March 24, 1925.

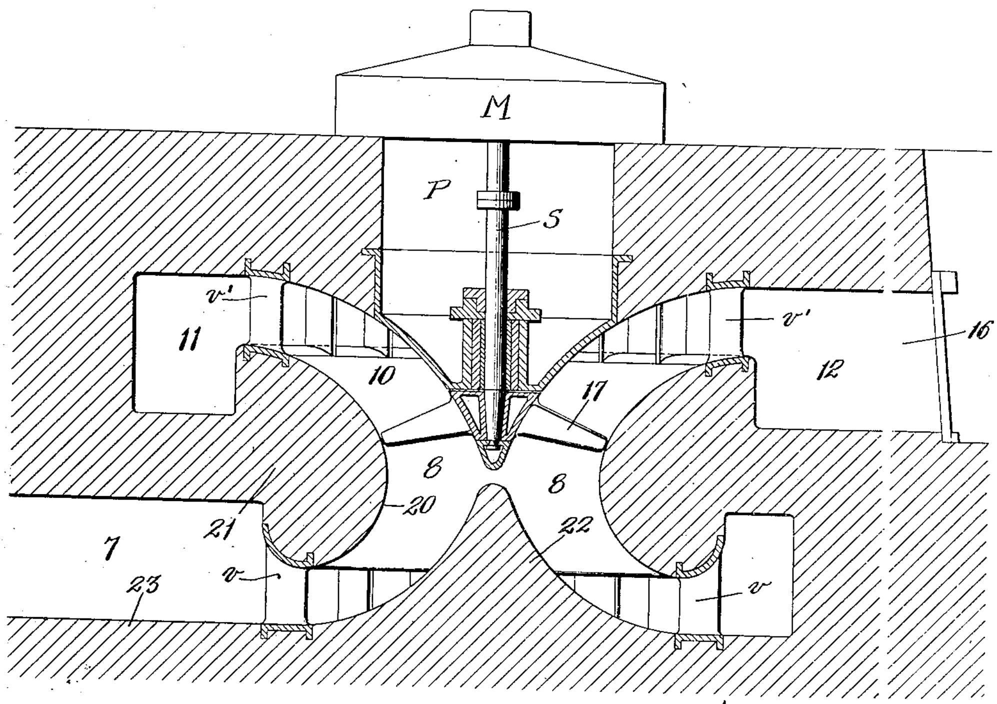
1,530,569

L. F. MOODY

HYDRAULIC PUMP

Original Filed Sept. 8, 1920

Fig: 1.



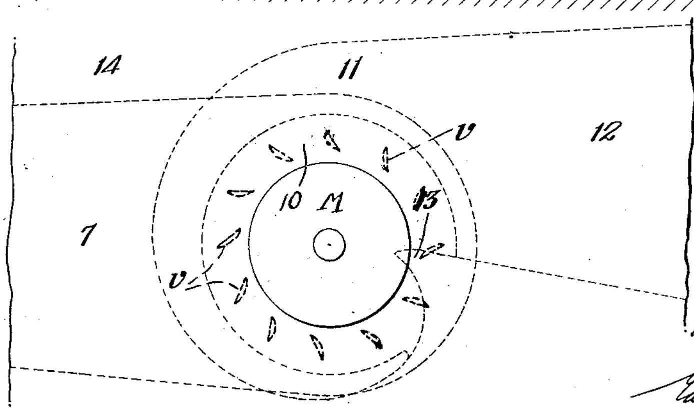


Fig: 2.

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UNITED STATES PATENT OFFICE.

LEWIS FERRY MOODY, OF PHILADELPHIA, PENNSYLVANIA.

HYDRAULIC PUMP.

Original application filed September 8, 1920, Serial No. 408,928. Divided and this application filed October 6, 1923. Serial No. 666,876.

To all whom it may concern:

Be it known that I, LEWIS FERRY MOODY, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Hydraulic Pumps, of which the following is a specification.

This invention relates to hydraulic machinery and particularly to a rotary machine which may be used either as a pump or turbine. In the specific embodiment herein disclosed, my invention comprises a machine of this character having a rotary propeller of the unshrouded axial or diagonal flow type.

One object of the invention is to provide such a machine of simple and efficient form and having a diffuser adapted to accommodate the whirling outflow from the pump impeller and to guide it out along a smooth expanding path. Another object is to provide a reversible machine provided with an efficient diffuser to receive the flow from the runner when the flow passes through the machine in either direction, thus allowing the machine to operate interchangeably as a turbine or pump.

Other objects of my invention, particularly the provision of an improved machine setting and the formation of the power station substructure to contain the machine and water passages, will appear from the following description taken in connection with the accompanying drawings in which—

Fig. 1 is a vertical section of a preferred embodiment of my invention and

Fig. 2 is a horizontal plan view of the same.

In the specific embodiment of the invention shown in the drawings an electric motor M on the station floor is connected to the pump-turbine impeller by the shaft S extending down through the pit P. When operating as a pump the impeller will be driven by the motor M; when operating as a turbine the impeller will drive the motor M.

During operation of the machine as a pump the supply is received from the lower level through intake passage 7 and the vertical intake chamber 8 which is of generally annular formation coaxial with the axis of rotation of the impeller. This intake chamber 8 begins to diverge slightly in advance of the runner and its walls merge into a spreading diffuser 10 receiving the discharge from the pump and passing it on expanding lines to the spiral diffuser 11 and discharge outlet 12, the baffle 13 intervening between the outlet 12 and the spreading and spiral diffuser as shown. The passages 7, 8, 10, 11 and 12 are preferably formed in the station substructure with piers 14 intervening between successive intake passages 7 of a series. Similarly a pair of piers 16 intervene between successive outlets 12 giving a very strong construction.

The runner is of the diagonal flow type passing the flow outward when acting as a pump and receiving it in a diagonally inward direction when operating as a turbine. The intake passage 7 surrounds the entrance to the intake chamber 8, which entrance is provided with a series of stay vanes *v* which are set at an angle to the radial direction so that the flow passing through them has tangential as well as radial components around the axis. The annular intake chamber 8 converges toward the runner between the outer wall 20 of the concrete substructure 21 and the central conical core 22 which rises from the floor 23 of the intake passage 7.

The entrance chamber 8 is preferably so designed that the velocity is accelerated at a gradual rate so that it will permit the runner 17 to operate as a turbine with reversed flow, the entrance chamber 8 then becoming a diffuser or draft tube. There is thus provided a pump capable of storing water in a reservoir and, when desired, utilizing the stored water to generate power by flowing through the machine in a reversed direction and driving the impeller or runner 17 in the opposite direction of rotation to drive the motor M as a generator thus regenerating energy used to operate the machine as a pump, the machine being so designed that the pump entrance conduit 7, 8 may become an efficient diffuser or draft tube and the pump diffuser 10 may become a well formed entrance passage. It is particularly well suited for operation as a turbine and it may be designed to produce the regenerative action described without material sacrifice of efficiency either when operating as a pump or turbine. It should be noted that the passage 8, 10 containing the runner is molded directly in the concrete without a metal casing and the structure will also preferably have the inflow guide and stay vanes v at the entrance to the converging intake passage 8 and the guide and stay vanes v' at the discharge from the diverging diffuser passage 10, these two sets of vanes being similar in form and similarly located and forming with the concrete substructure between them a continuous columnar support from the floor 23. When the direction of flow is reversed and the machine is operating as a turbine the stay vanes v' at the discharge from the diffuser will become guide vanes in what will then be the entrance passage to the turbine runner. Since both the directions of whirl and radial flow are reversed the direction and form of the vanes will be correct for the reversed flow.

When the machine is used as a pump the water enters through the stay vane ring v where it is given a whirl by reason of the inclinations of the guide vanes. It then passes through the transition space 8 which is of considerable length and in which the direction of flow is changed from radial to axial and the velocity increased by reason of the narrowing cross sectional area of the passage and decreasing radial distance from axis of unit. The discharge from the impeller is guided along smoothly expanding lines, the passage being designed gradually to decelerate the flow and efficiently to convert the velocity head into pressure head. When employed as a turbine the water entering through the stay vane ring v' is given a desired whirl by reason of the inclination of the guide vanes. The flow then passes through the transition space 10 from which it is turned from radial to axial direction and its speed increased by reason of the narrowing cross sectional area and decreasing radial distance from axis of the passage 10. Upon leaving the runner 17 the passage 8 now acts as a diffuser which gradually decelerates the discharge and efficiently converts the velocity head into pressure head.

In the hydraulic machine of this invention instead of employing a small or moderate transition space between the entrance guide vanes and the runner a space of considerable length is employed in whichever direction the machine is operated. When working as a pump, this increased length of transition space results in operating characteristics somewhat different from those of a pump having a small transition space, the latter characteristics partaking (to a limited degree) of the properties of a positive displacement pump, that is the pump endeavors to maintain its discharge against an increased head. This characteristic is desirable under some conditions but under others it is objectionable, for example, when it is necessary to operate the pump against a closed valve requiring increased motor capacity. By modifying the design the power required to operate the pump against a closed valve can be reduced. With a given impeller design this can be accomplished to some extent by increasing the distance between the discharge edges of the entrance vanes and the entrance edges of the impeller vanes, thus enlarging the transition space. In the pump here disclosed a long transition space 8 is provided. As the radius of this space decreases in approaching the impeller the linear velocity of whirl will increase due to the principle of the constancy of moment of momentum, and by properly inclining the entrance vanes this velocity of whirl at the impeller entrance can be made suitable for the impeller to give the highest obtainable degree of efficiency. At the same time this design would reduce the power under shutdown conditions.

Under these conditions there would be no continuous flow from the entrance vanes into the transition space and the water within this space will not receive its direction of motion from the entrance vanes. Instead the water in this space will receive a high degree of whirl from impact of the impeller vanes but by the time this whirl reaches the entrance vanes it will be reduced in the inverse ratio of the radii and the impact on the entrance vanes will be greatly reduced because of their location at a greater distance from the axis.

The hydraulic action within this inflow chamber 8 when the pump is operating at zero discharge is similar to its action as a draft tube when the machine is employed as a turbine. By giving the chamber 8 the form of a spreading draft tube the whirl in the contained water originating at the impeller is greatly diminished by the time it reaches the guide vanes and creates but little disturbance by impinging on them. At the same time the guide vanes can be given the proper angle of discharge to enable high efficiency to be secured during operation of the pump at normal flow.

It will be seen from the drawing that the entrance and discharge passages 8 and 10 are of the same general form. The entrance passage 8 of the pump is so designed that the velocity is accelerated at a sufficiently gradual rate so that this passage will act as an efficient diffuser under reversed flow when the machine is operated as a turbine.

The machine of this invention has a simple symmetrical design and is well adapted to form one of a series of units placed side by side in a power house. Such arrangement permits a close and economical spacing of the machines. The spreading diffuser receiving and guiding the discharge on naturally expanding lines decelerates the whirling stream effectively in advance of the collection chamber in which the flow lines are gathered in a single expanding stream. The regaining of the velocity head as pressure head is thus made gradually and efficiently, without abrupt change of direction or loss by eddies and disturbances. At the same time the water passage walls are not complicated in shape but follow simple geometrical shapes quite easy to construct.

This case is a division of my application Serial No. 480,928, filed September 8, 1920, now Patent No. 1,476,210 of December 4, 1923.

I claim:

1. In combination, a turbine-pump hydraulic machine and a generator-motor electrical machine, directly connected to said hydraulic machine, flow guiding means passing water in one direction through said hydraulic machine to effect operation of the latter as a turbine to drive said electrical machine as a generator and passing water in the opposite direction when said electrical machine is operating as a motor to drive said hydraulic machine as a pump, the turbine pump hydraulic machine having a rotor passing the flow outward when acting as a pump and receiving it in an inward direction when operating as a turbine.

2. In combination, a turbine-pump hydraulic machine and a generator-motor electrical machine, directly connected to said hydraulic machine, flow guiding means passing water in one direction through said hydraulic machine to effect operation of the latter as a turbine to drive said electrical machine as a generator and passing water in the opposite direction when said electrical machine is operating as a motor to drive said hydraulic machine as a pump, said guiding means acting to decelerate the discharge in either direction to convert its velocity head into effective pressure head.

3. A rotary hydraulic machine having a runner and having entrance and discharge conduits leading to and away from said runner, said machine being adapted for use at times as a pump and at other times as a turbine, the directions of flow and of rotation of the runner being simultaneously reversed in changing from pump to turbine operation or vice versa.

4. A rotary hydraulic machine having a runner and having entrance and discharge conduits leading to and away from said runner, said conduits being of similar form and said machine being adapted for use at times as a pump and at other times as a turbine, the directions of flow and of rotation of the runner being simultaneously reversed in changing from pump to turbine operation or vice versa.

5. A rotary hydraulic machine having an entrance passage in which the flow converges towards the axis from all sides, a discharge passage in which the flow diverges from the axis on all sides and a runner interposed in the flow between said passages, said machine being arranged for operation either as a turbine or a pump by simultaneously reversing the directions of flow therethrough and of rotation of the runner and said entrance and discharge passages being each formed to act as efficient diffusers when receiving the flow from the runner.

6. A rotary hydraulic machine having an entrance passage in which the flow converges toward the axis from all sides, a discharge passage in which the flow diverges from the axis on all sides, vanes at the entrance to said entrance passage formed to deliver a whirling flow, vanes at the discharge from said discharge passage formed to receive a whirling flow and a runner between said passages, said machine being arranged for operation either as a turbine or pump by simultaneously reversing the direction of flow and of rotation of the runner.

7. In a convertible pump and turbine an impeller, a pit surrounding the impeller shaft, similarly formed inlet and outlet passages coaxial with said pit and other passages communicating with said first mentioned passages and extending in opposite directions at right angles to said shaft.

8. A pump having similar symmetrical annular inlet and discharge passages, an impeller and a series of guide vanes in each of said passages, the guide vanes in one of said passages being located at a considerable distance from said impeller.

9. In a convertible pump and turbine the combination with a runner and a runner shaft therefor of a pit surrounding said shaft, annular inlet and discharge passages coaxial with said pit, the walls of said passages being formed to approach one another gradually and to expand in a direction away from said runner so as to cause said passages gradually to increase in cross sectional area in said direction.

10. In a convertible pump and turbine the combination with a runner and a runner shaft therefor, of a pit surrounding said shaft, annular inlet and discharge passages coaxial with said pit, the walls of said passages being formed to approach one another gradually and to expand in a direction away from said runner so as to cause said passages gradually to increase in cross sectional area in said direction and inclined guide vanes at the ends of said passages farther removed from said runner.

11. In a convertible pump and turbine a vertical shaft impeller, a concrete structure in which is formed similarly shaped symmetrical annular passages coaxial with said impeller and curving outwardly away therefrom so as to gradually increase in area away from said impeller and supporting means for said concrete structure compris-

ing stay vane rings located at one end of each of said passages.

12. A convertible pump and turbine comprising an impeller, a series of fixed vanes on each side of said impeller and a vane-free transition space between said impeller and each of said series of fixed vanes.

13. A rotary hydraulic machine having a runner of unshrouded type and having entrance and discharge conduits leading to and away from said runner, said machine being adapted for use at times as a pump and at other times as a turbine, the directions of flow and of rotation of the runner being simultaneously reversed in changing from pump to turbine operation, or vice versa.

14. A rotary hydraulic machine having an unshrouded runner of substantially axial flow type and having entrance and discharge conduits leading to and away from said runner, said machine being adapted for use at times as a pump and at other times as a turbine, the directions of flow and of rotation of the runner being simultaneously reversed in changing from pump to turbine operation, or vice versa.

15. A pump having annular inlet and discharge passages, an unshrouded impeller, and a series of fixed vanes in each of said passages, the fixed vanes in one of said passages being located at a considerable distance from said impeller.

16. A pump having annular inlet and discharge passages, an unshrouded impeller, a series of fixed vanes in each of said passages and a vane-free transition space between said impeller and each of said series of fixed vanes.

17. A pump having annular inlet and discharge passages, an unshrouded impeller having a hub enlarging in the direction of flow through said impeller, and a series of fixed vanes in each of said passages spaced from said impeller a sufficient distance to provide a vane-free transition space between said impeller and each series of fixed vanes.

18. In a convertible pump and turbine, a runner, similarly formed inlet and outlet passages coaxial with said runner and other passages communicating with said first-mentioned passages and extending in opposite directions at right angles to the axis of said runner.

19. In a convertible pump and turbine the combination with a runner of annular inlet and discharge passages coaxial with said runner, the walls of said passages being formed to approach one another gradually when approaching said runner and to expand in a direction away from said runner so as to cause said passages gradually to increase in cross sectional area in passing away from said runner.

20. In a convertible pump and turbine the combination with a runner of annular inlet and discharge passages coaxial with said runner, the walls of said passages being formed to cause said passages gradually to increase in cross sectional area in passing away from said runner, and inclined stationary vanes in said passages spaced away from said runner.

21. A hydraulic pump having a runner passage contained within an outer wall formed as a surface of revolution which approaches the axis and recedes therefrom with gradual curvature, an unshrouded runner within said passage at a point near its section of least diameter and a diffuser passage of gradually increasing area continuous with and extending from said runner passage on the discharge side of the runner, said runner passage being molded in the concrete structure surrounding the runner so that the runner operates directly within the concrete walls of the passage.

22. A pump having an unshrouded impeller of substantially axial flow type, fixed radial-flow guide vanes at entrance to said impeller but spaced therefrom to leave a vane-free transition space, and a discharge passage leading away from said impeller, said discharge passage being contained between inner and outer coaxial surfaces of revolution.

LEWIS FERRY MOODY.