the outside of said hub into the latter and adapted to be connected to a supply source of a fluid medium containing at least one gas, branch conduit means leading from said hub through said studs into each of said blades, and dividing conduit means in said blades communicating with said branch conduit means and leading to different and spaced points on each of said blades along the said inner and outer peripheries thereof for the discharge of said fluid medium directly into said first and second gap means and substantially in the plane of the respective blade.

7. An arrangement according to claim 6, and control valve means interposed in said main supply conduit means and adjustable for selective connection with either one of at least two different supply sources of the medium to be conveyed through said main supply conduit means.

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