A. B. WOOD.

HYDRAULIC TURBINE.

APPLICATION FILED FEB. 10, 1912.

1,055,588.

Patented Mar. 11, 1913.

3 SHEETS—SHEET 1.

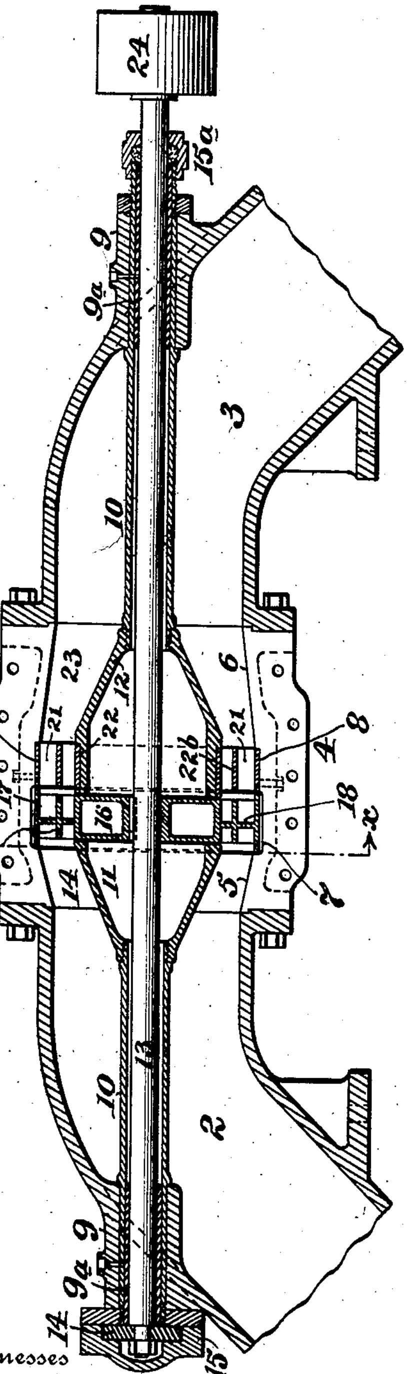

FIG. 1.

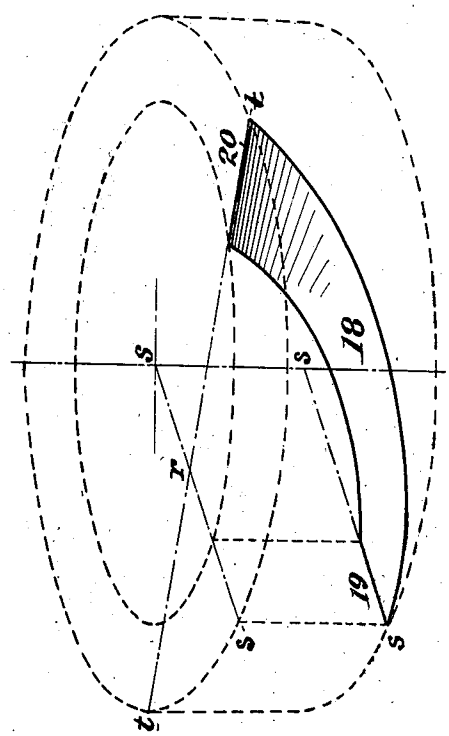

FIG. 6.

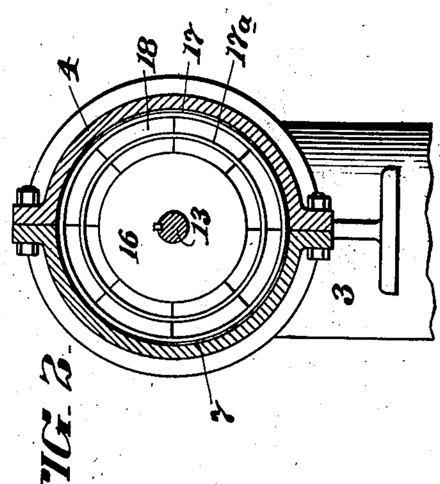

FIG. 2.

Witnesses

Daniel Webster, Jr.

R. M. Kelly

Inventor

Albert B. Wood

By [signature]

Attorney

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3 SHEETS—SHEET 2.

FIG. 3.

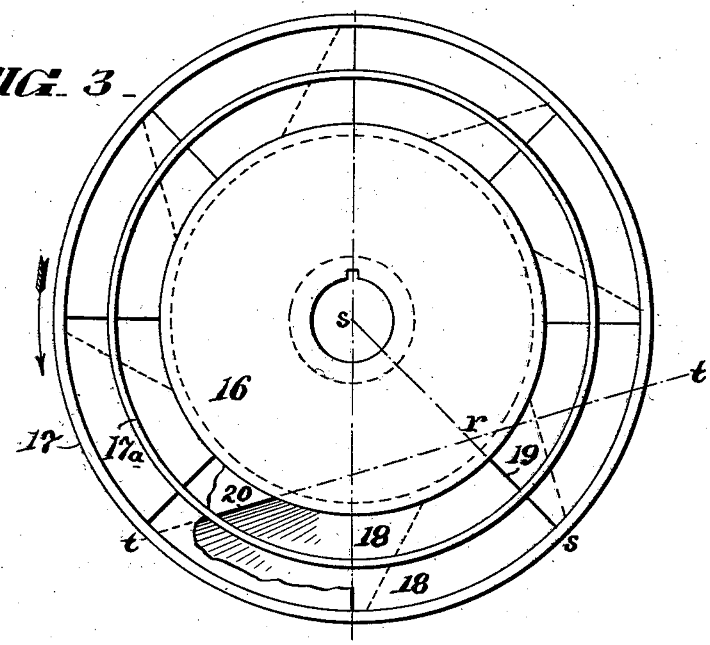


FIG. 4.

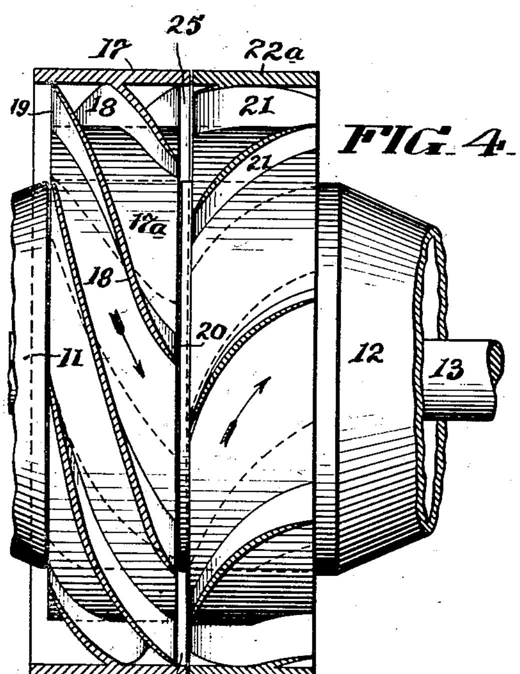
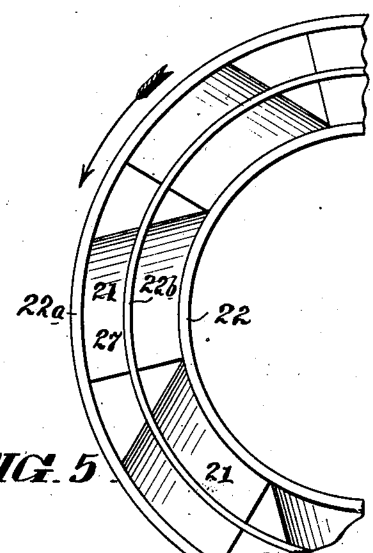


FIG. 5.



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Albert B. Wood

By [signature]

Attorney

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3 SHEETS—SHEET 3.

FIG. 7.

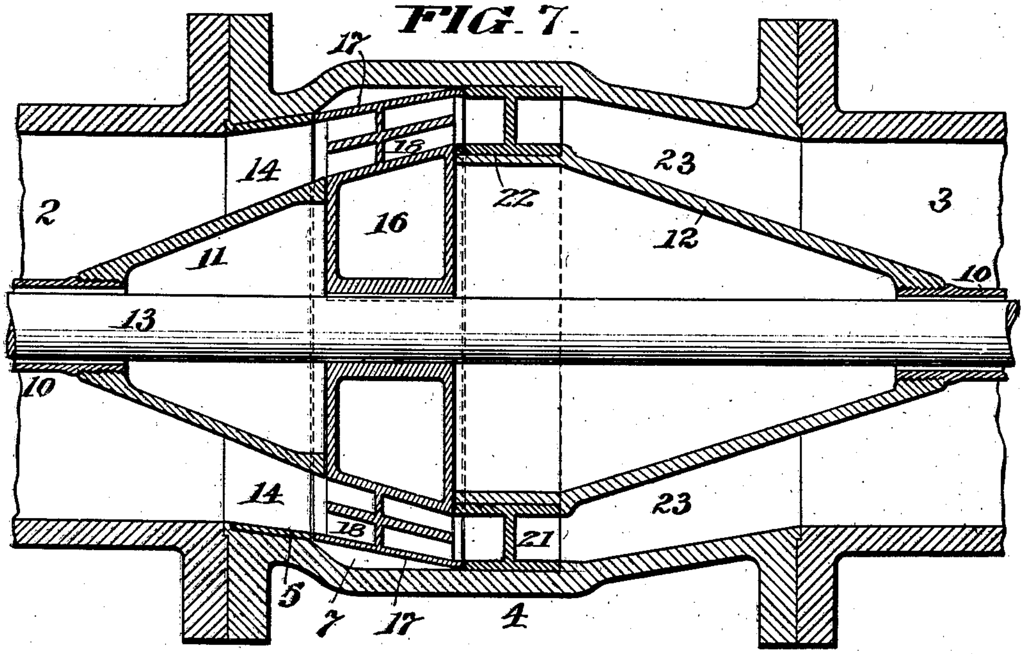
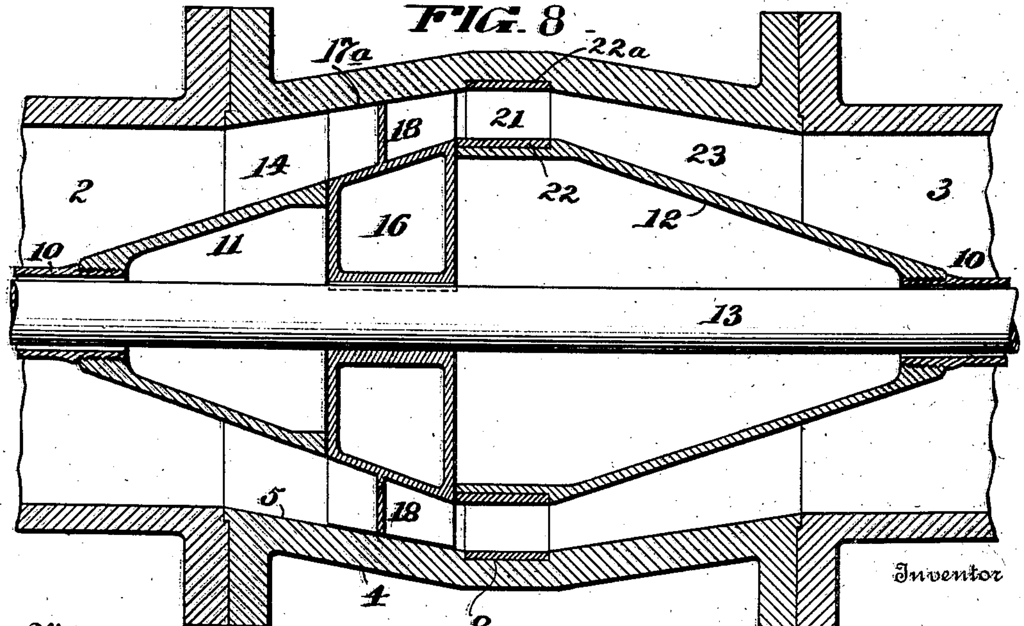


FIG. 8



Witnesses
Daniel Webster, Jr.
A. M. Kelly

Inventor
Albert B. Wood

By [signature]
Attorney

UNITED STATES PATENT OFFICE.

ALBERT BALDWIN WOOD, OF NEW ORLEANS, LOUISIANA.

HYDRAULIC TURBINE.

1,055,588. Specification of Letters Patent. Patented Mar. 11, 1913.

Application filed February 10, 1912. Serial No. 676,819.

To all whom it may concern:

Be it known that I, Albert Baldwin Wood, a citizen of the United States, and a resident of New Orleans, parish of Orleans, State of Louisiana, have invented an Improvement in Hydraulic Turbines, of which the following is a specification.

My invention has reference to hydraulic turbines and consists of certain improvements which are fully set forth in the following specification and shown in the accompanying drawings which form a part thereof.

My improvements are more particularly designed for purposes of pumping water, but may be employed, without material change in structure, as a hydraulic turbine for providing motive power. I therefore, do not restrict myself to the use to which my invention may be applied, although in most cases it will be utilized as a hydraulic pump.

The object of my invention is to provide a construction in a turbine or rotary screw pump which shall be especially adapted for handling large quantities of water at relatively low heads and which, moreover, shall be positive in action at various speeds with capacity for moving the water with a minimum slip. The general type of pump may be designated as one having axial flow and hence, in its use for pumping water, may be called an axial flow pump in the class of hydraulic turbines.

My object is further to provide a construction which shall develop very high efficiency and capable of retaining said efficiency when being driven at relatively high speeds; thereby reducing the cost of the engine or motor required to drive the turbine or pump.

My invention embodies in its construction a body having a tubular passage terminating in inlet and outlet portions and also having intermediate portions divided into annular passages in alinement adjacent to each other, one of said annular passages being in communication with the tubular passage on the inlet side and the other in communication with the tubular passage on the outlet side; combined with a rotor or runner having impelling blades or vanes of special construction fully specified hereinafter; further in the said construction when the annular passage through the runner tapers in longitudinal section but has the same or approximately the same cross sectional area throughout its length; and further, in more specific form, having the runner located in one of the annular passages comprising a drum having a plurality of vanes or blades of a construction for cutting into the body of water under axial flow in the inlet passage with the least possible disturbance and propelling the water, so sliced off the inflowing body, toward the other annular passage and at the same time imparting to it a rotary motion about the axis of the turbine or pump, and said other annular passage provided with a plurality of stationary diffusion vanes or blades for changing the direction of flow of the water from a rotary movement into an axial flow movement, the construction being such that the body of water is moved in a direction axially of the pump and during such passage has its direction of flow changed into a rotary one and then back again into an axial flow during the continued transfer of the water from the inlet to the outlet sides of the pump. My improvements thus generally referred to in respect to their utilization as a pump, are equally capable of use as a turbine engine or prime-mover where the head of water available is sufficient for the purpose and I, therefore, do not restrict myself to the utilization of my invention for pumping purposes alone.

My invention also comprehends details of construction which, together with the features above specified, will be better understood by reference to the drawings, in which:—

Figure 1 is a sectional side elevation of a hydraulic turbine embodying my improvements; Fig. 2 is a cross section of the same on line $x—x$; Fig. 3 is a plan view of the runner or driven part of the turbine with a portion broken away; Fig. 4 is a side view, partly in section, showing the blades thereof; Fig. 5 is a plan view of a portion of the diffusion blades and connections; Fig. 6 is a perspective view illustrating one of the runner blades and diagrammatically illustrating its shape; Fig. 7 is a sectional elevation showing the arrangement of the runner and adjacent parts in another form of my invention; and Fig. 8 is a similar view of a similar construction to Fig. 7 but with the employment of the stationary diffusion blades.

Figs. 1 to 6 illustrate the construction of my pump or turbine in that particular form in which there are both runner blades and diffusion blades in the annular part of the body, the construction in Fig. 8 also illustrates a somewhat similar form employing both runner and diffusion blades but in which the water passage through the runner is tapered with preferably a uniform cross sectional area, and the construction illustrated in Fig. 7, while approximating that shown in Fig. 8, has no diffusion blades, the blades of the runner being the only blades employed in the device.

I will now refer to the specific construction shown in Figs. 1 to 6. 2 is a tubular passage constituting the inlet end of the pump, and 3 is a tubular passage constituting the outlet end of the pump, and these passages 2 and 3 are united by annular passages formed within an annular body part 4 arranged between the elbows or inlet and outlet portions. The interior walls of this intermediate body portion 4 comprises a conical wall 5 at the inlet side, a conical wall 6 on the interior at the outlet or discharge side, a cylindrical wall 8 adjacent to the conical wall 6, and a clearance space 7 formed by an annular channel intermediate of the conical wall 5 and the cylindrical wall 8. The body part is preferably formed in two semicircular portions bolted together, as shown, so as to permit of easy access into the interior and for the necessity of properly assembling the parts. Each of the elbow portions which provides the passages 2 and 3 is furnished with journals 9 in which are fitted stationary tubular parts 10 forming tunnels through which the rotor shaft 13 extends. Within the journals 9 suitable bearings 9^a are provided in which the shaft rotates and by which it is held clear of the tubes 10. One end of the shaft is provided with a collar 14 which is confined within a thrust bearing 15, by which the shaft is held against longitudinal movement. This thrust bearing is substantially liquid tight and the other bearing is provided with a stuffing box 15^a which prevents the escape of water around the shaft at the discharge end of the pump. The shaft may be provided with a belt pulley 24 by which it may be driven, or the said shaft may be directly rotated by an engine or other means. Secured upon the inner end of the tube 10 on the inlet end of the pump is a guide cone 11, and likewise on the inner end of the tube 10 on the outlet side is another guide cone 12, the large ends of said cones being directed toward each other and separated a distance equal to the thickness of the runner drum 16 which is securely keyed to the rotor shaft 13. The conical surface of the guide cone 11 is arranged within the conical part 5 of the body portion 4 and thereby forms a conical passage 14 between the rotor and the inlet 2 of the pump through which the water is directed to the rotor; and similarly, the conical surface of the guide cone 12 is within the conical surface 6 of the body portion 4 to form the tapered annular passage 23 for the delivery of the water from the diffusion blades into the discharge or outlet end of the pump. The guide cone 12 is furthermore provided with a cylindrical portion adjacent to the runner, upon which is sleeved the hub ring 22 carrying the diffusion blades 21, said diffusion blades being surrounded by a shroud ring 22^a which fits into the cylindrical portion 8 of the body part. In this manner, the diffusion blades are properly positioned within the annular passage of the pump. These diffusion blades may be of any suitable construction, as indicated in Figs. 4 and 5, and if desired, may be reinforced by one or more annular bracing or shroud rings 22^b. If desired, the diffusion blades may be omitted and the shroud rings 22^b may be employed as guides. They would be suitably supported in alinement with the corresponding shroud rings 17^a of the rotator or rotor. The runner drum 16 is provided about its circumference with the rotor blades or vanes 18, said blades being rigid with the drum on their inner edges and preferably confined at their outer edges with a shroud ring 17, which latter fits into the clearance space 7 of the body 4. This shroud ring is preferably somewhat longer in a direction parallel with the axis of the rotor than the depth of the blades 18, so that the discharge ends 20 of these blades do not come into close contact with the leading edges of the diffusion blades, but instead provide an annular passage 25 between the diffusion blades and the rotor blades. If desired, there may be one or more annular bracing rings 17^a extending through the rotor blades between the drum and the shroud and in substantial alinement with the corresponding bracing rings 22^b of the diffusion blades, as will be understood by reference to Figs. 1, 3, 4 and 5. These strengthening or bracing rings 17^a and 22^b may be dispensed with if so desired, but it will be advantageous where heavy duty is required of the pump and where the blades or vanes are particularly wide in a radial direction, as they provide great stiffening effect to the blades. The additional shroud or bracing rings 17^a and 22^b not only assist in strength, but also increase the efficiency of the pump by guiding the water in approximately an axial direction in separate bodies, while being acted upon by the blades, there being in this case two or more bodies of water acted upon by each blade.

The rotor blades in my improved pump have a special construction which I have found commercially very effective and advantageous, and while there are general characteristics to this form of blade, the angles which the cutting and discharge ends make to the plane of rotation will vary with each pump according to the duty it is to perform and under the conditions which it is to operate. The general configuration of the rotor blades will be understood from Figs. 3, 4 and 6. By examining Fig. 4, it will be seen that the advancing edge 19 forms an acute angle with the plane of rotation, whereas the discharge end forms a much more obtuse angle with said plane of rotation, the effect of which is to cut into the annular body of water being delivered to the rotor blades by the annular tapered passage 14 and to deliver the said water, so sliced off, from the discharge ends of the blades in such a manner as to cause it to assume a direction of travel more approximating the axial line of the pump, but at the same time to be given a rotary motion within the space 25 so that the said body of water is forced across the forward edges of the diffusion blades 21, and being caught by them, is passed forward and into a positive axial flow through the annular expanding passage 23. In Fig. 4, the outer shroud ring is cut away to illustrate the outer edges of the diffusion blades. The innermost edges of the diffusion blades are indicated by dotted lines, and the intermediate juncture of said blades with the strengthening bracing rings 17^a is indicated in solid lines. In the particular pump from which the present drawings are taken, the acute angle at the forward edge of the rotor blade is $16\frac{3}{4}°$ with the plane of rotation of the runner adjacent to the hub 16, while the acute angle adjacent to the shroud ring 17 is $11\frac{1}{2}°$; and these angles along the inner and outer boundaries of the blades gradually increase respectively from $16\frac{3}{4}°$ to $66\frac{1}{2}°$ and from $11\frac{1}{2}°$ to $25\frac{1}{4}°$; but these angles, as before stated, are peculiar to this particular pump to suit the particular duty which it is to perform and the speed under which it is to operate, and I therefore do not confine myself in any manner to these specific angles. The angles may be generally defined by stating that the angle between the surface of vanes at any point and a plane perpendicular to the shaft at that point changes not only with the radial distance of the point from the center of the shaft, decreasing in proportion to the distance, but also increases as the point is moved in a direction parallel to the shaft from the entering edge to the discharge edge. This peculiar configuration produces a form of blade which will be understood by reference to Figs. 3 and 6, in which we have the entering edge 19 of the smaller angle and the discharge edge 20 with the larger angle and also in which, owing to the greater rate of increase of the angle adjacent to the drum 16 than adjacent to the shroud ring 17, the discharge edge 20 assumes an oblique angle to a radial line and constituting in effect a portion of a chord of the circle of the shroud ring. This edge continued would strike a plane through the axis of the rotor shaft and including the entering edge 19 of the blade, such chord or line being indicated by line $t—t$ and intersecting the plane at r. This peculiarity of the rotor blades will exist in all cases, though the chord line $t—t$ will vary according to the size, shape and duty of the rotor, and also upon the general width and depth of the space between the drum and shroud ring which is to be occupied by the blades themselves. The more acute angle upon the inner edge of the blade adjacent to the drum 16 than that adjacent to the shroud ring is not only required because of the fact that the surface speed adjacent to the drum is less than that adjacent to the shroud ring, but also to insure the same delivery of water adjacent to the hub as adjacent to the shroud ring. In general, the larger the diameter of the rotor, the greater will be the chord line $t—t$; and likewise, the smaller the diameter of the drum relatively to the diameter of the shroud ring, the shorter will be the chord line $t—t$.

Referring now to the construction shown in Fig. 7, I have in this case shown the use of the diffusion blades with the rotor conical in shape, the hub 16 thereof having a conical periphery which may, if desired, approximate the taper of the cone guide 11, and having its shroud ring 17 also conical and approximating the interior wall 5 of the body part 4, so that the annular passage 14 within the pump body and the annular passage between the hub and shroud ring of the rotor form together a tapering annular conical passageway, providing a free annular tapered passage for the water from the inlet side of the pump through the rotor and to the annular passage 23 of the discharge side. In this construction, under the most approved design of my invention, the taper of the water passage through the rotor is such that the cross sectional area is approximately the same at the inlet and outlet ends and preferably throughout the whole length of the passage from the suction to the discharge side, and moreover, this same uniformity of cross sectional area may, if desired, be continued through the annular passage 14 leading to the rotor (as more accurately indicated in Fig. 8), it being evident that by this construction, the velocity of movement of the body of water is not affected by the area of the passage and hence any effect upon the annular body of water by the rotor blades is utilized wholly in the displacement of the water which produces the velocity that determines the capacity of the pump.

In the construction shown in Fig. 8, I

have embodied the same general structure of Fig. 7, and have also shown the diffusion blades 21 arranged at the discharge side of the rotor blades 18 as in the case of Fig. 1. I have also shown the rotor without any shroud ring 17, the outer edges 17^a of the blades making a reasonably close fit to the inner conical wall of the body 4. There is some advantage in this omission of the shroud ring, in that the friction of the water against the stationary surface of the body will tend to reduce the freedom of rotation of the body of water when acted upon by the rotor, and hence will cause a more positive propulsion of the same toward the diffusion blades of the discharge side of the pump. The objection, however, to this omission of the shroud ring is in the weakening of the rotor blades, but the width of these blades in a given capacity of pump may be reduced by increasing the diameter of the rotor and in that way maintaining the strength required without the necessity of the shroud ring. For small diameters in which the width of the blade must be materially great, the shroud ring construction is preferable to insure the requisite strength.

From the foregoing description of Figs. 1 and 8, it will be seen that the body of water passes from the inlet side 2 axially toward the rotor under whatever head may be available to insure the delivery of the water to the rotor, and as it approaches the rotor it passes about the conical guide and takes an annular form and in which condition it is supplied to the blades or vanes 18 of the rotor under the initial pressure. The rotor being rapidly driven by the shaft 13, causes the forward edges of the blades to cut into the annular body of water delivered to them, the angle of the cut being an acute angle, and in the example shown of approximately 11½ degrees to the plane of rotation, thereby as it were, slicing off the water, and by the inclined plane of action of the blades, causing it to be moved forward and at the same time given a rotary motion, this latter being especially due to the fact that the rotor blades at their discharge ends assume an obtuse angle, and in the example shown, of approximately 25¾ degrees to the plane of rotation. The body of water which is thus supplied to the rapidly rotating rotor blades 18 is being divided into a plurality of streams, each of which is acted upon by one of the blades and propelled forward toward the stationary or diffusion blades 21, and at the same time given a rotary motion in the plane of rotation of the rotor; and these streams of water produced by the rotating rotor leave the discharge end of the rotor blades in substantially a direction of flow which would be more or less parallel to the axis of the rotor, and hence may be considered as an axial flow supplemented by the rotary movement in an annular direction about the axis. By the combined action of these two directions of flow of the water so put in motion by the runner, said water is caused to be delivered to the inlet side of the diffusion shroud and received upon the advance edges of the diffusion blades 21 thereof, which blades being stationary and inclined in the opposite direction to the angle of the rotor blades, in turn slice off the moving water and cause it to flow forward between the blades and change its direction of movement from one of rotary motion to substantially rectilinear motion to constitute an "axial flow" at the discharge side of the pump. The flow at the discharge side of the diffusion blades being guided by the annular passage 23 formed by the conical guide and the contracting body of the pump structure, changes from an annular body of water into a solid body during its discharge passage through the pump.

The tendency to cause the water to rotate in the annular passage by the action of the rotor would largely depend upon the speed of the rotor and the differential pressure on the inlet and outlet ends of the pump. Where the flow is rapid and the difference in the head of water at the inlet and outlet is relatively small, the impelling action of the rotor blades will produce less rotation relative to the axial flow than would be the case where the difference in the heads was very great. It is therefore evident that where large volumes of water at relatively small differences in heads or pressure are to be pumped, the diffusion blades may be omitted, but in those cases where the pump is required to deliver the water against a considerable pressure, it is more desirable that the diffusion blades be employed in conjunction with the rotor.

I have described my invention more particularly in respect to its utilization as a pump, but it is evident that it may be equally employed as a turbine for generating power by simply reversing the direction of flow through it. When employing it as a power producing turbine, it would be more desirable that the diffusion blades 21 be employed.

The illustrations forming part of this specification are given by way of example and not as restrictions with respect to design or the minor details of the structure, and it is also evident that while I have shown the apparatus with a horizontal shaft, the position of the shaft is not confined to such horizontal arrangement, but that instead, the pump or turbine may be arranged in any suitable position found desirable.

While I have shown my invention in the form which I have adopted in commercial practice, I do not restrict myself to the details as these may be modified in various ways without departing from the spirit of the invention.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. In a machine of the character described, the combination of a tubular body through which fluid may pass said body having an annular passage in the direction of its length intermediate of its inlet and outlet ends, a rotor or runner comprising a drum having curved impelling blades extending radially about it and arranged in the annular passage so as to act upon or be acted upon by the fluid, a shaft supporting the said rotor or runner and extending throughout and to the outside of the body, cone-shaped guides arranged upon each side of the rotor or runner drum with their apices respectively directed toward the inlet and outlet portions of the tubular body and providing annular tapered conical passages leading to and from the annular passage in which the blades of the rotor or runner are located, said cone-shaped guides being out of contact with the shaft, bearings at each end of the body for the rotating shaft, tubular supports respectively having one of their ends secured to and supporting the cone-shaped guides and having their other ends secured to the body adjacent to the bearings of the shaft, and shielding the rotating shaft from the water, and stationary diffusion blades arranged at the discharge side of the blades of the rotor or runner and located in the annular passage.

2. In a machine of the character described, a rotor or runner formed of a drum, a shroud ring surrounding the drum, a plurality of impelling blades arranged between the drum and shroud ring and curved in the direction of the axis of the drum, and a bracing ring or shroud for the blades intermediate of the outer shroud ring and the drum and straight in longitudinal section said shroud rings maintaining the flow in a constant substantially straight direction from one end of the rotor longitudinally to the other end.

3. In a machine of the character described, a tubular body through which fluid may pass said body having a tapered conical annular passage in the direction of its length intermediate of its inlet and outlet ends, combined with a rotor or runner of greatly less length than the length of the conical annular passage and comprising a conical-shaped drum having curved impelling blades extending radially about it and arranged in a portion only of the conical annular passage so as to act upon or be acted upon by the fluid, the annular passage through the space traversed by the blades of the rotor or runner being formed in tapered conical shape and with a substantially constant cross sectional area throughout its length, and stationary diffusion blades at the discharge side of the blades of the rotor or runner.

4. In a machine of the character described, a tubular body portion having its inner walls formed with a gradually enlarged diameter and provided with a cone-shaped guide within a portion only of the body of gradually increasing diameter to form an annular conical tapered passageway, combined with a rotating shaft, and a rotor or runner secured to the shaft and having a drum portion immediately adjacent to the large end of the cone-shaped guide and said drum formed with a conical circumferential part as a continuation of the general taper of the cone-shaped guide and provided with a plurality of curved blades, of such form that the annular space occupied by the travel of the blades is tapered and conical, the larger ends of the blades being directed toward the tapered passage about the larger end of the cone-shaped support.

5. In a machine of the character described, a rotor or runner consisting of a drum about which are arranged a plurality of impelling blades curved in the direction of the axis of the drum and said blades so curved throughout their length that the angle between the surface of the blade at any point and a plane perpendicular and transversely to the axis of the drum at that point decreases as the radius increases and decreases throughout its length as the point is moved in a direction parallel to the axis of the drum and in which the advancing edges of the blades are in substantially radial lines of the drum and the discharging edges are in lines pronouncedly oblique to the radial lines of the drum.

6. In a machine of the character described, a rotor or runner comprising a drum provided about its periphery with a plurality of curved impelling blades and in which the said blades have their angle of curvature changed throughout their length, said change of curvature being more rapid adjacent to the drum than at the outer portion of the blades, and in which further, the edge of each blade having the greatest obliquity to a transverse perpendicular plane to the axis of the drum is arranged in a substantially radial line from the axis of the drum, and the edge of each blade having the least obliquity to a transverse perpendicular plane to the axis of the drum is arranged obliquely to a radial line from the axis of the drum and in a line constituting a chord across the circle of the drum.

7. In a machine of the character described, the combination of a tubular body through which fluid may pass said body hav-

ing inlet and outlet ends, combined with a rotor arranged within the tubular body and comprising a conical shaped drum provided with blades the peripheral outer edges of which are inclined and with greatest radial depth arranged at their forward or intake ends and their least radial depth at their discharge ends, a conical stationary guide arranged within the tubular body and with its large end adjacent to the small end of the conical drum of the rotor to provide an annular tapered passage for delivering an annular body of water to the rotor blades, and stationary diffusion blades arranged in the tubular passage immediately adjacent to the discharge side of the conical rotor for changing the flow of the fluid from a rotary to an axial flow.

In testimony of which invention, I hereunto set my hand.

ALBERT BALDWIN WOOD.

Witnesses:

R. D. SULLIVAN,

JOHN C. BARTLEY.