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TORQUE REDUCING MEANS

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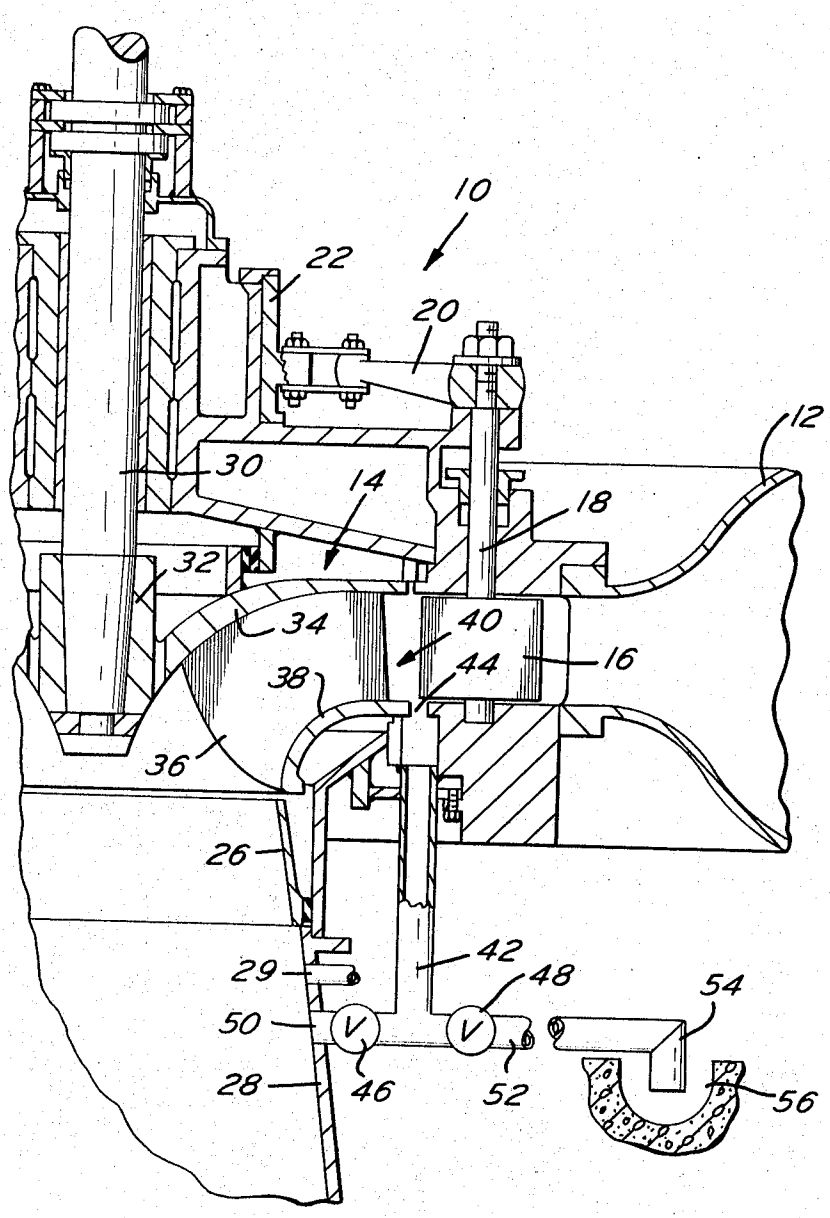

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TORQUE REDUCING MEANS

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This invention relates to a torque reducing means and more particularly to a torque reducing means for reducing the torque of a synchronous motor which is connected to a pump-turbine.

Reversible pump-turbines differ considerably in design from conventional turbines. Pump-turbines are normally larger and will ordinarily be set lower with respect to tail water level. The differences are necessitated because a pump-turbine must be designed primarily as a pump. An effective pump will also perform well as a turbine in the reverse direction of rotation but an effective turbine may make an entirely unsatisfactory pump.

The most unusual condition encountered in pump-turbine operation is the initiation of operation of the unit as a pump. Normally synchronous motors are connected to the pump-turbine unit and are utilized to bring the unit from standstill to rated speed. As designed, synchronous motors normally have available only a very small percentage of their torque capacity to enable them to be brought from a standstill to rated speed for synchronizing with the powerline frequency. Thus, when a synchronous motor is connected to a pump-turbine and the unit is to be started in a pumping direction, it is standard practice that such starting of the unit as a pump will be made with tail water depressed below the runner by means of compressed air. Also, the wicket gates will be closed and suitable means utilized to avoid the collection of an annular layer of water in the annular chamber defined between the runner tips and the wicket gates. It has been found, however, that due to water pressure outside the closed wicket gates there is an appreciable amount of leakage which escapes past the gates and which thereafter contacts the runner. It has been suggested that to prevent such leakage the provision of a main shut-off valve is desirable and in some cases necessary. However, the provision of such a main shut-off valve is expensive and should be avoided where possible.

It has further been suggested that in order to prevent a large quantity from building up inside the wicket gates and partially filling the runner, that vent pipes in the annular chamber between the outside diameter of the runner and the cylinder formed by the closed wicket gates, be provided. It has been suggested that these pipes be connected to the draft tube so that the leakage water can be conducted away from the annular chamber. However, to keep the annular chamber from filling up with water, it has been found that only a very small pressure head is available to force the water through the vent pipes and into the draft tube. The pressure which is available is equal to the height of water to which the annular chamber has been partially filled.

It is an object of the present invention to overcome the deficiencies in prior art pump-turbine units.

It is another object of the present invention to provide a means for reducing torque on a synchronous motor which is connected to a pump-turbine which is simple to use, readily installed and inexpensive to manufacture.

It is a further object of the present invention to provide a torque reducing means which is simple in operation and yet highly effective in use.

It is still another object of the present invention to provide a torque reducing means for a synchronous motor which is connected to a pump-turbine which functions to prevent water from accumulating in the runner area of the turbine when the runner is being brought up to desired speed.

It is still a further object of the present invention to provide a torque reducing means for a synchronous motor connected to a pump-turbine which utilizes a vent line having a large capacity and wherein suitable pressure is provided for facilitating movement of water from the runner area through the vent line to atmosphere rather than to the draft tube.

Other objects will appear hereinafter.

The above and other objects are accomplished by means of the present invention. The elimination of water in the runner area is accomplished by providing a vent pipe in the annular chamber between the outside diameter of the runner and the cylinder formed by the closed wicket gates. The vent pipes are provided with appropriate valving so that the pipes can be vented into atmosphere rather than the draft tube during the period when the motor is being brought up to speed and synchronized. The increased pressure in the vent pipe is available since the pump-turbine is set well below water level. The water in the draft tube is prevented from contacting the runner by compressed air. The air pressure utilized to depress the water is appreciably above atmospheric pressure thus providing a much greater pressure head to force the leakage water out of the annular chamber through the vent pipe to atmosphere.

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

The drawing is a partial section view of a pump-turbine constructed in accordance with the principles of the present invention.

Referring now to the drawing in detail, there is shown in the drawing a pump-turbine designated generally as **10**. While the turbine shown is of the low specific speed Francis type, it is to be understood that this invention is not limited to any particular type of pump-turbine. The present invention may be used in various types of hydraulic pump-turbine units.

The pump-turbine **10** has a spiral casing **12** through which water is delivered to a runner **14**. The pump-turbine **10** has a plurality of wicket gates **16** which are rotatably mounted by rods **18**. The rods **18** are connected to an arm **20** and a shifting ring **22** which cooperate to control the adjustment of the wicket gates **16**.

Water entering the pump-turbine **10** through the spiral casing **12** is adapted to flow through a discharge ring **26** into a draft tube **28**. The pump-turbine **10** is provided with a centrally mounted shaft **30** which is supported by suitable bearings.

A conduit **29** is connected to the pump-turbine and is utilized to admit compressed air into the runner area of this pump-turbine. The compressed air is utilized to depress the water in the draft tube below the runner **14** when the pump-turbine is to be started as a pump.

The runner **14** is connected to the lowermost end of the shaft **30**. The runner **14** comprises a hub **32** and a disk **34** which are connected to the shaft **30** for rotation therewith. The disk **34** is provided with a plurality of blades **36** attached thereto. The blades **36** have the outer ends thereof connected to a discharge band or shroud **38**. The hub **32** and disk **34** to which the blades **36** and the discharge band **38** are joined, all comprise the runner **14**.

An annular chamber **40** is defined between the outer diameter of the runner **14** and the inner surface of the cylinder formed by the wicket gates **16** when closed. A plurality of conduits **42** are adapted to communicate with the annular chamber **40**. For purpose of convenience only one such conduit has been shown in the drawing. Each

of the conduits 42 communicate with the chamber 40 through spaced gaps 44 in the housing which is provided for the pump-turbine 10.

A plurality of valves 46 and 48 may be connected to each conduit 42. Each conduit 42 divides into two separate lines 50 and 52. The disposition of the valves 46 and 48 determines through which of the lines the water will be permitted to flow. Each line 50 is in communication with the draft tube 28. Each line 52 is in communication with atmosphere and may have a downwardly bent end portion 54 which communicates with an open trough 56. Suitable means may be provided so that the valves 46 and 48 may be operated alternatively, that is, means may be provided to insure that when valve 46 is open, valve 48 will be closed; and vice versa.

When the pump-turbine 10 is to be operated as a pump, a suitable synchronous motor may be connected thereto for rotating the runner 14 thereof. The wicket gates 16 may be closed by appropriate movement of the shifting ring 22. A suitable servo-motor mechanism may be provided for initiating movement of the shifting ring 22. Such a servo-motor mechanism is well known in the art and therefore is not shown. Water in the draft tube 28 may be depressed to prevent such water from contacting the runner 14. Normally, compressed air will be used to insure that the tail water is depressed below the level of the runner. The level of the tail water may be as high as the top of the discharge ring 26, but in no event should it be allowed to contact the runner 14 and interfere with the free rotation thereof.

Water in the spiral casing 12 exerts great pressure on the closed wicket gates 16 and there is an appreciable amount of leakage which escapes past the wicket gates 16 and enters the annular chamber 40. During normal operation of the pump-turbine 10, valve 46 will be opened and valve 48 will be closed. Upon closure of the wicket gates 16 suitable automatic means as may be provided for opening the valve 48 and closing valve 46. Therefore, water which leaks past the wicket gates 16 into the annular chamber 40 may be received in the conduit and the line 52 and exhausted to atmosphere.

The discharge capacity of the vent pipes 42 is increased to an extent which is unexpected by venting the vent pipes 42 to atmosphere. Were the vent pipes 42 to be in communication with the draft tube 28, a very small pressure head would be available to force the water through the vent pipes 42 into line 50 and thereafter into the draft tube. The pressure head would be equal to the height of the water which would be in the annular chamber 40. However, when the conduits 42 and the lines 52 are vented to atmosphere, the air pressure which is utilized to depress the water beneath the runner in the draft tube 28 also exerts a force on the water in the annular chamber 40 and provides a much greater pressure head to force the leakage water out of the annular chamber through the conduits 42 and the lines 52 to atmosphere.

Thus, during periods when the synchronous motor is being brought up to speed and being synchronized, the runner is free to spin in air, thus reducing the starting torque requirements on the synchronous motor.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. A hydraulic machine comprising a runner, said runner including a plurality of blades, a plurality of wicket gates mounted in said hydraulic machine, said wicket gates having an opened and a closed position, an annular chamber defined between said runner and said wicket gates when said wicket gates are in closed position, means for introducing compressed air into said chamber and the space below the blades, means selectively communicating with said annular chamber for venting said annular chamber to atmosphere.

2. A hydraulic machine as set forth in claim 1 wherein said last mentioned means includes at least one vent pipe connected to said annular chamber.

3. A hydraulic machine as set forth in claim 2 including a draft tube, said vent pipe having two lines connected thereto, one of said lines communicating with said draft tube, and the other of said lines communicating with atmosphere.

4. A hydraulic machine as set forth in claim 3 including a valve in each of said two lines, each of said valves having an opened position and a closed position, said valves being operated alternatively so that water in said annular chamber flows through said vent pipe and through only one of said lines.

5. A means for reducing the torque of a synchronous motor which is connected to a pump-turbine wherein said pump-turbine includes a draft tube, a runner, a plurality of wicket gates, said wicket gates having an opened position and a closed position, an annular chamber defined between said runner and said wicket gates when said wicket gates are in closed position, said means including at least one vent pipe connected to said annular chamber, said vent pipe being connected to atmosphere at its other end, a valve in said vent pipe, said valve being in normally closed position, said valve being movable to an open position when it is desired to reduce the torque of the synchronous motor and means for introducing compressed air into said chamber and the space below said blades.

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