May 9, 1933. T. VARNEY 1,907,908

FLUID MOTOR

Filed Jan. 16, 1931

Fig. 1.

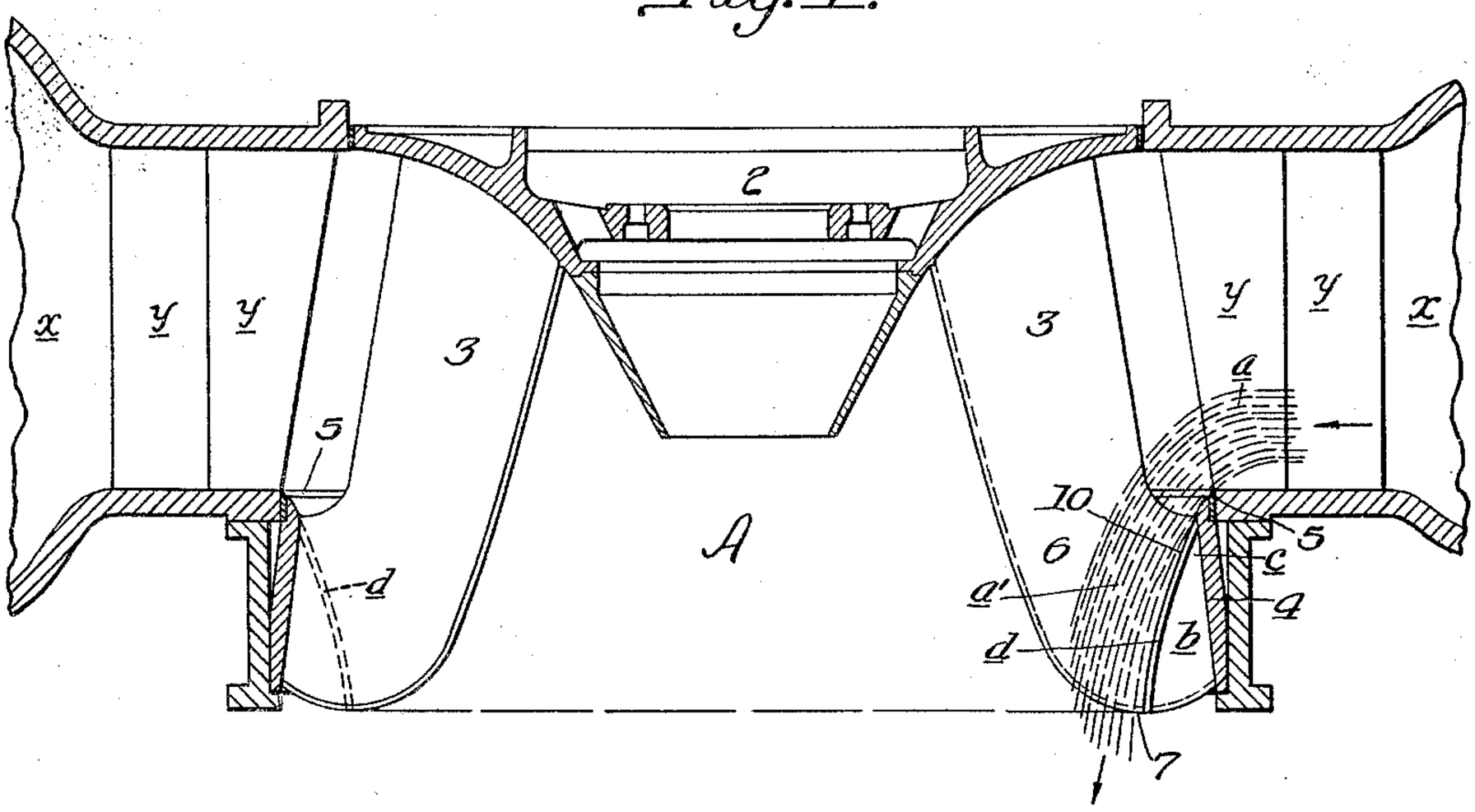


Fig. 2.

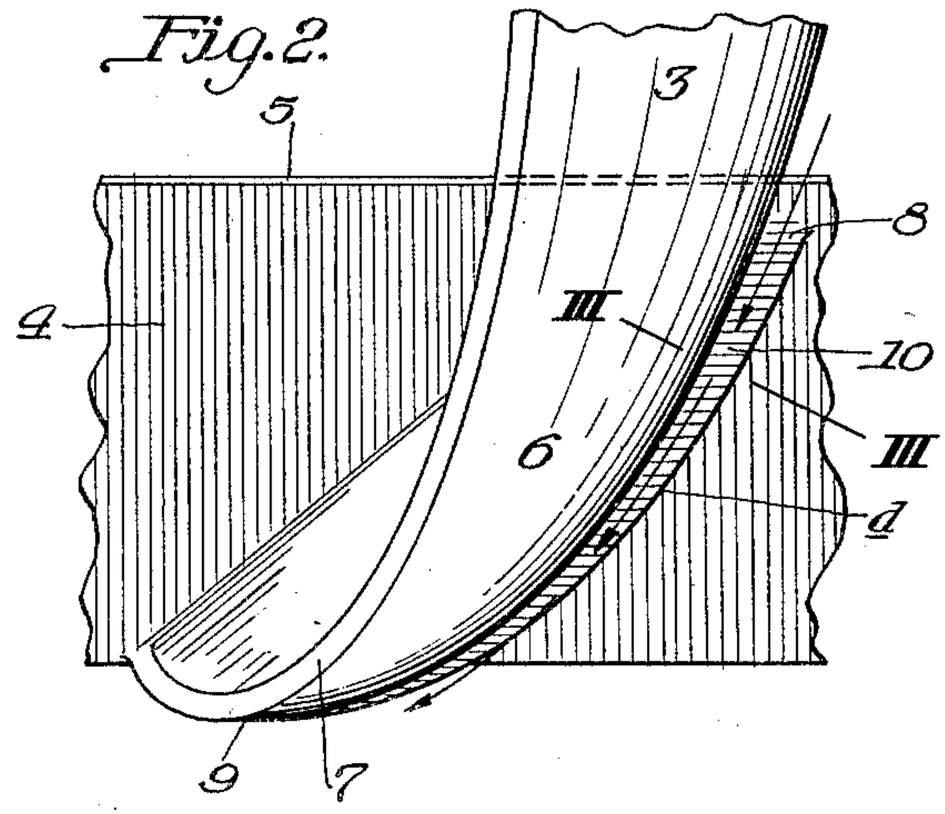
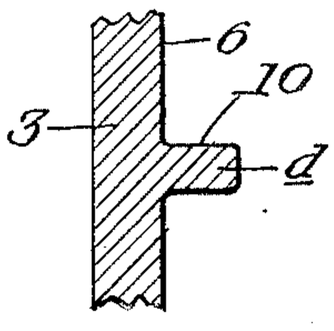


Fig. 3.



INVENTOR.
Theodore Varney
BY W. F. Woodlock
ATTORNEY

Patented May 9, 1933 1,907,908

UNITED STATES PATENT OFFICE

THEODORE VARNEY, OF NEW YORK, N. Y., ASSIGNOR TO ALUMINIUM LIMITED, OF TORONTO, ONTARIO, CANADA

FLUID MOTOR

Application filed January 16, 1931. Serial No. 509,118.

My invention relates to improvements in fluid motors, and more particularly to hydraulic turbines and the construction of rotors or runners therefor. The present application is a continuation in part of my pending application Serial No. 439,497, filed March 27, 1930.

While I have illustrated and described my invention in connection with hydraulic turbines, it should be understood that it is not limited thereto, for my invention may be employed in connection with blades of propellers and the like that are subjected to the harmful effects of pitting.

In prior constructions, the buckets of the turbine rotor or runner rapidly deteriorate by pitting of the metal at the lower portion of the convex surfaces thereof. Such deterioration is especially true in large units where the speed of operation of the turbine and the draft head or vacuum on the discharge side of the runner or rotor are maintained as high as is practicable to minimize the cost of operation.

The said pitting of the runner buckets occurs in well defined zones on the rear convex surfaces, and results from cavitation or the formation of numerous small vacuum pockets, the latter being due to the pulsating and swirling action of the water set up in the edge of the jet as it passes through a low pressure zone between the buckets. The vacuum pockets so formed are conveyed into a zone of higher pressure wherein they collapse and their water envelopes strike the convex surface of the buckets, the impact thereof being effected with the extremely high velocities, whereby the surface metal of said buckets is pitted or worn away.

I have discovered that in operating hydraulic turbines, the velocity of the water jet over the runner band produces a vacuum or a partial vacuum between the jet and the upper edge of the runner band; in other words, there is a rarefied air and/or vapor condition in a zone immediately below the upper edge of the runner band and it is in this zone that cavitation occurs. The vacuum pockets formed in this zone pass on with the jet and cause pitting.

An object of the present invention is to prevent pitting, which results from cavitation, by overcoming cavitation itself or by preventing the formation of the vacuum pockets or the like in the jet.

A further object is to prevent pitting in the manner set forth and at the same time guide the flow of water over the major portion of the convex surfaces of the buckets while in contact with said surfaces.

My invention contemplates providing a barrier or a separating rib positioned upon the rear lower convex surface of the runner bucket and extending from a point adjacent the upper edge of the runner band to the trailing edge of the bucket, whereby the jet impinging upon the bucket is separated from or prevented from reaching the zone of cavitation, as well as the zone of pitting. The said barrier or separating rib is disposed normally with respect to the said convex surface of the bucket, and is formed with a very abrupt surface adapted to contact with and guide the jet until the same passes over the trailing edge of the bucket.

The air or vapor in the area or zone between the runner band and the barrier or rib will, as stated above, become rarefied, thereby providing a medium for the formation of vacuum pockets or vortices should the jet pass thereover. However, by means of the barrier, the water jet is effectively separated from the said rarefied air or vapor area, thereby preventing cavitation, and in turn pitting. By means of the barrier, the jet is confined to the remaining or major portion of the convex surface of the bucket until discharged therefrom over its trailing edge.

Additional objects and advantages will become apparent from the following description taken in connection with the accompanying drawing, wherein:

Fig. 1 is a central vertical section through the hydraulic turbine rotor or runner of the Francis type, illustrating the application of my invention thereto;

Fig. 2 is an enlarged elevational view of the lower portion of a runner bucket, and

particularly showing the position of the barrier or rib thereon; and

Fig. 3, an enlarged detail fragmentary section taken on the line III—III of Fig. 2.

Referring to the drawing, A designates generally an hydraulic rotor or runner of a turbine, of the well known Francis type, adapted for rotation about a vertical axis, and mounted within a suitable casing. As is understood by those skilled in the art, the water jet for this type of turbine is introduced to the rotor or runner from a surrounding scroll case or tube *x* having suitable guide vanes *y* therein to provide a substantially radial flow of said jet, as diagrammatically shown at *a* in Fig. 1.

The rotor or runner A comprises a hub 2 having depending therefrom a plurality of spiral buckets 3. The lower outer portions of said buckets are secured to or integral with a circular runner band 4, which may be mounted in suitable bearings within the turbine casing.

The water jet, a portion *a* being shown, is introduced over the upper or inflow edge 5 of the runner band 4 with considerable velocity, but, due to the action of gravity thereon, said jet passes over the convex surface 6 of the buckets 3 in a parabolic path, as indicated at *a'* in Fig. 1. By reason of this flow, a zone or area of rarefied vapor or air is produced, said zone being free from the main body of the jet but being subjected to the fringe or spray edge thereof. The zone just mentioned is indicated by *b*, and it is in this zone or area that pitting occurs. The pulsating or swirling action of the said jet fringe on the rarefied zone creates a number of minute vacuum pockets or vortices, particularly at the region *c* of the zone *b*, or immediately below the upper runner band edge 5 and between the main body of the jet and the runner band 4.

As the vacuum pockets so formed pass along the bucket, they are collapsed upon approaching the trailing edge 7 of the bucket, due to the increased pressure in that region. The impact of the collapsing water envelopes of said pockets takes place at extremely high velocities, whereby the surface of the bucket is worn away. The pitting of the zone *b*, resulting from the foregoing action, may become so rapid as to materially lessen the life of a turbine rotor or runner. The prevention of this pitting, therefore, becomes a desirable objective in reducing the cost of operating such turbines.

To this end, I have provided a barrier, rib, shelf, or projecting water guide element *d* secured to or formed integral with each of the buckets 3 of the turbine rotor or runner A, of such construction and positioned in such a manner as to prevent the formation of cavitation, vacuum pockets, or vortices in the jet, thereby eliminating the cause of pitting of the buckets. Said barrier or rib *d* is a plate-like projecting element, and is positioned on the lower convex surface 6 of a bucket, normally disposed with respect to said surface, and extending from a point adjacent the upper edge 5 of the runner band 4 to the trailing or discharge edge 7 of the bucket. The plane of the barrier, rib, or shelf is curved to conform with the natural curve of the jet, which, under the combined action of its momentum and gravity, approximates a parabola. Its position on the convex surface of the bucket is such that it forms an efficient barrier to separate the water jet, and more specifically the parabolic portion *a'* thereof, from the said rarefied air space or zone, and cavitation of that portion of the jet is prevented.

To insure the separation of the jet from said zone and region, the barrier *d* is tapered in height from a maximum at 8, adjacent the upper edge 5 of the runner band, to a minimum at 9, on the trailing edge 7 of the bucket. The inner or front face 10 of the barrier or rib is abruptly formed and is preferably perpendicular to the convex surface 6 to facilitate the passage of the jet over the convex surface, and for positively separating said jet from the region *c* of the zone *b*.

Hence, the jet *a* is prevented from passing over the region *c* or the pitting zone *b*, due to the comparatively high portion 8 of the barrier or rib *d*, and the parabolic portion *a'* of said jet is completely separated from the said zone by means of the barrier. Thus, when applied in the manner stated, the barrier or rib prevents the pitting heretofore encountered by preventing cavitation or the formation of the vacuum pockets or vortices in the jet. In addition, the jet is confined to the major portion of the convex surface 6 and is maintained in intimate contact therewith until discharged over the trailing edge of the bucket.

While I have shown my invention as applied to the Francis type of turbine, it is to be understood that it is not to be limited thereto, but may be applied to other turbine runners, and altered or modified within the scope of the following claims.

I claim:

1. In a hydraulic turbine, a turbine rotor including a bucket having an extensive convex surface and a runner band, means for directing a jet to the runner, and means for preventing cavitation of said jet adjacent the inflow edge of the runner band including a projecting flow guide element on the said convex surface extending in the direction of flow and of sufficient height to prevent the jet passing thereover, said flow guide element extending from adjacent the inflow edge of the runner band over the convex surface to the trailing edge of the bucket.

2. In a hydraulic turbine, a turbine rotor including a bucket having an extensive convex surface and a runner band, means for

directing a jet to the runner, and means for preventing cavitation of said jet adjacent the inflow edge of the runner band including a projecting flow guide element carried by the runner and of sufficient height to prevent the jet passing thereover, said flow guide element extending from adjacent the inflow edge of the runner band over the convex surface to the trailing edge of the bucket and being of greater height at its end adjacent the runner band than at its lower end.

3. A turbine rotor of the Francis type having a bucket formed with a rear convex surface and a runner band, a projecting water guide element on the convex surface extending in the direction of flow and of sufficient height to prevent the jet passing thereover, said element being tapered and curved and formed with an abrupt front face.

In testimony whereof I affix my signature.

THEODORE VARNEY.