Aug. 12, 1924. 1,504,776

F. NAGLER

HYDRAULIC MACHINE

Filed April 8, 1922 2 Sheets-Sheet 1

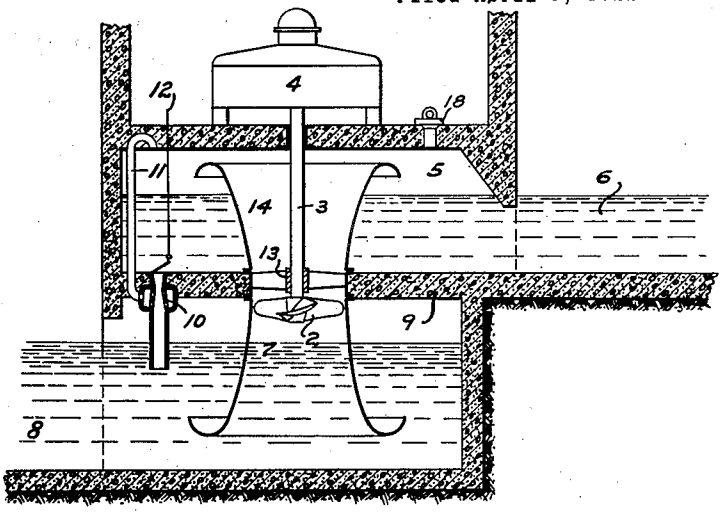


Fig. 1

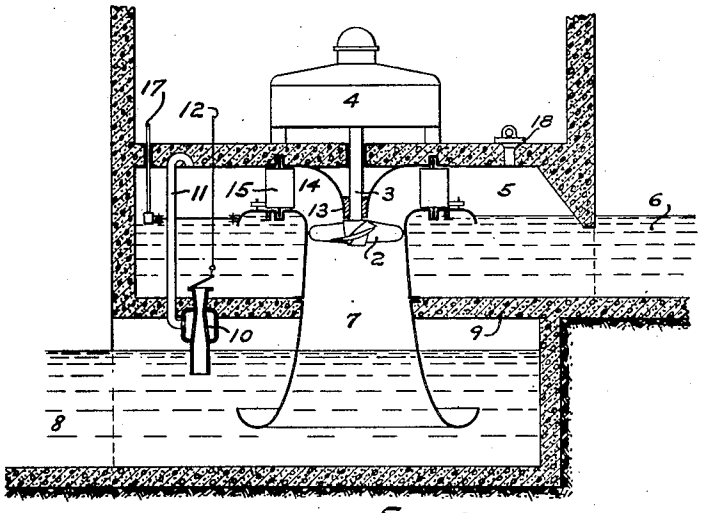


Fig. 2

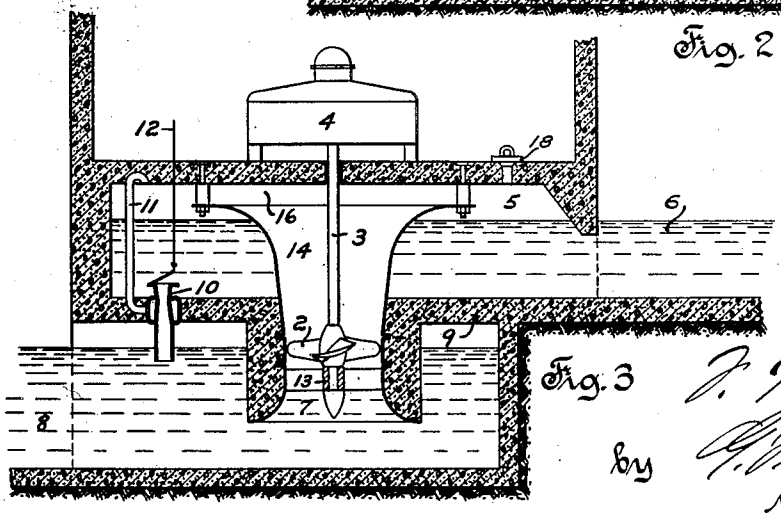


Fig. 3

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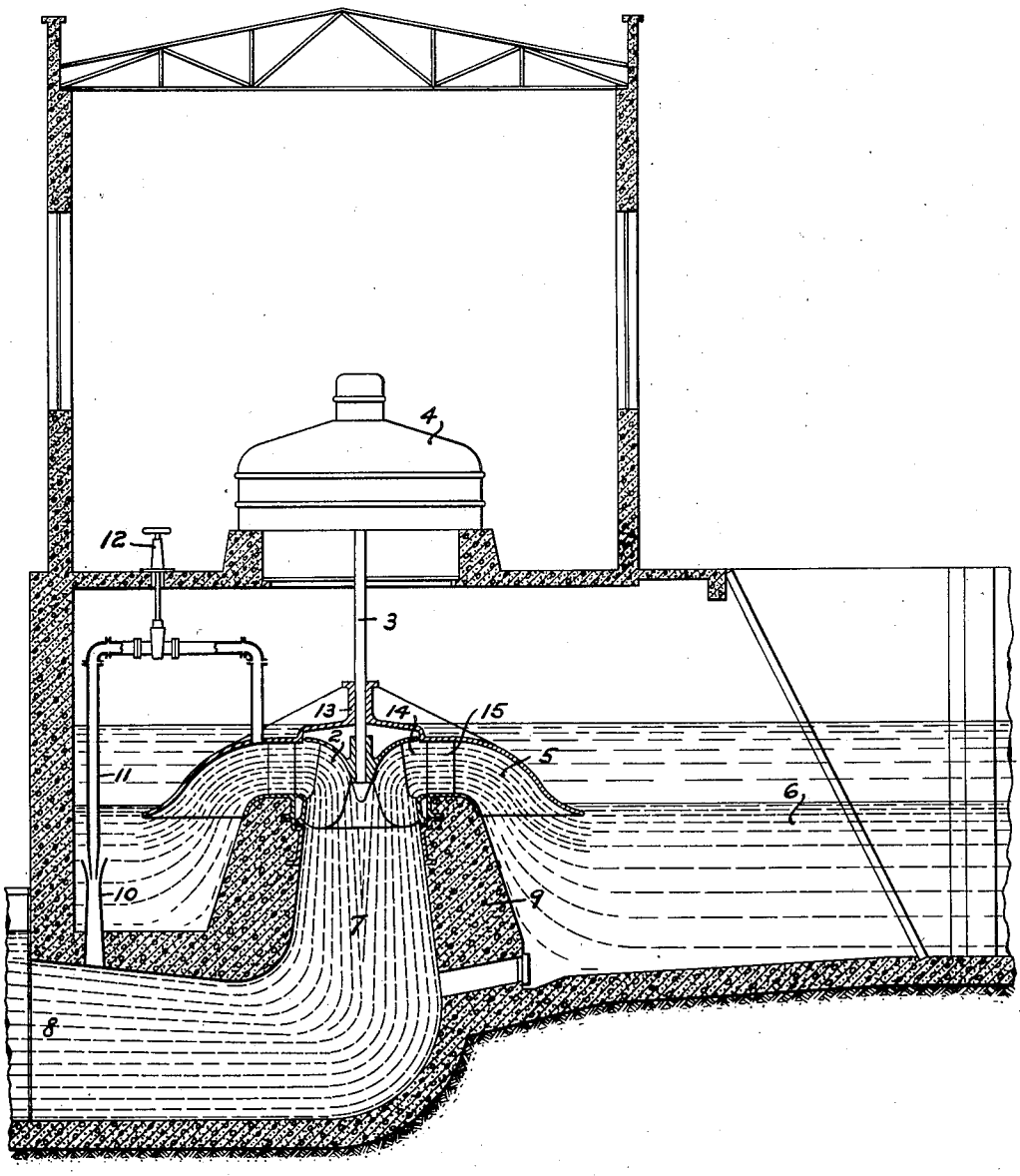


Fig. 4

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UNITED STATES PATENT OFFICE.

FORREST NAGLER, OF WAUWATOSA, WISCONSIN, ASSIGNOR TO ALLIS-CHALMERS MANUFACTURING COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF DELAWARE.

HYDRAULIC MACHINE.

Application filed April 8, 1922. Serial No. 550,612.

To all whom it may concern:

Be it known that FORREST NAGLER, a citizen of the United States, residing at Wauwatosa, in the county of Milwaukee and State of Wisconsin, has invented a certain new and useful Improvement in Hydraulic Machines, of which the following is a specification.

This invention relates in general to improvements in the construction and operation of hydraulic machines, and relates more specifically to improvements in energy converting installations such as hydraulic turbines and pumps.

An object of the invention is to provide an improved hydraulic machine which is simple in construction and efficient in operation. Another object of the invention is to provide an exceedingly simple and compact arrangement of the elements comprising a hydraulic machine such as a turbine or pump. A further object of the invention is to provide means whereby the cost of construction of hydraulic installations may be reduced to a minimum and the efficiency thereof increased to a maximum. Still another object of the invention is to provide means for preventing admission of air to a hydraulic machine. Another object of the invention is to provide a setting for hydraulic machines wherein the necessity of providing gates or valves, may be entirely eliminated. A further object of the invention is to provide a relatively long and efficient draft tube for vertical hydraulic turbines, without necessitating excessive excavation. These and other objects and advantages of the present invention will be apparent from the accompanying specification.

A clear conception of a number of embodiments of the invention and of the operation of devices constructed in accordance therewith may be had by referring to the drawings accompanying and forming a part of this specification, in which like reference characters designate the same or similar parts in the various features.

Fig. 1 is a diagrammatic longitudinal vertical section through a hydraulic installation which is capable of operation either as a pump or as a turbine.

Fig. 2 is a diagrammatic longitudinal vertical section through an improved hydraulic turbine installation.

Fig. 3 is a diagrammatic longitudinal vertical section through an improved hydraulic pump installation.

Fig. 4 is a longitudinal vertical section through a hydraulic turbine installation of the Francis type, having features of the present invention embodied therein.

Each of the hydraulic installations herein illustrated, comprises generally a hydraulic rotor 2 secured to the lower extremity of a vertical main shaft 3 the upper extremity of which is direct connected to an energy converter such as a dynamo electric machine 4.

Referring specifically to Fig. 1, the axial flow hydraulic rotor 2 is located in a medial portion of a vertical conduit formed by upper and lower wall portions 14, 7, the conduit thus provided being of gradually increasing cross sectional area receding upwardly and downwardly from the rotor 2. The vertical main shaft 3 is provided with a bearing 13 located above and adjacent to the rotor 2, the bearing being supported from the wall portion 14 by means of a series of radial vanes which may be formed either to produce or to obstruct whirling motion of the fluid passing through the conduit portion 14. Such vanes may also be located on either or both sides of the rotor 2. The upper extremity of the upper conduit portion 14 emerges into a sealed chamber 5 located above the liquid in the upper liquid basin 6, the chamber 5 being sealed by the wall structure 9 which supports the unit, and the wall of the conduit portion 14 projecting above the surface of the liquid in the basin 6 so that no liquid is free to flow by gravity alone, from the basin 6 through the conduit portion 14. The lower conduit portion 7 is directed toward the lower liquid basin 8 and is preferably submerged in the liquid of this basin. A hydraulic air ejector comprising a locally constricted laterally perforated tube 10 and an air conductor 11 connecting the chamber 5 with the interior of the tube 10 beyond the constriction and through the lateral perforations, provides means for removing air from the chamber 5. Operation of the air ejector may be effected with the aid of control mechanism 12 op-

erable from the power house. The chamber 5 is also provided with a vacuum breaker 18 for admitting air thereto. The installation embodies no valves or gates for controlling the flow of liquid through the rotor, and is adapted for use either as a motor driven pump or as a turbine driven generator.

Referring specifically to Fig. 2, the axial flow hydraulic turbine rotor 2 is located in the upper vertical portion of a conduit formed by upper and lower wall portions 14, 7, forming an upper inwardly and axially extending conduit of gradually decreasing cross sectional area approaching the rotor 2, and a vertical dicharge conduit of gradually increasing cross sectional area receding downwardly from the rotor 2. The vertical main shaft 3 is provided with a bearing 13 located above and adjacent to the turbine rotor 2, the wall of the conduit portion 14 adjacent to the bearing 13 being formed to gradually deflect the flow and to guide fluid advancing toward the rotor 2. A series of adjustable guide vanes 15 operable by mechanism 17 may be employed to produce variable whirling motion of the fluid advancing inwardly toward the main shaft 3, and may also be utilized to vary the quantity of fluid admitted to the rotor 2. The upper part of the conduit portion 14 is located in a sealed chamber 5 disposed above the liquid in the upper flume or liquid basin 6, the chamber 5 being sealed from the atmosphere by the wall structure 9 which supports the unit, and the lower outer wall of the conduit portion 14 projecting above the surface of the liquid in the basin 6 so that no liquid is free to flow by gravity alone, from the basin 6 through the conduit portion 14 The lower conduit portion 7 forms a draft tube which is directed toward the tail-race or lower liquid basin 8 and is preferably partially submerged in the liquid of the basin 8. A hydraulic air ejector comprising a locally constricted laterally perforated tube 10 and an air conductor 11 connecting the chamber 5 with the interior of the tube 10 beyond the constriction and through the lateral perforations, provides means for removing air from the chamber 5. Operation of the air ejector may be effected with the aid of control mechanism 12 operable from within the power house. The chamber 5 is also preferably provided with a vacuum breaker 18 for admitting air. The guide vanes 15 of this installation may be employed merely to produce variable whirl of the entering liquid, and may also be utilized to throttle the flow of liquid to the rotor 2, the installation being primarily a turbine unit.

Referring specifically to Fig. 3, the axial flow hydraulic pump rotor 2 is located in a lower portion of a vertical conduit formed by upper and lower wall portions 14, 7, the conduit thus provided being of gradually increasing cross sectional area receding upwardly from the rotor 2 and may be of the same or of increasing or decreasing cross sectional area receding downwardly from the rotor 2. The vertical main shaft 3 is provided with a bearing 13 preferably located below and adjacent to the rotor 2, the bearing 13 being supported from the wall portion 7 by means of a series of radial vanes which may be formed to either produce or to obstruct whirling motion of the fluid passing through the conduit portion 7. Such guide vanes may also be provided above the rotor 2. The upper extremity of the upper conduit portion 14 is formed with an outward flare and emerges into a sealed chamber 5 located above the liquid in the upper liquid basin 6 through an annular diffusing space 16. The chamber 5 is preferably sealed from atmosphere by the wall structure 9 which supports the unit, and the wall of the conduit portion 14 projects above the surface of the liquid in the basin 6 so that no liquid is free to flow by gravity alone, from the basin 6 through the conduit portions 14, 7. The lower conduit portion 7 is directed toward the lower liquid basin 8 and is preferably entirely submerged in the liquid of the basin 8 so that the rotor 2 is at least partially submerged in this liquid. A hydraulic air ejector comprising a locally constricted laterally perforated tube 10 and an air conductor 11 connecting the chamber 5 with the interior of the tube 10 beyond the constriction and through the lateral perforations, provides means for removing air from the chamber 5. Operation of the air ejector may be effected with the aid of control mechanism 12 operable from the pumping station. The chamber 5 may also be provided with a vacuum breaker 18 for admitting air thereto. The installation embodies no valves or gates for controlling the flow of liquid through the pump rotor, and is adapted for use primarily as a pump for elevating water from the lower basin 8 to the upper basin 6.

Referring specifically to Fig. 4, the Francis hydraulic turbine rotor 2 is located in the extreme upper portion of a vertical conduit formed by upper and lower wall and casing portions 14, 7, the upper portion 14 of the conduit thus formed comprising an inwardly directed annular passage of decreasing cross sectional area approaching the rotor 2, and the lower portion 7 forming a draft tube of gradually increasing cross sectional area receding downwardly from the rotor 2. The vertical main shaft 3 is provided with a bearing 13 formed in the upper turbine casing and located above the rotor 2. Guide vanes 15 operable in any convenient manner, may be located in the

upper conduit portion 14 for the purpose of directing and controlling the liquid entering the rotor 2. The upper conduit portion 14 communicates with a chamber 5 which is sealed from atmosphere and which is located above the liquid basin 6. The chamber 5 is preferably sealed by the turbine casing structure and the wall adjacent the lower outer part of the conduit portion 14 preferably projects above the normal level of the liquid in the basin 6 so that no liquid is free to flow by gravity alone, from the basin 6 through the conduit portion 14. The lower conduit portion 7 is directed toward the lower liquid basin 8, the portion 7 forming a draft tube and preferably having its lower end submerged in the liquid of the basin 8. A hydraulic air ejector comprising a locally constricted tube 10 and an air conductor 11 connecting the chamber 5 with the interior of the tube 10, provides means for removing air from the chamber 5. Operation of the air ejector may be effected with the aid of control mechanism 12 operable from within the power house, and a vacuum breaker may also be provided. While this installation embodies adjustable guide vanes 15, these guide vanes need not serve to throttle the fluid admitted to the turbine rotor, and may only be utilized in order to vary the degree of whirl of the entering fluid.

During normal operation of either of the units illustrated in Figs. 1 and 3, as a pump, the rotor 2 is rotated by means of the driving motor 4. The air is removed from the chamber 5 when starting, by manipulating the mechanism 12 thus permitting water to flow through the tube 10 and to withdraw air from the chamber 5 through the pipe or connection 11. This withdrawal of the air from the chamber 5 causes liquid to flow over the top of the upper conduit portion 14 and to fill the vertical conduit which surrounds the rotor 2. When the conduit has been thus filled with liquid, the pump has been primed and continued rotation of the rotor 2 produces upward flow of liquid from the lower basin 8 through the chamber 5 to the upper basin 6. When the rotation of the rotor 2 is discontinued, and the mechanism 12 is manipulated to close the upper end of the tube 10, admission of air to the chamber 5 with the aid of the vacuum breaker 18, causes the liquid in the chamber 5 to assume a level below the top of the wall portion 14 as indicated in the drawings, and the liquid from within the vertical conduit flows by gravity into the lower basin 8.

During normal operation of the unit illustrated in Fig. 1 as a turbine, the air ejector is utilized when starting in order to remove the air from the chamber 5 and to produce a whirling flow of fluid from the upper basin 6 through the conduit portion 14, rotor 2, and conduit portion 7 to the lower basin 8. When the flow of fluid has been thus established, the mechanism 12 may be manipulated to close the ejector tube 10 and the flow of fluid from the basin 6 to the basin 8 through the chamber 5, will continue by virtue of the siphon action. The fluid flowing through the vertical conduit surrounding the rotor 2 will produce rotation of this rotor and of the generator 4. If it is desired to discontinue the operation of the machine, air may be admitted to the chamber 5 with the aid of the vacuum breaker 18, thereby causing the liquid in the chamber 5 to again assume a level below the top of the upper wall portion 14 as indicated in Fig. 1.

During normal operation of either of the units illustrated in Figs. 2 and 4, the air ejector is utilized in starting to remove the air from the chamber 5 and the guide vanes 15 are adjusted to permit fluid to flow from the basin 6 through the inwardly extending conduit portion 14 to the rotor 2. The fluid thus flowing produces rotation of the rotor 2 and of the generator 4 and is eventually delivered through the lower conduit portion 7 to the tail-race 8. In the conduit portion 7 the velocity and whirl energy of the fluid is converted into pressure energy by diffusion in a well known manner. The guide vanes 15 may be adjusted to vary the speed of the rotor 2 by varying the degree of whirl of the liquid or by varying the quantity of fluid admitted to the rotor 2. Operation of the unit may be discontinued either by closing the guide vanes 15 or by admitting air to the chamber 5 through a vacuum breaker 18.

It will be noted that by providing a sealed chamber 5 above the rotor 2, a relatively long and efficient draft tube is provided without necessitating undesirable and expensive excavation in order to produce a desirably long draft tube. The chamber 5 also augments the efficiency of the unit by preventing the admission of air with the liquid. By permitting the annular wall of the upper conduit portion 14 to extend above the normal level in the basin 6, the use of gates and guide vanes may be entirely eliminated and the rotor is freely accessible for inspection when the unit is shut down. By applying the present invention to a pump, no gates or valves are necessary and the pump may be readily primed by merely operating the air ejector. The upper conduit portion 14 may be utilized to produce an effective diffuser when applied to pumping units, as illustrated in Figs. 1 and 3. While the invention is especially applicable to purely axial flow hydraulic installations such as are illustrated in Figs. 1, 2 and 3, wherein relatively low heads may be utilized to produce relatively high specific speeds of the

rotor, it will be obvious that some of the features of the invention are also applicable to other types of turbines such as shown in Fig. 4.

It should be understood that it is not desired to limit the invention to the exact details of construction and of operation herein shown and described, for various modifications within the scope of the claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In a hydraulic machine, a rotor, a continuous wall forming a conduit extending above the lower portion of and surrounding said rotor, and means forming a liquid sealed chamber extending above and below the upper end of said wall.

2. In a hydraulic machine, a rotor, a continuous wall forming a conduit extending above the lower portion of and surrounding said rotor, means forming a liquid sealed chamber above said wall, and a liquid basin communicating with said chamber only below the top of said wall.

3. In a hydraulic machine, a rotor having an axis of rotation, a wall extending entirely around said axis above the lower portion of said rotor, said wall forming a conduit communicating with said rotor, and means forming a liquid sealed chamber located above said wall and extending below the exterior thereof.

4. In a hydraulic machine, a rotor having a vertical axis of rotation, a wall completely surrounding said axis and forming a conduit communicating with the top of said rotor, means forming a sealed chamber extending laterally from said axis and beyond said wall, and a liquid basin communicating with said chamber at the exterior and below the top of said wall.

5. In a hydraulic machine, a rotor having a vertical axis of rotation, an annular wall completely surrounding said axis and extending upwardly from the lower portion of said rotor, said wall forming a conduit communicating with the top of said rotor, means forming a sealed conduit directed toward the axis of said rotor above the top of said wall, and a liquid basin communicating with said sealed conduit below the top of the exterior of said wall.

6. In a hydraulic machine, a rotor having a vertical axis of rotation, an annular wall completely surrounding said axis and extending upwardly from the lower portion of said rotor, said wall forming a conduit directed along the axis of said rotor, means forming a sealed annular conduit directed toward the axis of said rotor and extending downwardly beyond the periphery of said wall, and a liquid basin communicating with said downwardly extending conduit portion below the top of said wall.

7. In a hydraulic machine, a rotor having a vertical axis of rotation, a wall surrounding and extending above the lower portion of said rotor, said wall forming a conduit communicating with said rotor, means forming a sealed chamber above said wall, and means for removing air from said chamber.

8. In a hydraulic machine, a rotor having a vertical axis of rotation, a wall completely surrounding said axis and extending above the lower portion of said rotor to form a conduit communicating with said rotor, means forming a sealed chamber above said wall, a liquid basin communicating with said chamber below the top of the exterior of said wall, and means for removing air from said chamber.

9. In a hydraulic machine, a rotor, a continuous wall extending entirely above and forming a conduit communicating with said rotor, means forming a sealed chamber extending below the upper end of the exterior of said wall, and means for removing air from said chamber.

10. In a hydraulic machine, a rotor, an annular wall extending above and below said rotor, means forming a sealed chamber extending below the upper end of the exterior of said wall, a liquid basin communicating with said chamber entirely below the top of said wall, and a liquid basin extending above the lower end of said wall.

11. In a hydraulic machine, a rotor, an annular wall forming a conduit extending above and below said rotor, means forming a sealed chamber located above and extending below the exterior of the upper extremity of said conduit, a liquid basin communicating with said chamber entirely below the upper extremity of said conduit, and a liquid basin sealing the lower extremity of said conduit.

12. In a hydraulic machine, a rotor having a vertical axis of rotation, an annular wall forming a vertical conduit extending above and below said rotor, the portion of said conduit on one side of said rotor forming a decelerating passage, means forming a sealed chamber above said wall and extending below the exterior of the upper end of said conduit, a liquid basin communicating with said chamber entirely below the top of said wall, and a liquid basin below said conduit.

13. In a hydraulic machine, a pair of liquid basins located at different elevations, means forming a conduit directed toward the lower of said basins and extending entirely above the upper of said basins, and a rotor located in said conduit.

14. In a hydraulic machine, a pair of liquid basins having different elevations, means forming a sealed conduit having its one end immersed in the liquid of the lower of said basins and having its upper end lo-

cated entirely above the liquid level in the upper of said basins, a rotor in said conduit, and means for removing air from said conduit to establish a flow of liquid through said rotor.

15. In a hydraulic machine, a pair of liquid basins having different elevations, means forming a vertical annular conduit extending entirely above the upper and below the lower of said basins, an axial flow rotor located in a medial portion of said conduit, and an ejector for removing air from said conduit.

16. In a hydraulic machine, a rotor having a vertical axis of rotation, and means forming an open vertical flow decelerating conduit within which said rotor is located, the upper end of said conduit communicating with a liquid basin and the wall of said conduit forming a continuous crest extending above the level of the liquid in said basin to permit drainage of liquid from said conduit without permitting flow of liquid from said basin into said conduit.

17. In a hydraulic machine, a rotor having a vertical axis of rotation, means forming an open vertical flow decelerating conduit within which said rotor is located, and means forming a liquid basin in which the liquid level is maintained below the top opening of said conduit.

18. In a hydraulic machine, a rotor having a vertical axis of rotation, and means forming a conduit surrounding said axis above said rotor, said conduit being formed to decelerate liquid delivered from said rotor, and a liquid basin below the upper extremity of said conduit but communicable with said conduit extremity by siphon action during operation of said rotor.

19. In a hydraulic machine, a rotor having a vertical axis of rotation, means forming a liquid basin surrounding said axis above said rotor, and means forming a flow decelerating conduit extending entirely above the level of the liquid in said basin and adapted to gradually decelerate the liquid delivered from said rotor.

20. In a hydraulic machine, a rotor, means forming a liquid basin surrounding the axis of said rotor, means forming a coaxial inlet passage communicating with said rotor, said passage extending entirely above the liquid in said basin, and means for decelerating the flow of liquid discharged from said rotor.

21. In a hydraulic machine, a rotor, a trumpet shaped casing forming a flow decelerating conduit communicating with said rotor, and a liquid basin through which said casing extends, said casing forming an annular continuous crest extending above the level of the liquid in said basin.

22. In a hydraulic machine, a rotor, and means forming a flow decelerating conduit within which said rotor is located, the upper extremity of said conduit being located entirely above the normal level of the head water communicating therewith during operation of said rotor.

23. In a hydraulic machine, a rotor, means forming a long flow decelerating passage rising vertically from said rotor, and means forming a passage descending from the upper extremity of said conduit toward the head water level.

24. In a hydraulic machine, a rotor through which a whirling stream of liquid is adapted to advance in an axial direction only, means forming an annular passage communicating axially with said rotor, means forming a flow decelerating conduit communicating with the opposite side of said rotor, and means forming liquid basins communicating with said passage and with said conduit respectively, the upper end of said conduit being located entirely above the level of the liquid in the upper of said basins and forming an annular continuous crest.

25. In a hydraulic machine, a rotor having a vertical axis of rotation, means forming a vertical flow decelerating conduit within which said rotor is located, a liquid basin communicating laterally with the lower extremity of said conduit, a liquid basin extending laterally toward the upper extremity of said conduit, and a liquid sealed chamber above the upper of said basins and communicating openly with the upper extremity of said conduit.

In testimony whereof, the signature of the inventor is affixed hereto.

FORREST NAGLER.