

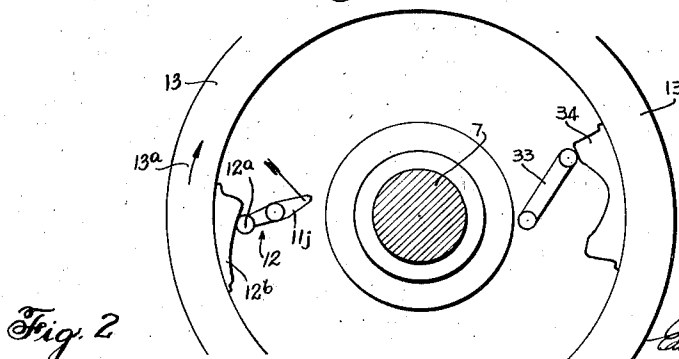
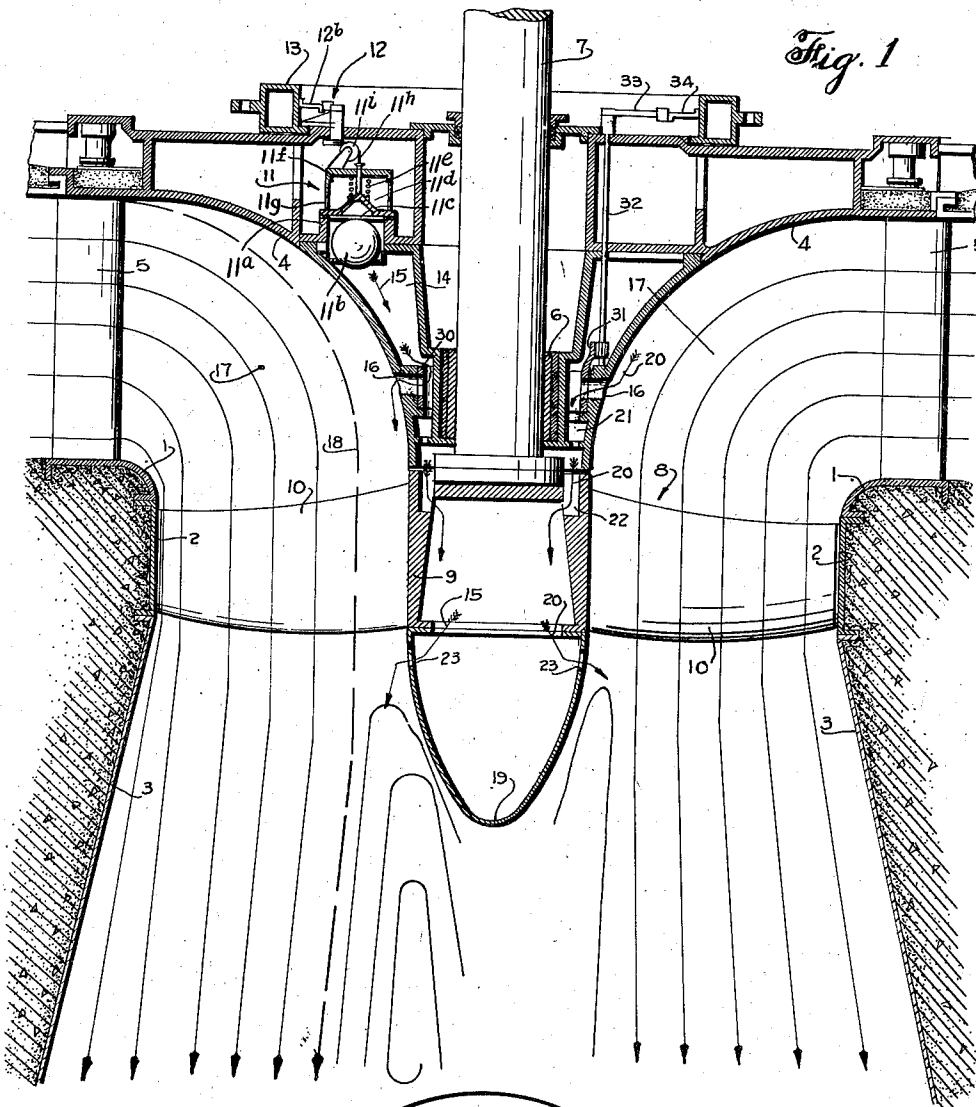
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S. L. KERR

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CAVITATION CONTROL OF HYDRAULIC MACHINES

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INVENTOR
S. L. KERR

BY

Edward J. McQuay
ATTORNEY

UNITED STATES PATENT OFFICE

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CAVITATION CONTROL OF HYDRAULIC MACHINES

Samuel Logan Kerr, Philadelphia, Pa., assignor to
Baldwin-Southwark Corporation, a corporation
of Delaware

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This invention relates generally to rotary hydraulic machines such as hydraulic turbines or pumps and more particularly to improved means for controlling or correcting cavitation.

A great many attempts have been made to correct or control cavitation in hydraulic machines and various theories have been advanced as to the cause of cavitation. It is known that cavitation may occur during full gate operation of a machine depending upon various conditions of design or operation, and it is also known that cavitation may occur very materially during part gate operation. The usual manner of correcting cavitation is to allow air to flow into the fluid stream thereby filling any voids within the flow passages particularly below the runner. However, during full gate operation this method is not adapted to be fully or effectively used to completely eliminate cavitation.

It is one object of my invention to provide an improved method and arrangement whereby cavitation may be effectively controlled or corrected during either full or part gate operation. Another object is to provide improved means whereby water may be employed to effect the desired correction.

A still further object is to provide improved means whereby usual air inlet passages for part gate operation may be employed to divert a part of the fluid stream during full gate operation and to discharge this diverted water below the runner in such a manner as to fill the usual voids that occur or cause eddy currents. It will of course be understood that passages other than the air inlet openings may be employed to divert this fluid stream to a point below the runner but in the preferred embodiment of the invention the air inlets are adapted also to perform the water diverting function.

As a result of my improved invention, it has been found in actual practice that a materially improved mode of operation is effected including elimination or minimizing of vibration of the unit and also of improving the efficiency thereof.

Other objects and advantages will be more apparent to those skilled in the art from the following description of the accompanying drawing in which:

Fig. 1 is a vertical section through a hydraulic machine of the high specific speed propeller type although the invention is equally applicable to Francis turbines in accordance with the disclosure herein;

Fig. 2 is a sectional plan view to show cams for operating the air valve and auxiliary port valve.

In the illustrated embodiment of the invention which is shown herein merely for the purpose of disclosing one specific form among others that the invention might take, I have provided a suitable passage wall 1 turning from a radial toward an axial direction as at 2 and continuing into a suitable draft tube 3. The walls of these elements are formed as surfaces of revolution with the wall 2 preferably slightly contracting in the direction of flow. A head cover 4 may be suitably supported in a foundation or by stay vanes. Also usual wicket gates 5 may be pivotally adjustably supported about their vertical axes to effect part or full gate operation. The head cover 4 may be of any usual or desired form having, for instance, a suitable bearing 6 to guide a runner shaft 7 which carries a runner generally indicated at 8. This runner includes preferably a hollow hub 9 and a series of preferably substantially radially extending unshrouded blades 10 which may be of either the fixed or adjustable blade type. Also any well-known or suitable type of propeller or Francis runner may be employed in my improved arrangement as will be evident from the disclosure herein.

An air valve 11 of any suitable form may be manually controlled or if desired automatic means generally indicated at 12 may be actuated from a usual shifting ring 13 whereby upon a predetermined part gate position of shifting ring 13 and wicket gates 5, valve 11 will open to admit air therethrough. This air will thence flow downwardly within the hollow portion 14 of the head cover and discharge as indicated by arrows 15 through any desired number of vents or ports 16 and 23. The air in flowing into transition space 17 formed between guide vanes 5 and runner blades 10 will fill any voids in the water column caused by part gate operation. Such a space may exist between the dotted line 18 and the wall of the cover 4 and runner hub 9. The air will thus flow downwardly into this space and below a usual hub tip 19 to prevent excessive eddy currents or cavitation, a tip or cap 19 constituting broadly a part of said hub.

The air valve 11 comprises generally a cage 11a in which a float ball check 11b is disposed and adapted in case water should back up into space 14 from the flow passage to close orifice 11c. However, normally float check 11b is in its lower position as shown, thereby not obstructing flow of air from port 11c downwardly around ball 11b to chamber 14. Port 11c is normally closed by a conical valve member 11d urged downwardly by spring 11e interposed between the valve

member and a cap 11f having lateral air ports 11g. To open the air port 11c a flexible cord 11h is connected to valve 11d and passes over a pulley 11i for connection to the outer end of a lever 11j forming a part of the cam control mechanism generally indicated at 12. This lever is pivotally supported to permit the cam follower 12a to ride upon cam 12b. Due to the shape of cam 12b, valve 11d is open during part gate operation but is closed during further opening movement of the gates as by operation of the shifting ring 13 in the direction of arrow 13a.

During full gate operation the passages are assumed to be completely filled with water and the turbine if properly designed is supposed to function without cavitation. However, such theoretical conditions are not always possible and due to the undesirable presence of air or voids during full gate operation, I have provided a relatively simple means for correcting or controlling cavitation during full gate operation. To accomplish this, after the valve 11 is closed automatically upon a predetermined opening of the gates 5, water will then flow as indicated by arrow 20 from the transition space through port 16 and into the space 14 from which the water continues downwardly through a series of openings 21 and passages 22 formed in hub 9 to pass through the hollow portion of the hub and thence discharge through the series of outlet ports 23 formed in the hub cap or tip 19. The water in emerging below the runner blades or on the discharge side thereof will fill any voids or eliminate excessive eddy currents adjacent this point of usual cavitation.

Hence it is seen that I have provided a relatively simple arrangement which has been found to be highly effective in practice to correct or control cavitation during either full or part gate operation without requiring complicated controls or close attention by the attendants. It is also seen that the cavitation control during substantially full gate will occur automatically and that if no cavitation conditions exist, then substantially no fluid will be diverted through ports 16 and 23. On the other hand, if cavitation conditions automatically arise, then the fluid flow is automatically diverted in response to such conditions. This is accomplished without in any way impairing the ability to control cavitation during part gate operation by use of air.

The disclosure so far has assumed that ports 16 will be open at all times which is one desired mode of operation under certain operating conditions, although under other conditions it is desirable to variably control ports 16 so that upon initial opening of the wicket gates these ports are open thus allowing air to flow through air valve 11 and ports 16 and 23. Ports 16 are controlled by an annular valve 30 having a gear segment 31 actuated by a pinion on a shaft 32. This shaft carries an arm 33 engaging a cam 34 secured to the shifting ring. The contour of the cam is such as to move ports in annular valve 30 into register with ports 16 during initial gate opening simultaneously with opening of the air valve 11. However, by the time the turbine gates reach a predetermined partially open position, air valve 11 has become closed whereupon further opening of the turbine gates causes valve 30 to be moved to reclose or restrict said ports 16. By the time the gates are moved to full open, then valve 30 has reopened ports 16 but air valve 11 still remains closed. If it is desired to maintain

said ports either full open or closed at all times, it is only necessary to disconnect the cam mechanism 33 and 34 and adjust valve 30 accordingly. Valve 30 and the automatic control can of course be of various types to effect any desired degree of port opening or closing in relation to the air valve.

It will of course be understood by those skilled in the art that various changes may be made in the details of construction and arrangement of parts without departing from the spirit of the invention as set forth in the appended claims.

I claim:

1. A hydraulic machine comprising, in combination, a fluid passage, adjustable gate mechanism therefor, a runner disposed in said passage, means for admitting air to the central portion of said passage during part gate operation, and means for admitting auxiliary streams of water to the central portion of said passage on the discharge side of said runner during substantially full gate operation, thereby to control cavitation throughout operation of said runner.

2. A hydraulic machine comprising, in combination, a fluid passage, adjustable gate mechanism therefor, a runner disposed in said passage, means for supplying air to the central portion of said passage during part gate operation, and means for diverting a portion of the fluid flow from the inlet side of said passage to the central portion of said passage on the discharge side of said runner during substantially full gate operation, thereby to control cavitation throughout operation of said runner.

3. A hydraulic machine comprising, in combination, a fluid passage formed by a head cover, adjustable gate mechanism associated therewith, a runner disposed in said fluid passageway and having a hollow hub rotatably supported by said head cover, ports in said cover communicating with the interior of said hub and with said passage at the central portion thereof below the discharge side of said runner whereby during substantially full gate operation water may be diverted from the inlet side of said passage to the discharge side of said runner, and means whereby during part gate operation air is supplied to said passage through said ports in said cover.

4. A high specific speed propeller type turbine having two modes of operation, one at part gate operation and one at substantially full gate operation, and comprising a runner, a guiding wall leading thereto, means for supplying air to the inlet side of said runner during one mode of turbine operation, and means for supplying auxiliary streams of water to the discharge side of said runner during another mode of turbine operation.

5. A high specific speed propeller type turbine having two modes of operation, one at part gate operation and one at substantially full gate operation, and comprising, in combination, runner blades supported by a hollow hub which is provided with a cap, means forming a passage for said runner including a wall leading to said hub, ports formed in said wall, and in said cap whereby during one mode of turbine operation water may flow into said wall ports and out through said cap ports, and air inlet means adapted to communicate with at least certain of said ports to supply air to the central portion of said passage during another mode of turbine operation.