Aug. 24, 1954 R. E. B. SHARP 2,687,280

PUMP-TURBINE

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FIG. 1

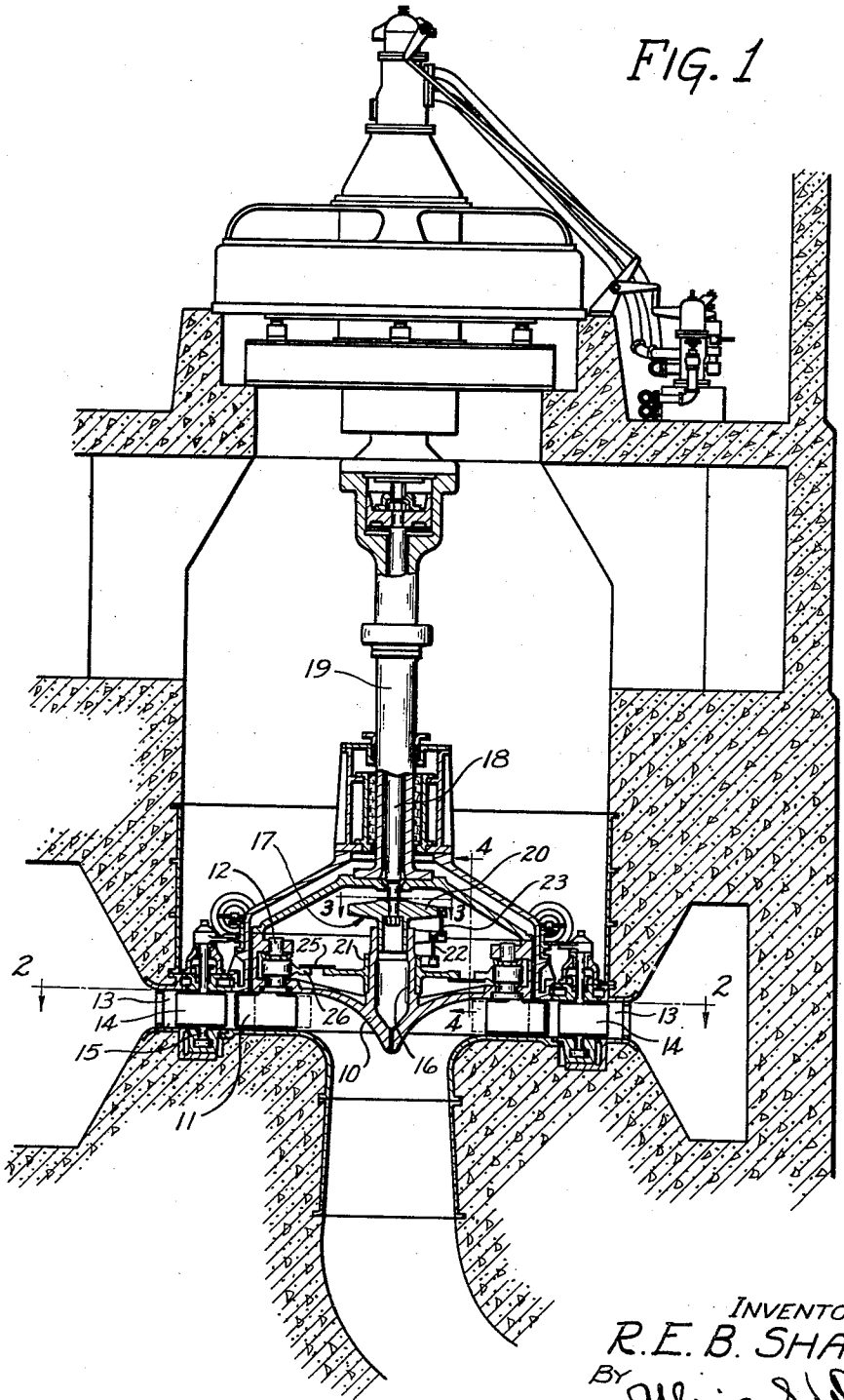

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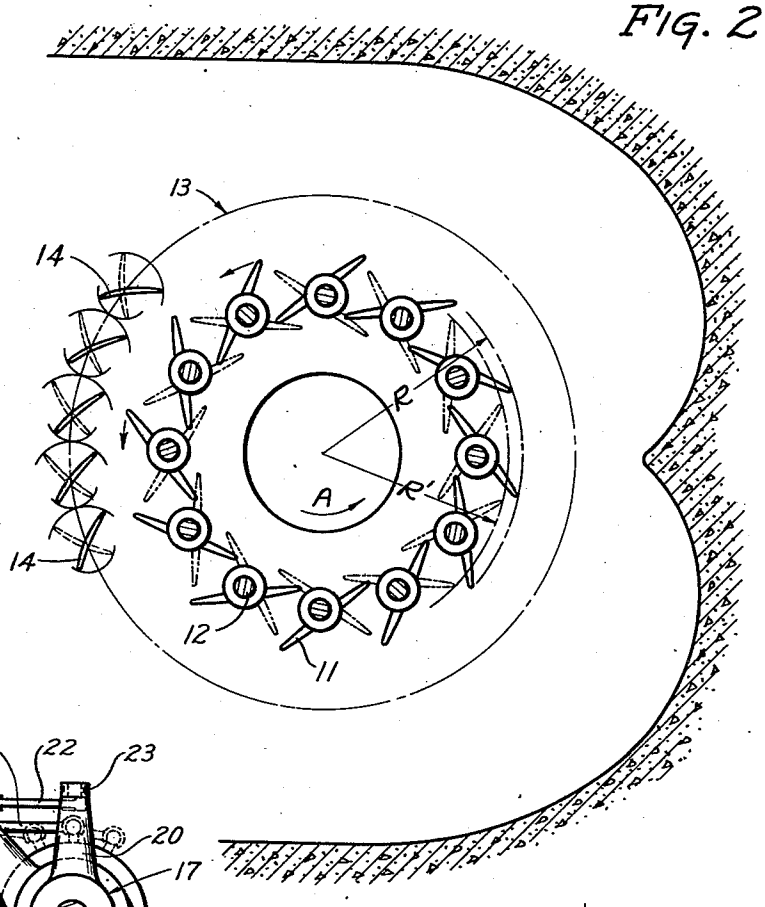
FIG. 2



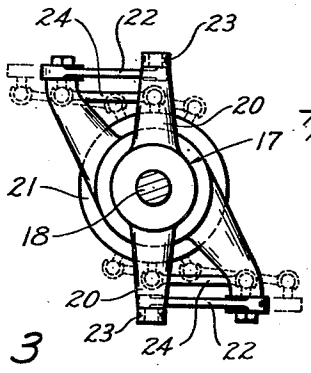


FIG. 3

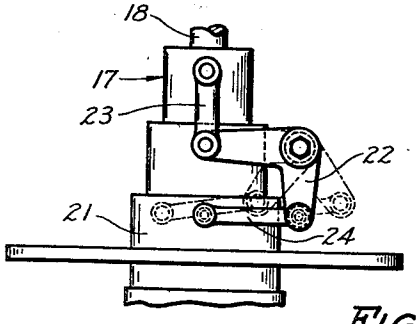


FIG. 4

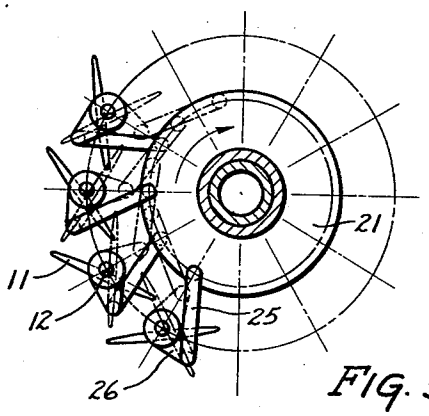


FIG. 5

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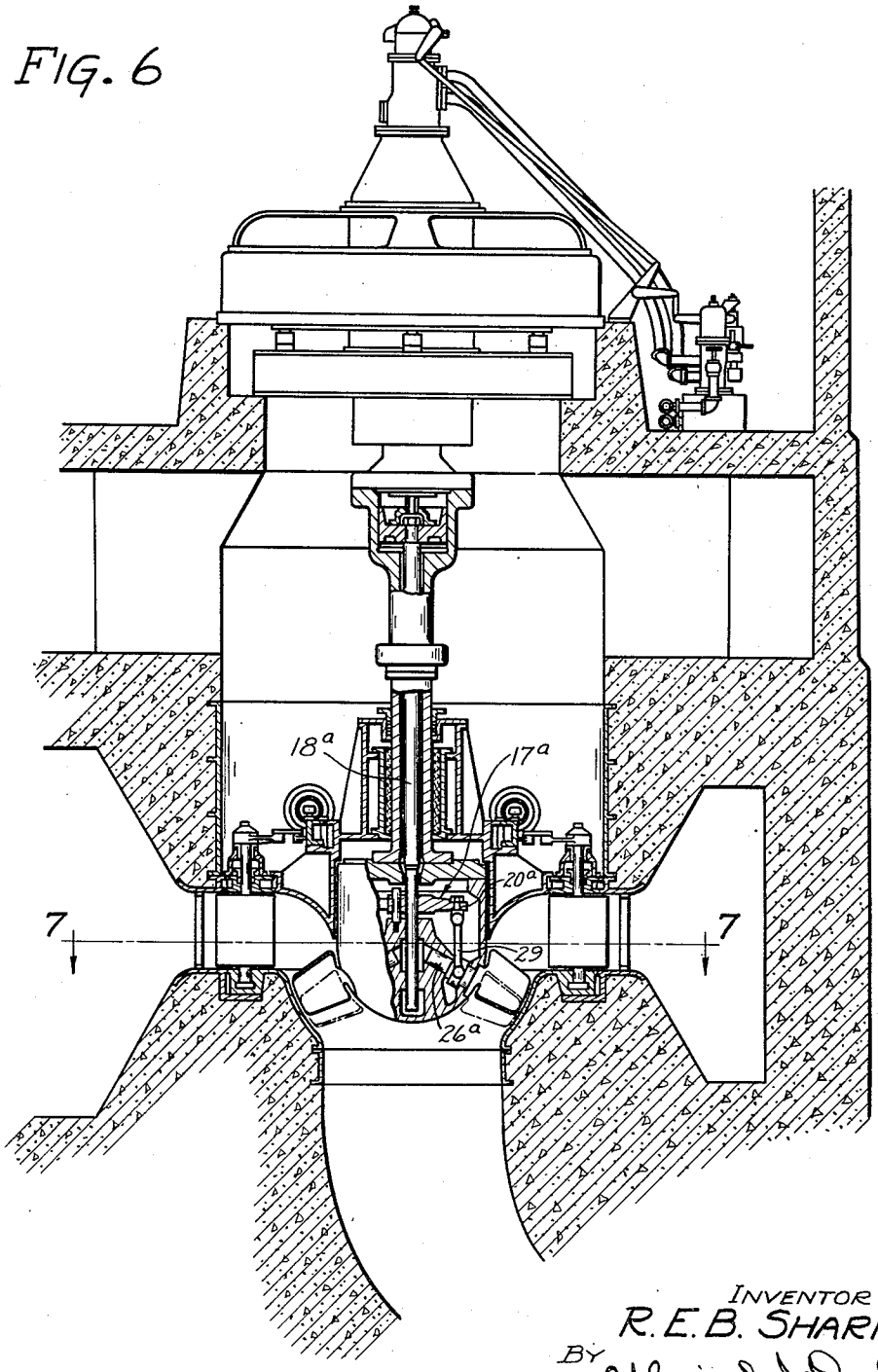
FIG. 6



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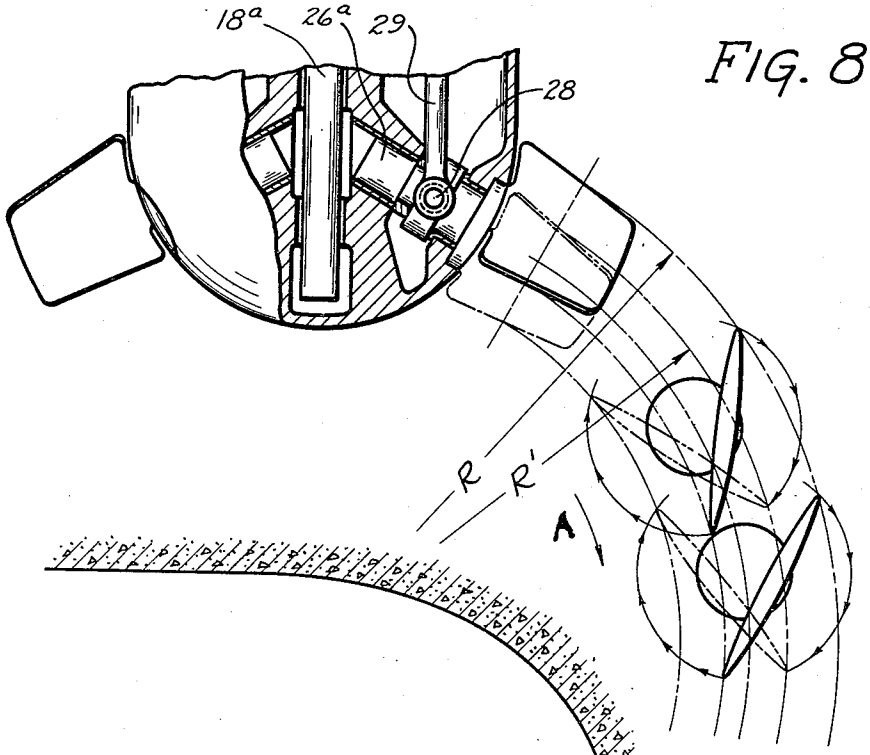

FIG. 8

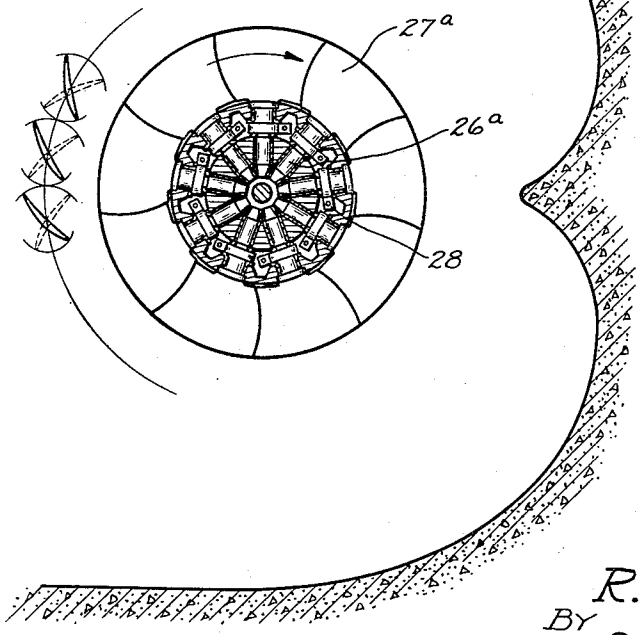

FIG. 7

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PUMP-TURBINE

Robert E. B. Sharp, York, Pa.

Application September 23, 1949, Serial No. 117,313

6 Claims. (Cl. 253—148)

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This invention relates to hydraulic machines and more particularly to pump-turbines having uni-directional rotation for both pump and turbine operation.

This type of unit is especially adaptable for use in connection with water power development where during off-peak conditions it is desirable to pump water up into the forebay in order to use this energy during peak load conditions. One of the difficulties that has been encountered in connection with units of this type has been the loss of efficiency, particularly when generating, due to the economic necessity of having to operate at the same speed both during pumping and generating, that is, it has been necessary to proportion the pump turbine so that it would pump water against the head required, and this results in a severe overspeed condition when generating, with low efficiency. It is well known that a centrifugal pump or a mixed flow pump will attain good efficiency both when operating as a turbine and when operating as a pump but the best efficiency point will occur at an appreciably higher speed when pumping than when generating, on the basis of essentially the same head during both operations.

An important object of this invention is the provision of a pump turbine of the uni-directional type wherein the impeller diameter is greater when pumping than when generating thereby reducing the speed for best efficiency when pumping and bringing it more nearly to that of best efficiency for generation.

A more specific object of the invention is the provision of a pump turbine wherein the reversal of operation is obtained by reversal of the runner blades with the blades so pivoted that the outer diameter of the runner blades is greater when pumping than in the reversed position for generating.

Still another object is the provision of a simple and readily controllable blade mounting for this purpose which may be easily incorporated in pump-turbine units of either the radial or mixed flow type.

These and other objects are obtained by the constructions illustrated in the accompanying drawings wherein for the purpose of illustration I have shown a preferred form of my invention and wherein:

Figure 1 is a vertical section through a pump-turbine of the radial flow type embodying my invention;

Figure 2 is a semi-diagrammatic section on line 2—2 of Figure 1 the blades and gates being shown

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in solid lines in their pumping position the direction of rotation for both pumping and turbine operation being shown by the arrow A;

Figure 3 is a section on line 3—3 of Figure 1;

Figure 4 is a fragmentary section on line 4—4 of Figure 1;

Figure 5 is a fragmentary plan view showing one method of controlling the runner blades;

Figure 6 is a vertical section through a mixed flow turbine utilizing my invention;

Figure 7 is a semi-diagrammatic section on line 7—7 of Figure 6 the arrow showing the direction of rotation, and

Figure 8 is a diagrammatic view illustrating the diametral gain effected by reversal of blade position in this type of pump turbine the arrow showing the direction of rotation.

Referring now to the drawings and more particularly to Figures 1 to 5 thereof illustrating a radial flow turbine constructed in accordance with my invention, the numeral 10 designates a runner having hub means by which blade units 11 are supported on rotatable shanks 12, the axes of which are parallel to that of the runner. Surrounding the runner is a gate case 13 including gates 14 mounted on shanks 15 the axes of which are also parallel with the runner axis. As at present described the unit might be standard construction constituting a simple unit of the ordinary reversible radial flow type.

In accordance with my invention the blades of the blade units 11 are eccentrically or chordally disposed relative to their shanks 12 in the direction of blade thickness and the blade shank rotation is made sufficient to move the blade from a position where by reason of the chordal attachment, the blade can be said to lie inwardly of the shank axis to a position where it lies outwardly thereof. In Figure 2 where the pumping and generating positions are shown in solid and dotted lines respectively it becomes obvious that this shift produces a marked variation in the effective diameter of the runner shown by radii R and R'. By proper selection of the chordal displacement of the blade in the shank for the desired diameter for pumping and for generating, the optimum efficiency can be attained for both functions at a uniform speed.

While many means may be provided for reversing the blades Figures 1 to 5 disclose a preferred apparatus for this purpose. As disclosed the runner 10 includes an internal hub 16 including a cylindrical guide mounting the lower end of a rod 18 shiftable longitudinally in hollow runner shaft 19 and which rod mounts within the

runner, a crosshead 17. Crosshead 17 includes radial arms 20 connected to annulus 21 rotatably surrounding the runner hub 16, by means of bellcranks 22 pivoted on the hub 16 and linked to the arms 20 and annulus 21 by links 23, 24 having universal connections with the arms and annulus. Annulus 21 is linked at 25 to arms 26 on shanks 12 for transmitting the rotation of the annulus to these shanks and the blades 11.

In the form shown in Figures 6, 7, and 8 a turbine of the mixed flow type is illustrated. In such a structure the blade shanks 26*a* have both the radial and axial components varying as is well known with the head and specific speed of the pump turbine. The axial component of the blade shanks 26*a* will of course provide, in a slightly less degree the radial displacement of the blade and the desired increased runner diameter. By reason of the radial component of the blade shanks it becomes possible to simplify the operating connections for the blades. As shown these comprise links 29 universally connected to arms 28 on the blade shanks and arms 20*a* of crosshead 17*a*.

In either construction it is of course necessary to reverse the angle of the gates to properly position them with respect to the runner blades for either operation. While no specific mechanism is shown for this purpose it will be obvious that such a mechanism should embody some form of automatic control interlocked with the blade control for operation therewith at least during turbine operation of the unit.

It will be obvious from the foregoing that my invention may be applied with equal facility to pump-turbines of either the radial or mixed flow type and will provide therein a decided reduction of the gap ordinarily existing between efficiency in operation in their several capacities. It will also be obvious that the forms shown are purely illustrative and are capable of considerable modification within the scope of the appended claims.

I claim:

1. A uni-directional pump-turbine comprising in combination; a runner mounted for rotation about the axis of the pump-turbine and including hub means rotatable about said axis, a plurality of blade units having shanks supported by said hub means for pivotal movement about the axes of said shanks through an angle of approximately 90° to opposite positions and directions of inclination and in which positions said blade units respectively are operable in pumping and turbine capacities, said shanks being eccentric to said blades, whereby said blades are displaceable radially relative to the shanks thereof when pivotally moved from one to the other of said positions of inclination, said blade units when positioned to serve as a pump providing a greater effective runner diameter than when operating as a turbine, and means interconnected to said

blade units and operable to move the blades thereof to the desired positions; means operable to rotate said runner uni-directionally when operating either as a pump and turbine; and a case at least partially surrounding said runner and defining passages to and from said runner.

2. A turbine of the type claimed in claim 1 wherein the blade shanks have axes paralleling the axis of rotation of the runner.

3. A turbine as claimed in claim 1 wherein the axes of the blade shanks have components both radial and axial to the axis of rotation of the runner.

4. A uni-directional pump-turbine comprising in combination; a runner mounted for rotation about the axis of the pump-turbine and including hub means rotatable about said axis, a plurality of blade units having shanks supported by said hub means for pivotal movement about the axes of said shanks through an angle of approximately 90° to opposite positions and directions of inclination and in which positions said blade units respectively are operable in pumping and turbine capacities, said blades being chordally disposed relative to the shanks thereof and radially displaced in the direction of blade thickness from the axes of said shanks, whereby said blades are bodily displaceable radially relative to the shanks thereof when pivotally moved from one to the other of said positions of inclination, said blade units when positioned to serve as a pump providing a greater effective runner diameter than when operating as a turbine, and means interconnected to said balde units and operable to move the blades thereof to the desired adjusted positions; means operable to rotate said runner uni-directionally when operating as a pump and turbine; and a case at least partially surrounding said runner and defining passages to and from said runner.

5. A turbine of the type claimed in claim 4 wherein the blade shanks have axes paralleling the axis of rotation of the runner.

6. A turbine as claimed in claim 4 wherein the axes of the blade shanks have components both radial and axial to the axis of rotation of the runner.

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