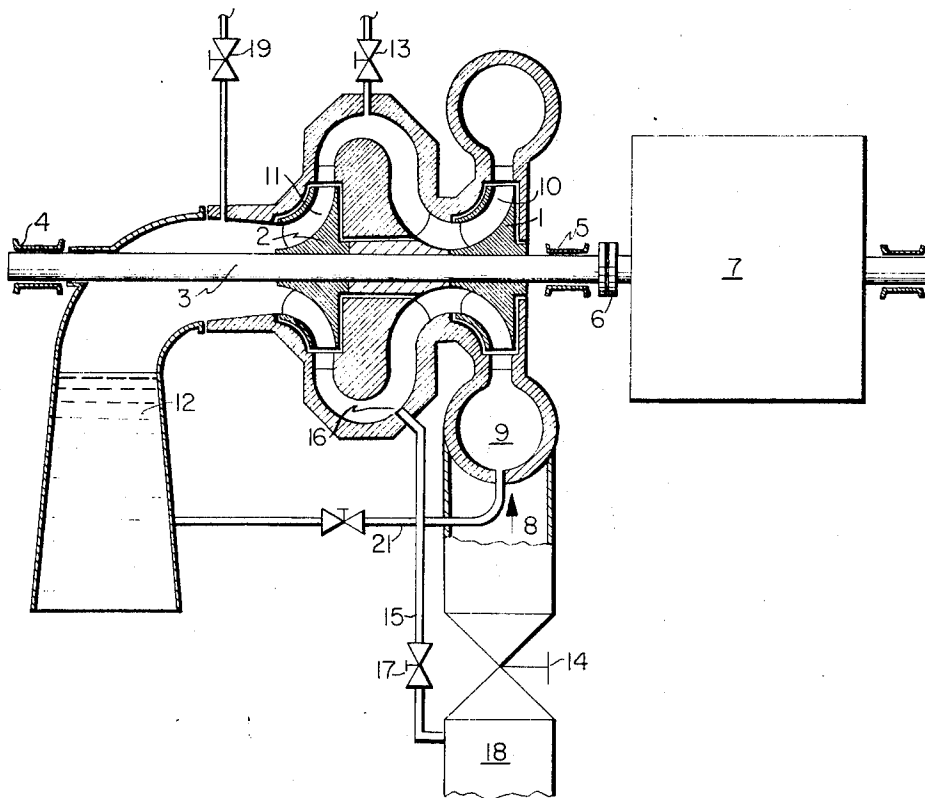


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H. CARDINAL VON WIDDERN
FILLING A TWO-STAGE OR MULTI-STAGE HYDRAULIC
TURBOMACHINE WITH WATER
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INVENTOR
HERMANN CARDINAL VON WIDDERN

BY *Rodge and Son*
ATTORNEYS

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FILLING A TWO-STAGE OR MULTI-STAGE HYDRAULIC TURBOMACHINE WITH WATER

Hermann Cardinal von Widdern, Ravensburg, Germany, assignor to Escher Wyss Limited, Zurich, Switzerland, a corporation of Switzerland

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2 Claims

ABSTRACT OF THE DISCLOSURE

A two-stage or multi-stage hydraulic turbomachine, for example a turbine, centrifugal pump or reversible pump-turbine, after its runner has previously been rotating in air, is filled with water while running by supplying at least part of the filling water at a point situated between two stages of the turbomachine.

This application is a continuation of Ser. No. 620,798, filed Mar. 6, 1967, now abandoned.

BACKGROUND OF THE INVENTION

Hydraulic turbomachines, such as turbines, e.g. Francis turbines, Kaplan turbines or combined turbines, as well as centrifugal pumps or pump-turbines, coupled to a motor-generator, are sometimes operated for a considerable time under no-load conditions, for example in phase-shifter operation of the plant. In order to keep the no-load losses low, as a rule, the water is then forced out of the machine housing by admitting air into the latter with the turbomachine shut off on the pressure side, so that the runner or runners of the machine rotate in air. On resumption of normal operation, the air must then be removed again and the turbomachine filled with water.

It is known either to allow water to enter from the suction side of the still running hydraulic turbomachine or to fill the machine from the pressure side by the supply of water under pressure.

Both of these methods, however, have disadvantages which will now be described with reference to a hydraulic pump.

If a pump is to be filled from its suction side the valve incorporated in the pressure pipe-line first remains closed and the tail water level is slowly lifted by releasing the air under pressure from the pump casing. As soon as the tail water level gets in contact with the blading of the rotating runner the latter is suddenly loaded to an undesired amount, pressure and power consumption thereby increasing abruptly to undesired values. At the same time the pump starts in delivering water, whereby the air volume enclosed in the pump casing is partly compressed to a plug and partly whirled by the runner blading together with the water. In this condition removing of the remaining air from the machine is difficult, since considerable quantities of water would escape through the venting pipe together with the air to be removed. It will thus elapse a relatively long period until the delivery pressure of the pump, after having attained a certain partial pressure, will increase to the final delivery pressure, so that the main valve may be opened to start water delivery into the pressure pipe-line.

When filling the machine from its pressure side abrupt loading of the pump will be avoided at the beginning. The filling process, however, can only extend to a condition in which the pressure of the filling water, which, as a rule, is taken from the pressure pipe-line, equalizes the pressure resulting from centrifugal action of the water

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rotating with the machine runner. In this way it is not possible to completely fill the entire rotor with water. A certain quantity of air still remains in the core of the runner.

In this condition delivery of water by the pump cannot yet take place, since an air cushion still separates the tail water level from the runner blading. When lifting the tail water level by releasing the enclosed air under pressure, however, the pump starts water delivery as soon as the main valve of the pressure pipe-line is opened, but the air core contained in the rotor must first be ejected by water current, which results in considerable troubles due to variation of delivery pressure and power consumption of the pump.

In order to avoid the formation of an air core between the runner blades, according to another known proposal, a booster pump is incorporated in the filling pipe, this booster pump serving to raise the pressure of the filling water to such an amount that it surpasses the pressure due to centrifugal action of the water rotating with the pump runner and thus allows to completely fill the hydraulic machine from its pressure side. Without regarding to the constructional complication implied with this measure with a pump of this kind the operation of the plant is made difficult to such an extent, that this measure has practically not been used up to now.

All the practically feasible filling processes have thus the disadvantage that they either lead to abrupt loading of the machine or do not allow to completely fill the machine, so that when starting delivery of the pump the enclosed air core gives rise to troubles due to variations in delivery pressure and power consumption.

SUMMARY OF THE INVENTION

The aim of this invention is to provide a process for filling a still running two-stage or multi-stage hydraulic turbomachine with water, after operation in air under no-load condition, which allows on one hand to complete the filling operation in a relatively short time and on the other hand to avoid undesired variations in delivery pressure and power consumption. This process, according to the invention, consists in that at least part of the filling water is supplied between two stages of the hydraulic machine.

This process makes use of the fact that the single stages of the two-stage or multi-stage machine are only capable of producing a part of the pressure head of the complete machine. The pressure of the filling water, which, as a rule, is taken from the delivery pressure pipe-line, considerably surpasses the delivery pressure of the single stages, so that these single stages therefore, are completely filled in a relatively short period. Once the filling process is completed, a water column is formed which extends throughout the whole runner, so that after lifting the water level on the low pressure side of the machine and opening the main valve of the pressure pipe-line the machine is fully operable in normal condition.

The invention further relates to an apparatus for carrying out the process according to the invention and consists in that at least at one point located between two stages of the hydraulic machine, a closable filling conduit is arranged to open into the flow space of the turbomachine.

BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawing shows in an axial longitudinal section an embodiment of a hydraulic turbomachine for carrying out the process according to the invention. The turbomachine is a two-stage reversible pump-turbine, with reference to which the invention will now be described by way of example.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The pump-turbine has two runner wheels 1 and 2 arranged on a common shaft 3 which is journaled in two bearings 4 and 5 and directly coupled to a motor-generator 7. The driving water of the hydraulic machine, when the latter acts as a turbine, arrives from a source of water (not shown) at a higher level through a penstock 18 in which is provided a main valve 14 and flows through an inlet pipe 8 and the spiral casing 9 of the pump-turbine into the vane system 10 of the runner wheel 1 and then into the vane system 11 of the runner wheel 2, from which it finally discharges through a draft tube 12 to the tail water.

In case the motor-generator 7, for example, is required to operate as a phase-shifter, the water is removed from the machine casing by introducing air under pressure through pipe-lines having closure members 13 and 19, respectively, after the inlet pipe 8 has been closed by the main valve 14, and if necessary, a discharge pipe 21 leading from the spiral casing 9 to the draft tube 12 has been opened. The water level in draft tube 12 will thereby be lowered by such an amount that the rotating runner wheels 1 and 2 are out of contact with the water as illustrated in the drawing.

If the hydraulic machine has to be refilled with water, the filling water is introduced into the flow space of the pump-turbine at one or more suitable points situated between the two stages comprising the runner wheels 1 and 2, respectively, for example at a point 16. For this purpose a filling pipe 15 having a built in valve 17 is provided, which establishes communication between point 16 and the penstock 18 which, in turbine operation of the hydraulic machine, supplies the driving water to the inlet pipe 8. Opening of the valve 17 allows water to flow from penstock 18 to point 16 of the machine casing, since the pressure prevailing at point 16 is lower than that prevailing in penstock 18. The pressure of the water arriving from penstock 18 corresponds at least to the water pressure produced by centrifugal action in runner wheel 2 situated downstream of the point 16, so that the blading 11 will be completely filled with water from its upstream side. At the same time blading 10 of the runner wheel 1 receives water from its downstream side whereby, however, pressure variations are substantially avoided, since the water quantity arriving per unit of time through the filling pipe 15 is relatively small.

As soon as the blading 11 of the runner wheel 2 is completely filled with water and the spiral casing 9 is filled at least in its greater part, an uninterrupted water column extends through the entire runner to the interior of the spiral casing 9. On releasing the air pressure by

opening valve 19 the water level in draft tube 12 rises until it joins said water column. After valve 19 is closed again and main valve 14 is opened the pump starts water delivery without giving rise to variations in delivery pressure or power consumption.

The pressure of the filling water supplied to point 16 of the turbomachine, as explained, shall surpass the pressure produced by centrifugal action of the water body rotating with runner wheel 2, which pressure may be considerably lower than the pressure prevailing in penstock 18. In this case, if desired, filling pipe 15 instead of being connected to penstock 18 may be connected to a source of lower pressure than that prevailing in penstock 18.

In addition to the described filling water supply filling water may also be introduced at other points of the hydraulic turbomachine either upstream or downstream of the runner.

The process according to the invention is not limited to the use with machines having a horizontal axis but may also be employed with machines having a vertical shaft. The process also is not limited to pump-turbines but may be carried out with any of the hydraulic turbomachines mentioned at the beginning.

I claim:

1. A process for supplying filling water to a multistage hydraulic turbomachine, running in air under no load, and which process includes the step of venting air from the turbomachine, and characterized by completion of the filling of at least the first or low pressure stage by admitting the filling water at a point intermediate adjacent stages.

2. The combination defined in claim 1 in which all of the filling water is admitted at said point.

References Cited

UNITED STATES PATENTS

3,237,565	3/1966	Hartland	103—97
3,264,485	8/1966	Naganuma et al.	290—52
3,309,057	3/1967	Tonooka	253—1
3,238,534	3/1966	Hartland	103—97
3,282,563	11/1966	Willi	253—117

FOREIGN PATENTS

343,385	2/1931	Great Britain.
909,087	11/1945	France.

HENRY F. RADUAZO, Primary Examiner

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415—1, 145, 151, 500