

April 12, 1966

J. DESBAILLETS ETAL

3,245,656

AUTOMATIC SUPPLY OF SEALING FLUID FOR ROTARY FLUID MACHINES

Filed April 6, 1964

4 Sheets-Sheet 1

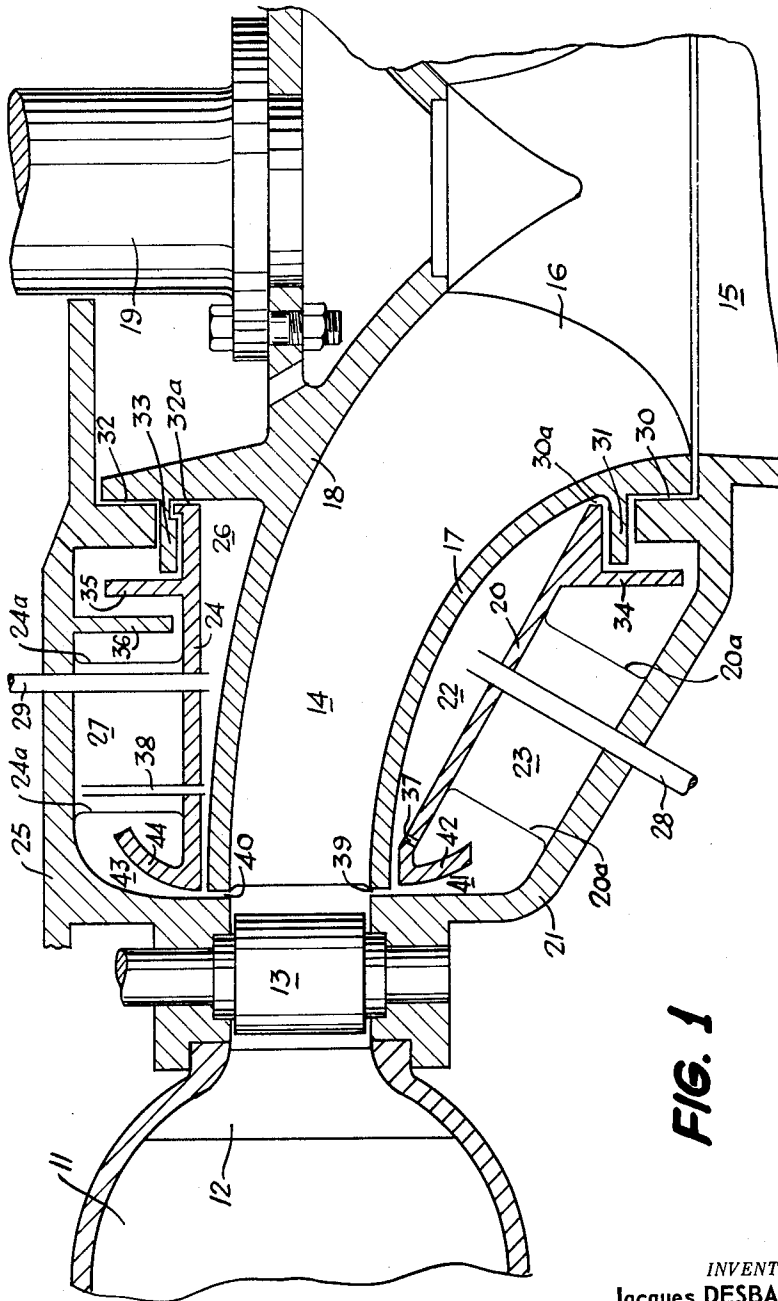


FIG. 1

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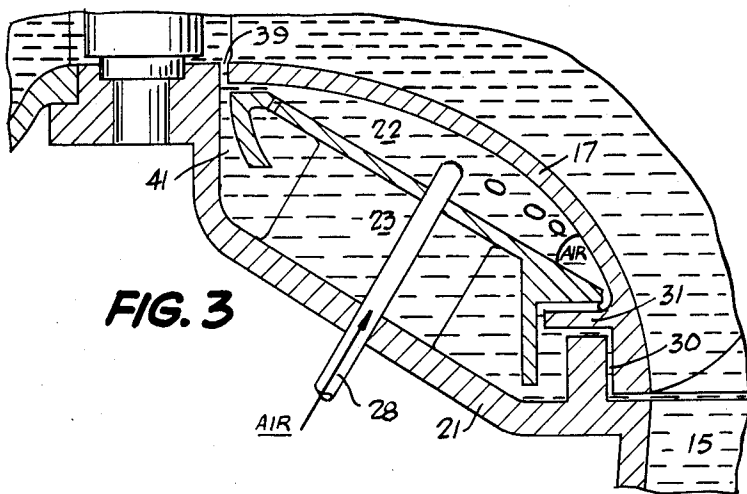
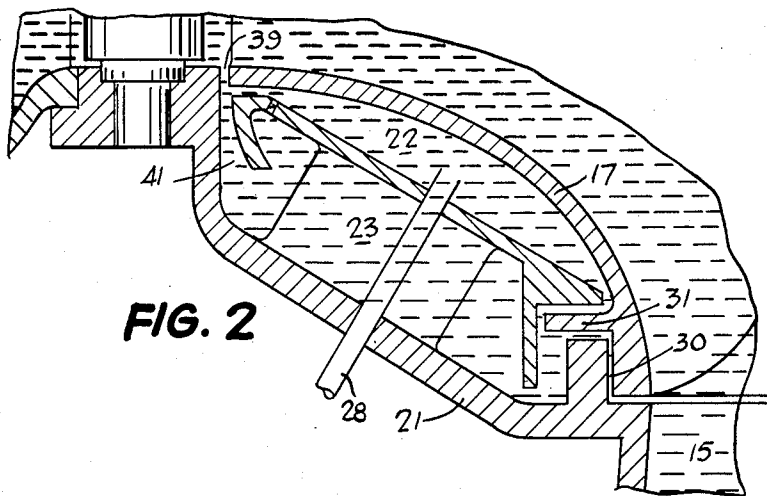
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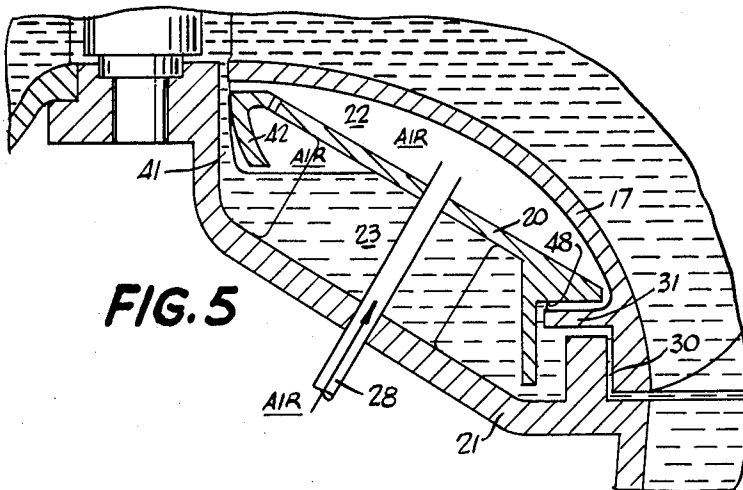
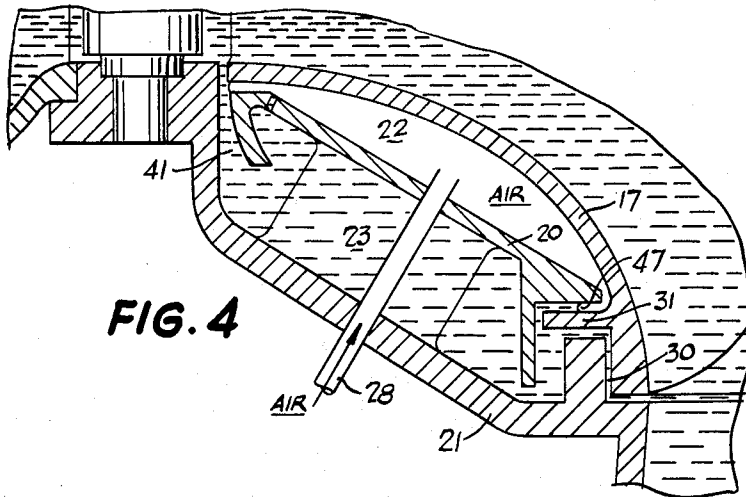
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

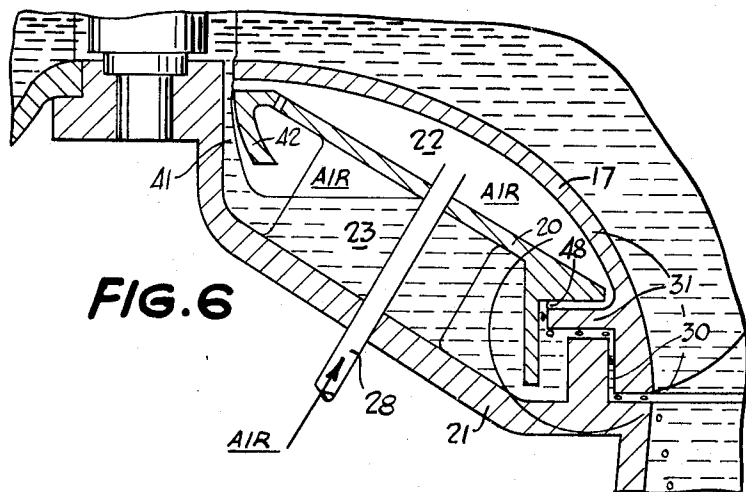


FIG. 6

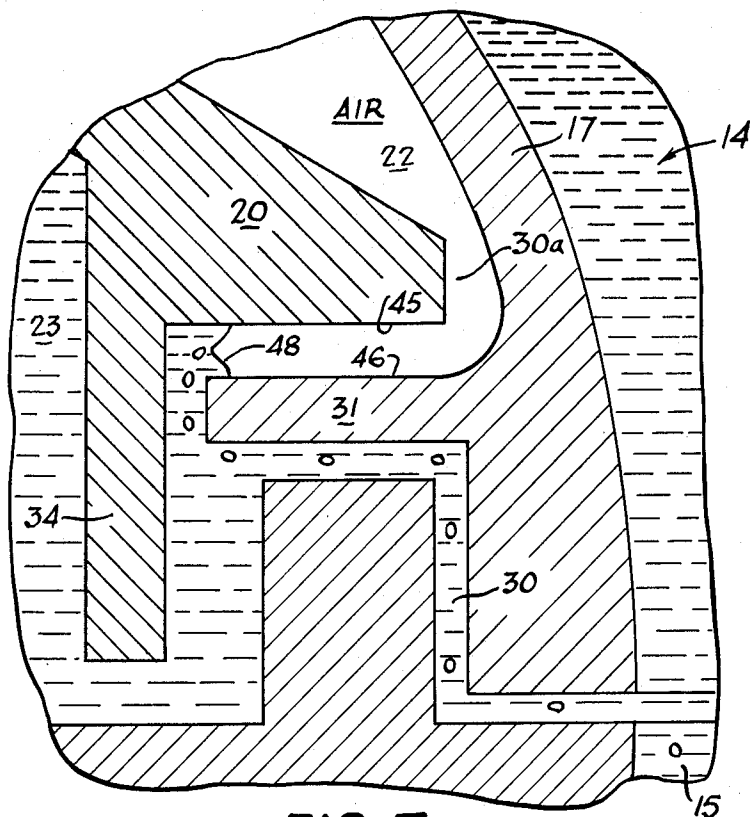


FIG. 7

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AUTOMATIC SUPPLY OF SEALING FLUID FOR ROTARY FLUID MACHINES

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 Filed Apr. 6, 1964, Ser. No. 357,448
 5 Claims. (Cl. 253-26)

This invention relates to rotary fluid machinery such as pumps, turbines and pump-turbines of the type which incorporate a shrouded impeller or runner, and in which means are provided for reducing the fluid friction on the impeller or runner by displacing, from the spaces between the outside of the runner or impeller shrouds and the adjacent stator structure, the working fluid with a second fluid which has both less density and less absolute viscosity than the corresponding properties of the working fluid.

In the application of this invention to an hydraulic turbine the working fluid will be water while compressed air, which possesses the necessary combination of density and viscosity, is an economical choice for the second fluid.

This invention will be described as embodied in an aerated vertical francis hydraulic turbine, but it will be understood that any pair of fluids possessing the above noted characteristics, in conjunction with a rotary fluid machine of the type above noted, will fall within the scope of this invention.

In co-pending U.S. continuation-in-part patent application Serial No. 201,881, filed June 12, 1962, now U.S. Patent No. 3,174,719, means were provided for reducing fluid friction in a francis type hydraulic turbine by introducing air into the spaces bounded by the runner shrouds and the adjacent stator structure, the air being maintained in the shroud spaces by space seals.

It was subsequently found that further improvement in efficiency could be obtained by reducing the quantity of air required for aeration. This was achieved by reducing the leakage of air through the space seals by means of centrifugal air-water separation. In co-pending U.S. patent application Serial No. 286,646, filed June 10, 1963, now U.S. Patent No. 3,174,720 and co-pending U.S. patent application Serial No. 326,608, filed November 27, 1963, centrifugal separators were added to the band and crown space seals to provide air-water separation at the seals and more effectively maintain the air in the shroud spaces.

The space seal centrifugal separator combination requires a continuous supply of sealing water at a pressure determined by the turbine operating conditions to establish the air-water seals, and this sealing water supply must be continually regulated in quantity and pressure.

The present invention provides means whereby this continuous supply of sealing water to the space seal centrifugal separator combination is provided by the leakage of water through the gaps between the outer periphery of the runner and the adjacent stator structure, this leakage water being fed internally and automatically to the sealing means in the required quantity and at the required pressure. Furthermore, air is supplied to the aerated shroud spaces at a pressure in excess of that demanded by the operating conditions of the machine, the air then expanding automatically to the correct operating pressure.

The configuration of the turbine, in accordance with the present invention, permits the escape of just sufficient air from the aerated spaces to maintain optimum aeration conditions, while preventing entry of water into the aerated spaces.

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In the preferred execution of this invention, as embodied in a low specific speed francis turbine, the leakage water, once it has passed through the peripheral gaps, is diffused through annular diffusing passages into the outer band and crown shroud chambers. The passage of the leakage water through the annular diffusing passages reduces the velocity of the water, and thus increases the pressure, to provide some pressure head recovery which, when added to the pressure head due to the height of the water in the outer shroud chambers above the centrifugal separators, balances the pumping action of the centrifugal separators.

It is, therefore, the main object of the present invention to provide, in a francis type turbine wherein fluid friction is reduced by maintaining the spaces between the outside surfaces of the runner shrouds and the adjacent stator structure filled with air, improved means for maintaining this air in these spaces, whereby leakage water from the leakage at the runner outer periphery, is fed internally, and automatically, to the sealing means, in the required quantity and at the required pressure.

Another object of the present invention is to provide, in a turbine of the type set forth, a continuous supply of air to the aerated shroud spaces which is at a pressure in excess of that demanded by the operating conditions of the turbine and this air then expanding automatically to the correct operating pressure, the configuration of the turbine permitting the escape of excess air from the aerated shroud spaces, in just sufficient quantity to maintain optimum aeration conditions, while preventing entry of water into the aerated spaces.

These and other objects and advantages of the present invention will be further apparent by reference to the following detailed specification and figures, in which:

FIG. 1 is a fragmentary diametral sectional view of a low specific speed francis type turbine embodying the features of the present invention.

FIG. 2 is a fragmentary sectional view of the band shroud and stator structure shown in FIG. 1, but showing the runner stationary and water flowing through the turbine.

FIG. 3 is a fragmentary sectional view similar to FIG. 2, but showing the runner rotating and air injected into the inner shroud space.

FIG. 4 is a fragmentary sectional view similar to FIG. 3, but showing the continuing supply of air now completely filling the inner shroud space.

FIG. 5 is a fragmentary sectional view similar to FIG. 4, but showing the continuing supply of air now leaking past the baffle outer periphery into the outer shroud space and depressing the level of the water therein.

FIG. 6 is a fragmentary sectional view similar to FIG. 5, but showing the continuing supply of air now further depressing the level of the water in the outer shroud space, thus reducing the back pressure on the centrifugal separator and permitting limited air leakage therethrough. This represents the stable operating condition.

FIG. 7 is an enlarged fragmentary sectional view of the band centrifugal separator, shown encircled in FIG. 6.

Referring now to the figures, wherein similar reference numerals designate corresponding parts throughout the several views, and with particular reference to FIG. 1, during the operation of this machine, water under pressure passes from the inlet casing 11 and is directed by stay vanes 12 and the wicket gates 13 to the runner, shown generally at 14, and is discharged at a reduced pressure into the draft tube 15.

Runner 14 comprises runner blades 16 connected together by band shroud 17 and crown shroud 18, and with shaft 19 connected to crown shroud 18.

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Stationary band baffle 20 is attached to band stator 21 and is positioned to divide the space between band shroud 17 and band stator 21 into band inner shroud space 22 and band outer shroud space 23. The attachment of band baffle 20 to band stator 21 is shown at 20a and is designed to permit essentially unrestricted radial flow of leakage water in band outer shroud space 23.

Stationary crown baffle 24 is attached to crown stator 25 and is positioned to divide the space between crown shroud 18 and crown stator 25 into crown inner shroud space 26 and crown outer shroud space 27. The attachment of crown baffle 24 to crown stator 25 is shown at 24a and is also designed to permit essentially unrestricted radial flow of leakage water in crown outer shroud space 27.

Air under pressure is injected into band inner shroud space 22 and crown inner shroud space 26 through pipes 28 and 29, respectively, to provide the required reduction in fluid friction on the outside surfaces of band and crown shrouds 17 and 18, respectively.

A band space seal 30 is formed between the outside diameter of the lower portion of runner 14 and the inside diameter of the adjacent stator structure and provides a minimum clearance annular seal. A further space seal 30a is formed by the restricted annular space between the inner periphery of band baffle 20 and the adjacent outside surface of band shroud 17. Band centrifugal separator 31 is positioned between band space seal 30 and space seal 30a.

A crown space seal 32 is formed between the outside diameter of the upper portion of runner 14 and the inside diameter of the adjacent stator structure and provides a minimum clearance annular seal. A further space seal 32a is formed by the restricted annular space between the inner periphery of crown baffle 24 and the adjacent outside surface of crown shroud 18. Crown centrifugal separator 33 is positioned between crown space seal 32 and space seal 32a.

Extending downwardly from the lower surface of stationary band baffle 20 is a band annular wall 34, which extends to a point below band centrifugal separator 31 and forms the end wall of an annular chamber therefor.

Extending upwardly from the upper surface of stationary crown baffle 24 is a crown annular wall 35, which extends to a point above crown centrifugal separator 33 and forms the end wall of an annular chamber therefor. A further annular wall 36 extends downwardly from the inner surface of crown stator 25, on a greater diameter than the diameter of crown annular wall 35.

Small diameter holes 37, positioned through stationary band baffle 20 close to the outer periphery, permit communication between band inner shroud space 22 and band outer shroud space 23. Small diameter stand pipes 38, positioned through stationary crown baffle 24, permit communication between crown inner shroud space 26 and the upper region of crown outer shroud space 27.

During the passage of water through runner 14, leakage takes place through peripheral gaps 39 and 40 formed between the outer peripheries of band and crown shrouds 17 and 18, respectively, and the adjacent stator structure.

The leakage water, which passes through peripheral gap 39, flows through annular diffusing passage 41 and into band outer shroud space 23. Diffusing passage 41 is formed between annular wall 42, which extends downwardly from the outer periphery of band baffle 20, and the adjacent inside diameter of band stator 21.

In a similar manner, the leakage water, which passes through peripheral gap 40, flows through annular diffusing passage 43 and into crown outer shroud space 27. Diffusing passage 43 is formed between annular wall 44, which extends upwardly from the outer periphery of crown baffle 24, and the adjacent inside diameter of crown stator 25.

Thus, diffusing passages 41 and 43 present passages having increasing cross-sectional areas leading from

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the peripheral gaps to the outer shroud spaces, and serve to reduce the velocity, and hence increase the pressure, of the leakage water flowing therethrough.

It will be understood that the configuration of diffusing passages 41 and 43 are in accordance with the preferred embodiment of this invention and that other configurations, having the aforementioned characteristics, may also be used. One such configuration may consist of substantially parallel annular passages, through which the leakage water flow from periphery gaps 39 and 40 and into outer shroud spaces 23 and 27, respectively, and having radial vanes extending across the parallel annular passages. The radial vanes will be tapered, in the direction of leakage water flow, to provide the required increasing cross sectional areas of the annular passages.

The following description of the operation of the complete turbine is based on observations made during laboratory tests.

Refer now to FIGS. 2 to 7 which show the stages of band aeration from stationary runner to the stable operating condition, with the understanding that the conditions depicted in these figures, together with the following description, will also apply to crown aeration. Also, for any particular operating condition of the turbine, the water pressure at peripheral gaps 39 and 40 is essentially constant.

FIG. 2 shows a fragmentary sectional view of the band shroud and stator structure with runner 14 at rest and with water flowing through the turbine, shroud spaces 22 and 23 being filled with water.

FIG. 3 shows a fragmentary sectional view similar to FIG. 2, but with runner 14 running up to normal operating speed and the commencement of air injection, through pipe 28, into band inner shroud space 22. Rotation of runner 14 imparts a rotary motion to the water in inner space 22 thereby subjecting it to centrifugal force. The air expands as it enters inner space 22 and centrifugal separation takes place between the air and the water, due to the difference in densities, resulting in the accumulation of air in the region of inner space 22 closest to the axis of turbine rotation, while the water is displaced radially outwards.

FIG. 4 shows a fragmentary sectional view similar to FIG. 3, but with the continuing supply of air having completely filled inner space 22 and with the air commencing to creep along the space between stationary radial face 45 of band baffle 20 and the opposing rotating radial face 46 of centrifugal separator 31 (see FIG. 7), as shown at 47 in FIG. 4. In this condition the air is also about to escape through the gap between the outer peripheries of band baffle 20 and band shroud 17.

FIG. 5 shows a fragmentary sectional view similar to FIG. 4, but with the continuing supply of air now causing some air to leak past the outer periphery of baffle 20 and collect in the annular pocket formed by annular wall 42 and band baffle 20, thus depressing the level of the water in outer shroud space 23 and reducing the back pressure on the water between stationary and rotating radial faces 45 and 46, respectively. This reduction in back pressure allows the air-water separation surface to move to the outer periphery of centrifugal separator 31, as shown at 48.

FIG. 6 shows a fragmentary sectional view similar to FIG. 5, but with the continuing supply of air now causing further leakage of air past the outer periphery of baffle 20 and producing further depression of the level of the water in outer shroud space 23. This produces further reduction in the back pressure on the water between stationary and rotating radial faces 45 and 46, respectively, and allows a small quantity of air to be carried by turbulence through the air-water separation surface 48 and be carried through space seal 30 to draft tube 15.

This condition represents the stable operating condition of the turbine whereby excess air is allowed to escape in-

wardly from inner shroud space 22. This balanced condition is dependent upon the turbine operating conditions, whereby under certain operating conditions the constant air input through pipe 28 will result in an increase in the excess air, resulting in further depression of the water level in outer space 23, further reduction of the back pressure on centrifugal separator 31 and allowing an increased quantity of excess air to escape from inner shroud space 22. Similarly, where operating conditions produce a decrease in the excess air supplied through pipe 28 the water level in outer shroud space 23 will be raised, increasing the back pressure on centrifugal separator 31 and thus allowing less air to escape from inner shroud space 22.

FIG. 7 is an enlarged fragmentary sectional view of the band centrifugal separator, shown encircled in FIG. 6, and showing in detail the stable condition whereby excess air is breaking through air-water separation surface 48 and is being carried through space seal 30 to the draft tube 15.

The water flowing continually through diffusing passage 41 and into outer shroud space 23 produces a measure of pressure head recovery. The physical dimensions of diffusing passage 41, and thus the degree of pressure head recovery obtained therefrom, are designed for the particular turbine installation, such that the pressure head due to the height of water in outer shroud space 23 above centrifugal separator 31, plus the pressure head recovered from diffusing passage 41, will balance the pumping action of centrifugal separator 31 and thus produce the stable condition wherein excess air is allowed to leak inwardly from inner shroud space 22.

It should be noted that the ratio of water continually flowing through space seal 30 from outer shroud space 23 to air escaping from inner shroud space 22 and passing through space seal 30, is very large, thus in no way disturbing the required water lubrication of space seal 30.

The air, injected into the inner shroud spaces, is supplied from a suitable source at a pressure not less than the water pressure at the runner outer periphery and in controlled quantity sufficient to maintain the aerated spaces filled with air, plus a small leakage therefrom.

This feature, which permits a small air leakage from the inner shroud spaces, emphasizes a particular advantage of the present invention which is that an excess quantity of air can be supplied to the inner shroud spaces, thus allowing the air to be supplied in constant quantity and not requiring a fine control of the air pressure.

One example of a source of suitable high pressure air, for injection into the inner shroud spaces, is a constant displacement pump.

If the injection of air into inner shroud spaces 22 and 26 is delayed until runner 14 has reached a relatively high rotational speed, it may be necessary to purge the shroud spaces with a high initial air flow for a short period of time in order to completely evacuate the spaces of water, as fully described in U.S. Patent No. 3,044,744.

Holes 37, of restricted diameter, through band baffle 20 will permit air entrapped in band outer shroud space 23 to escape to band inner shroud space 22 and, similarly, stand pipes 38, of restricted diameter, through crown baffle 24 will permit air entrapped in the upper region of crown outer shroud space 27 to escape to crown inner shroud space 26, thus permitting change in the level of water in the outer shroud spaces in response to change in turbine operating conditions.

Annular wall 34, extending downwardly from band baffle 20, prevents air in the band outer shroud space 23 from escaping through band space seal 30 and, similarly, annular wall 36, extending downwardly from the inner surface of crown stator 25, prevents air in the upper region of crown outer shroud space 27 escaping through crown space seal 32.

Where the invention is embodied in turbines of higher specific speed in which the configuration of the outer shroud spaces provides sufficient height of water above the centrifugal separators to balance their actions, then

the respective diffusing passages 41 and 43 may be omitted.

This invention has been described as embodied in a vertical francis type hydraulic turbine but it will be understood that it could equally well be applied to pumps and other hydraulic machines of the type previously set forth.

From the foregoing it will be seen that the present invention provides a new and improved means for accomplishing all of the objects and advantages as set forth.

What we claim is:

1. A rotary hydraulic machine comprising a rotor having peripheral portions of different diameters, a stator structure enclosing the rotor and having a water inlet through which water is delivered to the rotor, and a water outlet through which water passes from the rotor, the peripheral edges of the rotor and the portions of the rotor lying between said peripheral edges being spaced from opposing walls of the stator structure to provide a circumferentially extending space between the rotor and the stator structure, at least one stationary baffle member dividing said space into inner and outer chambers communicating with each other at opposite edges of said baffle member which are spaced from the rotor and the stator structure, the peripheral edge of the baffle member remote from the axis of the rotor and adjacent to said water inlet, forming a flange extending angularly with respect to the baffle to form an annular passage, the cross sectional area of said passage normal to the flow of water through said outer chamber increasing progressively in the direction of said flow, and means for introducing air under pressure into said inner chamber formed by and between opposing surfaces of the baffle member and the rotor, the progressively increasing cross sectional area of said passage causing the water adjacent the end of the baffle member remote from the axis of the rotor and adjacent to said water inlet to be maintained at substantially the same pressure as the water adjacent the end of the baffle nearest the axis of rotation to prevent substantial circulation of water through the inner chamber.

2. A rotary hydraulic machine as in claim 1 wherein said flange extends angularly toward said outer chamber.

3. A rotary hydraulic machine comprising a rotor having peripheral portions of different diameters, a stator structure comprised of a band stator and a crown stator enclosing the rotor and having a water inlet through which water is delivered to the rotor, and a water outlet through which water passes from the rotor, the peripheral edges of the rotor and the portions of the rotor lying between said peripheral edges being spaced from opposing walls of the stator structure to provide a first circumferentially extending space between the rotor and the band stator structure and a second circumferentially extending space between the rotor and the crown stator, at least one stationary baffle member located within each of said circumferentially extending spaces dividing each of said spaces into inner and outer chambers communicating with each other at opposite edges of said baffle which are spaced from the rotor and stator structure, the peripheral edge of each baffle member remote from the axis of the rotor and adjacent said water inlet forming a flange extending angularly with respect to the baffle to form annular passages, the cross sectional area of said passages normal to the flow of water through said outer chambers increasing progressively in the direction of said flow, and means for introducing air under pressure into said inner chambers formed by and between opposing surfaces of the baffle members and the rotor, the progressively increasing cross sectional area of said passages causing the water adjacent the end of each baffle remote from the axis of the rotor and adjacent to said water inlet to be maintained at substantially the same pressure as the water adjacent the end of each baffle nearest the axis of rotation to prevent substantial circulation of water through the inner chambers.

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4. A rotary hydraulic machine as in claim 1 wherein the edge portion of said baffle nearest the axis of the rotor and adjacent portion of the rotor is shaped to provide spaced opposing stationary and rotary surfaces lying in planes substantially perpendicular to the axis of the rotor and constituting the stator and rotor elements of centrifugal separators.

5. A rotary hydraulic machine as in claim 3 wherein the edge portion of said baffles nearest the axis of the rotor and adjacent portion of the rotor being shaped to provide spaced opposing stationary and rotary surfaces lying in planes substantially perpendicular to the axis of the rotor and constituting the stator and rotor elements of centrifugal separators.

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References Cited by the Examiner

UNITED STATES PATENTS

1,516,095	11/1924	Haerberlein.	
1,516,822	11/1924	McCormack	----- 253—117
1,823,702	9/1931	Ring.	
3,081,975	3/1963	Sproule et al.	----- 253—26
3,172,640	3/1965	Sproule	----- 253—26

FOREIGN PATENTS

10	714,290	11/1941	Germany.
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