Sept. 11, 1923. 1,467,672

V. KAPLAN

TURBINE

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FIG. 1.

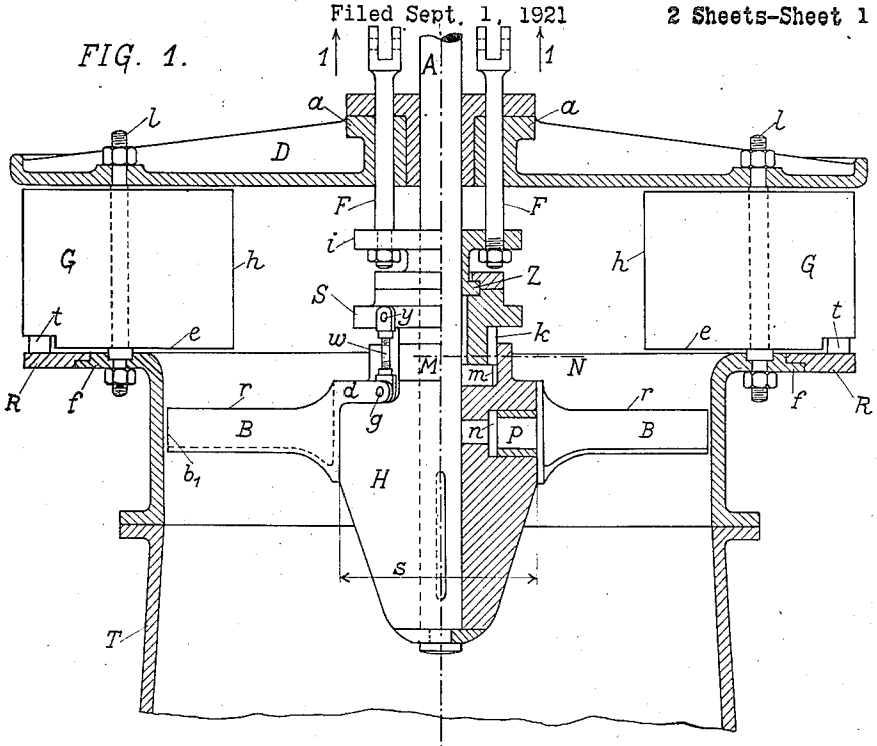
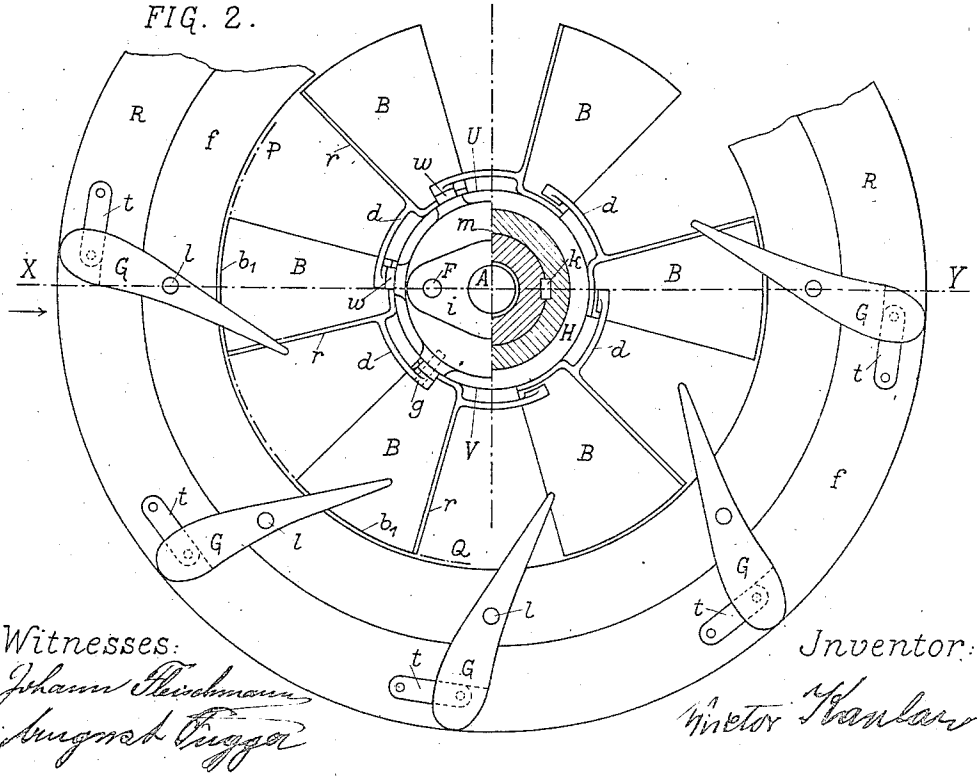


FIG. 2.



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TURBINE

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FIG. 3.

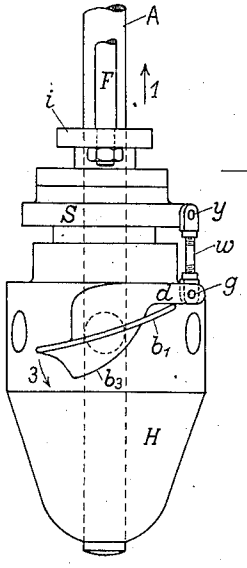


FIG. 4.

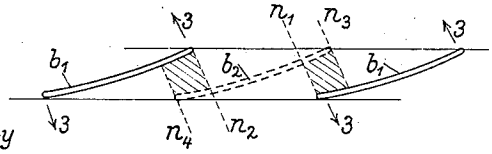


FIG. 5.

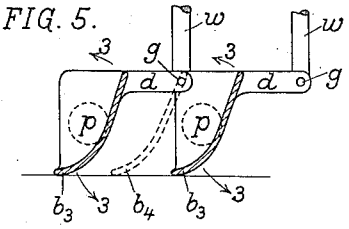


FIG. 7.

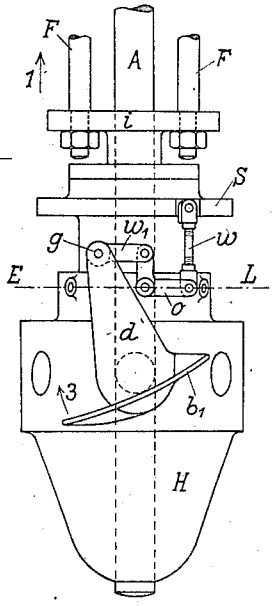


FIG. 6.

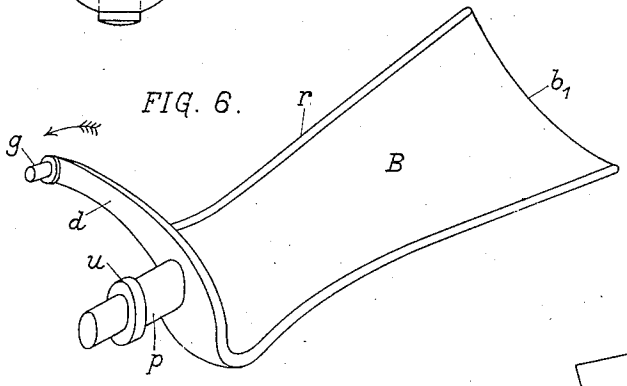


FIG. 8.

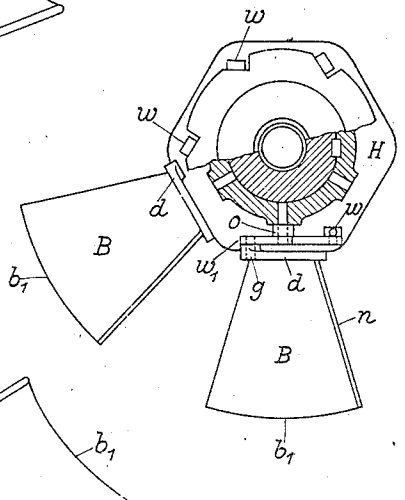


FIG. 10.

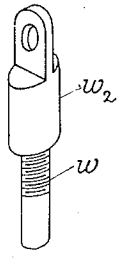
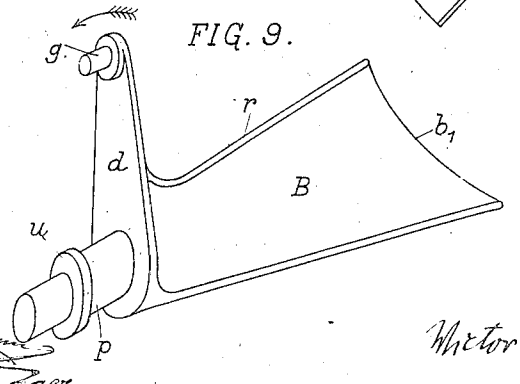


FIG. 9.



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UNITED STATES PATENT OFFICE.

VICTOR KAPLAN, OF BRUNN, AUSTRIA.

TURBINE.

Application filed September 1, 1921. Serial No. 497,680½.

To all whom it may concern:

Be it known that I, VICTOR KAPLAN, a subject to the Emperor of Austria, residing at the K. K. Deutsche Technische Hochschule at Brunn, Mahren, Austria, have invented certain new and useful Improvements in Turbines, of which the following is a specification.

My invention relates to improvements in turbines, and more particularly of that type described in my application Serial No. 854149, dated June 30, 1914. The improvements described in said application have reference to means for governing the admission of water to turbine-wheels, said means consisting in a rotor wheel for turbine machines comprising a series of rotatably mounted runner blades adapted to vary their inlet and outlet angles by being rotated and thereby to alter the inlet and outlet passages of the rotor wheel both according to the supply of the driving medium and the demand for work to be done.

By my present invention I succeed in so governing the admission that high-speed turbines will show high efficiency not only when the full admission but also when the admission is considerably reduced. This result I obtain by employing a series of wing-shaped blades rotatably mounted on the hub of the rotor-wheel. Moreover, I so shape the blades as to allow mainly axial admission.

The device of admitting the driving medium is adjusted in such a manner as to offer the least possible resistance to the free passage of the driving agent.

In the drawings herewith, in which I have shown my invention, by way of illustration.

Fig. 1 is a vertical section through the turbine, the right half showing a vertical section of the inner parts;

Fig. 2 is a plan view of Fig. 1, with the cover removed, the right hand side being a section along line M—N of Fig 1,

Fig. 3 is a side-elevation of the regulating or governing device;

Fig. 4 is a view of the outer ends of the blades;

Fig. 5 is a view of the inner ends of the said blades with the curved crank-shaped arms;

Fig. 6 is a perspective view of a runner blade formed integral with its crank arm and its end pivot.

Fig. 7 is a similar view as Fig. 3, showing modification of the regulating device.

Fig. 8 is a plan view, partly in section, of Fig. 7;

Fig. 9 is a perspective view of a runner blade, adapted to be employed in connection with the modification shown in Figs. 7 and 8, and

Fig. 10 is an enlarged view of a detail of the regulating device.

The turbine is equipped with a guide-wheel which may be constructed in the usual manner.

Said guide wheel comprises a series of vanes G, mounted, each, on a fixed pivot 1, the upper end of which, being threaded, extends upwards through the cover D, while the lower end extends downwards through the horizontal flange of the suction tube T, near the governing ring R. At a convenient distance below the lower edges of the guide vanes G the runner is located, consisting of a series of blades B, provided with trunnions placed in bearings of the regulating hub H and adapted to turn within said hub. The force of reaction exercised by the waterflow on the surface of the runner blades will be transmitted to the hub H and from the latter to the shaft A of the turbine, to which the hub is keyed. The water having exhausted its driving power in the machine, flows off through pipe T to a waste-channel.

The blades of the runner wheel may be adjusted as follows:

Each blade B has a projecting arm *d*, from which extends a crank-pin *g* in the same direction as the trunnion *p*, by which the said blade can turn within the hub H. The trunnion *p* is provided with a collar *u* (Figs. 6 and 9) for preventing its being displaced within the bore of the hub H. *w* is a connecting rod having yokes screwed to its upper and lower ends, the eye of the lower yoke being engaged by the said crank-pin *g* and the eye of the upper yoke by a bolt *y* connected to a sleeve S. The said sleeve S as well as the hub H are provided with guide-surfaces *m* (Fig. 1 and 2) providing for an axial displacement of the sleeve S. A key *k*, however, forces the said sleeve to participate in the rotary motions of the hub H. Near the upper end of the sleeve S a step-bearing is provided, into which fits the collar *z* (Fig. 1) of a tubular piece *i*, to which a vertical motion may be imparted

by the rods F, adapted to move in lugs *a* of the turbine casing. The upper ends of said rods F may be connected to levers, or any other means, by the aid of which the axial displacement of the said guide-rods may be effected by hand or mechanically.

If therefore, the rods F be moved upwards in the direction of the arrows 1 (Fig. 1), the sleeve S will be caused by the collar *z* to move in the same direction and, by means of the arms *d*, the blades B will be turned about their trunnions *p* in the direction of the arrows 3 in Figs. 3, 4 and 5. The angle of admission of the blade, thereby, will not only be increased, but also the area of the passage through the runner, and, thereby, the output of the turbine, without any material loss caused by eddies and shocks. If on the other hand, the rods F are moved downwards, the blades B will be turned in the opposite direction, narrowing the passage through the wheel and thereby diminishing the effective output.

As will be seen from Fig. 5 the arm *d* of the blade B extends about midway between two adjacent blades B. In an arrangement of this kind the length of the blade-arms *d* depends on the number of blades employed.

To allow the arms *d* to be given sufficient length where a large number of blades are used, I have constructed the modification shown in Figs. 7 to 9. In this case the arm *d* has such an inclination relative to the blade as to permit its being lengthened without interfering with the adjacent blades. Each increase of inclination of the arm relative to the blade, however, will increase the amount of force required for turning the blades. For this purpose I provide for each blade a double lever O (Fig. 7) pivoted to the hub H. The ends of said levers O are connected, respectively, with the crank-pin *g* and to the sleeve S by means of separate connecting rods *w* and w_1. The operation of this modification, is much the same as that described before except that by moving the sleeve S the blades will be moved in the reverse direction as before.

In order to provide for equal lengths of the connecting rods *w* and w_1 and to establish uniformity of the position of the crank arms *d* and of the blades B, relative to the shaft A, the length of the members *w* and w_1 can be adjusted. As will be seen from Fig. 10, the length of the rods *w* may be increased or shortened by screwing upon it an adjustable piece w_2.

Since the hub H and the regulating device are enclosed within the casing of the turbine, it is evident, that the diameter of the hub must be reduced as much as possible to allow of a sufficient passage for the driving water. Also it will be evident that the arrangement of the regulating device concentrically with, and in close proximity to the axis of the runner will be apt to reduce all frictional resistances caused by the water, as in wheels having a great number of revolutions, there still exist little peripherial velocities and such velocities used to cause trifling losses owing to the friction of water. It will, further, be evident, that by locating the regulating device in close proximity to the axis of the runner-wheel the centrifugal influence of the revolving parts will be greatly lessened.

In Fig. 4 I have shown the development of two adjacent outer edges of blades B, near the suction tube T, and it will be seen, that the normal trajectories n_1 and n_2 drawn from the blade sections b_1, b_1 do not intersect the adjacent profile. This arrangement of the blades offers the particular advantage of reducing the number of blades as compared with other turbines, even if the length of the blades should be equal or approximately equal. The fewer the blades, the more easily can be constructed their bearings within the regulating hub which has the advantage of enabling the diameter *s* (Fig. 1) of the hub to be reduced.

In Fig. 4 I have further indicated by broken lines another blade section b_2, to point thereby the space taken by an adjacent blade in the case of the doubling of the runner blades. It will be seen, that by so doubling the number of the blades, the normal trajectories n_3 and n_4 are drawn, which, together with the other normal trajectories n_1 and n_2, determine a channel-shaped space between the blades b_1 and b_2, the said space being indicated in Fig. 4 by cross-hatching. A cell-shape of this form, however, would not only materially increase the frictional resistance of the turbine, but also be objectionable as to the convenient arrangement of the bearings of the trunnions within the hub, as will be understood from Fig. 5. In the said figure I have indicated the development of two blade sections b_3, b_3, in proximity to the hub of the runner. Owing to the decrease of pitch with relation to the axis of the turbine, the respective distance between the sections has been equally reduced, but it is still sufficient to properly place the trunnions *p* of the blades in the hub H. Also the length of the arms *d* can still be selected of sufficient size to allow of conveniently turning the blade with little exertion and without interference with the adjacent blades. If the blades be doubled (i. e. if the blade b_4 shown in broken lines in Fig. 5 is drawn in full) it will be seen, that not sufficient room would be left for placing the trunnions of the blade in the hub, nor for conveniently placing the arms *d*.

The object of my invention, further, is to improve the position and the shape of the entrance edges *r* of the blades B. The said blades running at very high speed are very

much affected by the centrifugal force. Any tendency to deform the blades by the resistance of such forces will best be overcome by causing the blades to extend in a radial direction from the hub towards the wall of the suction-tube T. An arrangement of the kind requires, as an essential feature, a substantially radial course of the entrance edge of the blade. It is immaterial, however, whether said edge extends in a straight line or in the shape of a curve, if only the general feature of a radial or slightly inclined course of the entrance edge be adopted. For instance, I prefer to increase the breadth of the blade in the axial direction towards the axis, as indicated in Fig. 1, in order to increase the security of the blades against being deformed by the counteracting pressure of the water. The admission on the blade, therefore, is arranged, in general, in the axial direction.

The adjustment of the guide vanes is carried out in the usual manner by turning an adjustment ring R to which the vanes G are secured by links *t*, the vanes G turning round the bolts *l*. The arrangement may be modified so that the guide-vanes are caused to turn simultaneously with the runner-blades, as it has been fully described in my above said application No. 854,149.

The vanes G, as represented in Figs. 1 and 2 herein, are different from those usually employed, inasmuch as their outlet edges *h* project beyond the flange *f* (Fig. 1) of the suction tube T. In this way the water cannot only escape along the said outlet edges *h*, but also along the lower edges *e* of the vanes. In my Patent No. 1,399,009 I have described a guide-wheel of this kind, in combination with a runner wheel with axial admission. But good results may be equally obtained according to the present method of regulating the runner blades, provided that the lower edges *h* of the guide vanes do not extend beyond the rim of flange *f* (Fig. 1), as I have shown in my application No. 877,782 of December 17th, 1914.

Of course I do not limit my invention to the application of guide-wheels above mentioned, but a means may also be used with good results, which leads the water to the runner wheel in the axial or in an inclined direction.

Experiments have proved that rigid vanes used as guide-vanes will have good results with a runner wheel having adjustable blades, that materially improved results are obtained and that the variable admission, owing to the rotary faculty of the runner blades, is by far superior to the method hitherto in use according to which the blades of the runner were established rigid or motionless and the vanes of the guide wheel pivotally arranged. It will be well understood therefrom, that the position of the axis of the runner wheel has not the least influence on the applicability of the regulating system herein described. My invention, accordingly, will be applicable as well to turbines having vertical, horizontal or inclined positions of their axes. But I lay particular stress upon the wing-shaped form of the blades of the runner with axial admission, as thereby, I secure not only a perfectly safe bearing for the trunnions of the blades, but also a material decrease of losses caused through friction of water.

By practical tests I have ascertained that, owing to the wing-shaped form of the blades and the substantially axial admission, the specific speed hitherto obtained may be doubled with very good results, and that owing to these wing-shaped blades being made turnable, very good results may be obtained even with but half the admission of driving fluid.

A turbine with a runner wheel of the kind described, accordingly, will be applicable everywhere and particularly for high specific speeds and also for a scanty consumption of driving fluid. It is well known, that many water-courses cannot be utilized for the reason, that either the number of revolutions obtained is too small, and low specific speeds require expensive machinery and buildings, or that the water-course temporarily so much recedes, that, with the methods hitherto known no practical results can be expected for a continuous time. By the use of my invention a continuous good working result will be obtained.

I claim as my invention:

1. In a turbine, the combination with a guide-wheel having guide-vanes, of a runner comprising a hub and movable blades thereon for substantially axial admission of the driving medium, and means for turning said blades while in operation for adjusting the angles of entrance and discharge.

2. In a turbine, the combination with a guide-wheel having guide-vanes, of a runner comprising a hub and movable blades thereon for substantially axial admission of the driving medium and each carrying a crank-shaped arm near the said hub, and means for turning said blades by means of said arms while in operation.

3. In turbine, the combination with a guide-wheel having guide-vanes, of a hub, a sleeve movable relative thereto, blades movably mounted on said hub for substantially axial admission of the driving medium, connecting means between the said blades and the said sleeve, and means for axially displacing the said sleeve for adjusting the angular position of the said blades.

4. In a turbine, the combination with the guide-wheel having guide-vanes, of a hub, a sleeve movable relative to the said hub and provided with a ring-step bearing, a

tube-shaped member fitting in said bearing, rods carrying said tube-shaped member, movable blades mounted on said hub for substantially axial admission of the driving medium, connecting means between the said blades and the said sleeve, and means for axially displacing the said sleeve relative to the said hub by means of the said rods.

5. In a turbine, the combination with a guide-wheel having guide-vanes, of a movable sleeve, a hub, blades movably mounted on said hub, each blade being provided with a crank-arm, a rod connecting the said crank-arm with the said sleeve, and means for axially displacing the said sleeve relative to the said hub.

6. In a turbine, the combination with a guide-wheel having guide-vanes, of a movable sleeve, a hub, blades movably mounted on the said hub and each blade being provided with a crank-arm, a rod connecting the said crank-arms with the said sleeve, means for axially moving the said sleeve relative to the said hub, and means for varying the length of the said rods.

In testimony whereof I affix my signature in presence of two witnesses.

VICTOR KAPLAN.

Witnesses:
JOHANN FLEISCHMANN,
AUGUST FUGGER.