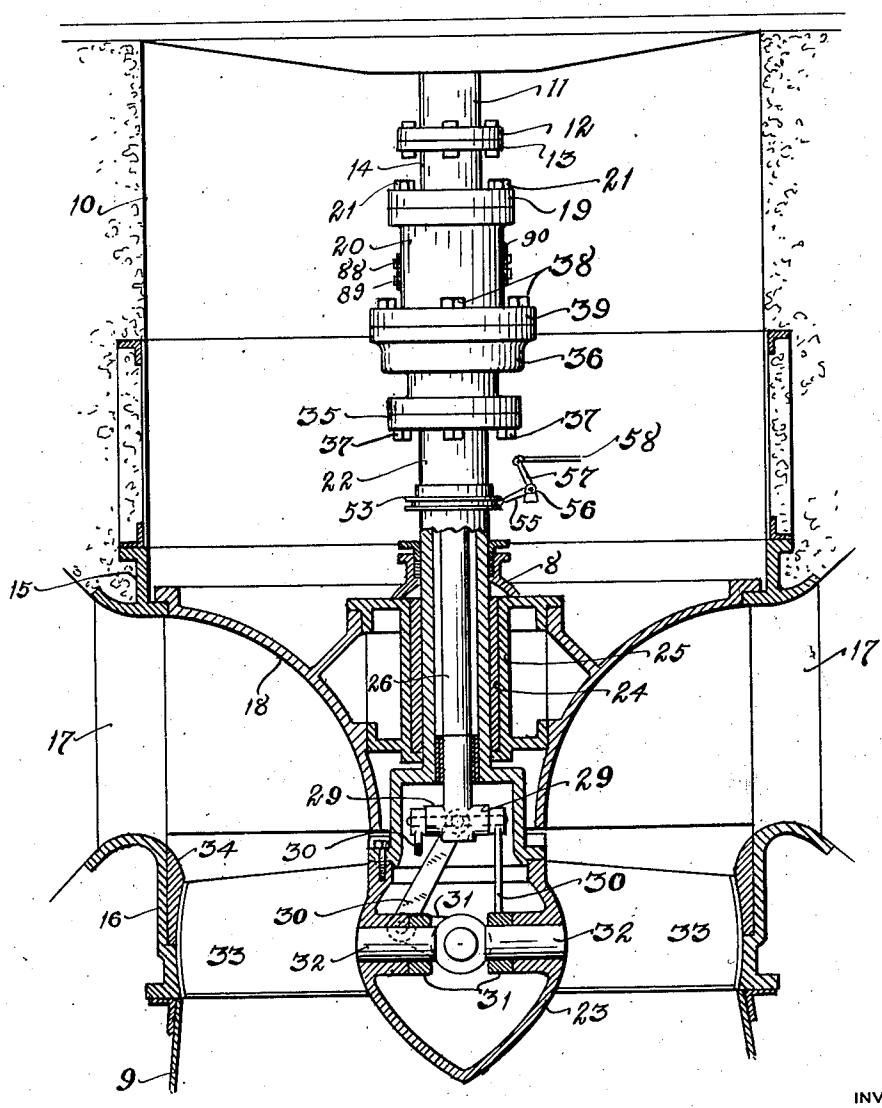
Sept. 13, 1932. H. E. POPP 1,877,048

ADJUSTABLE VANE HYDRAULIC TURBINE

Original Filed July 5, 1928 2 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

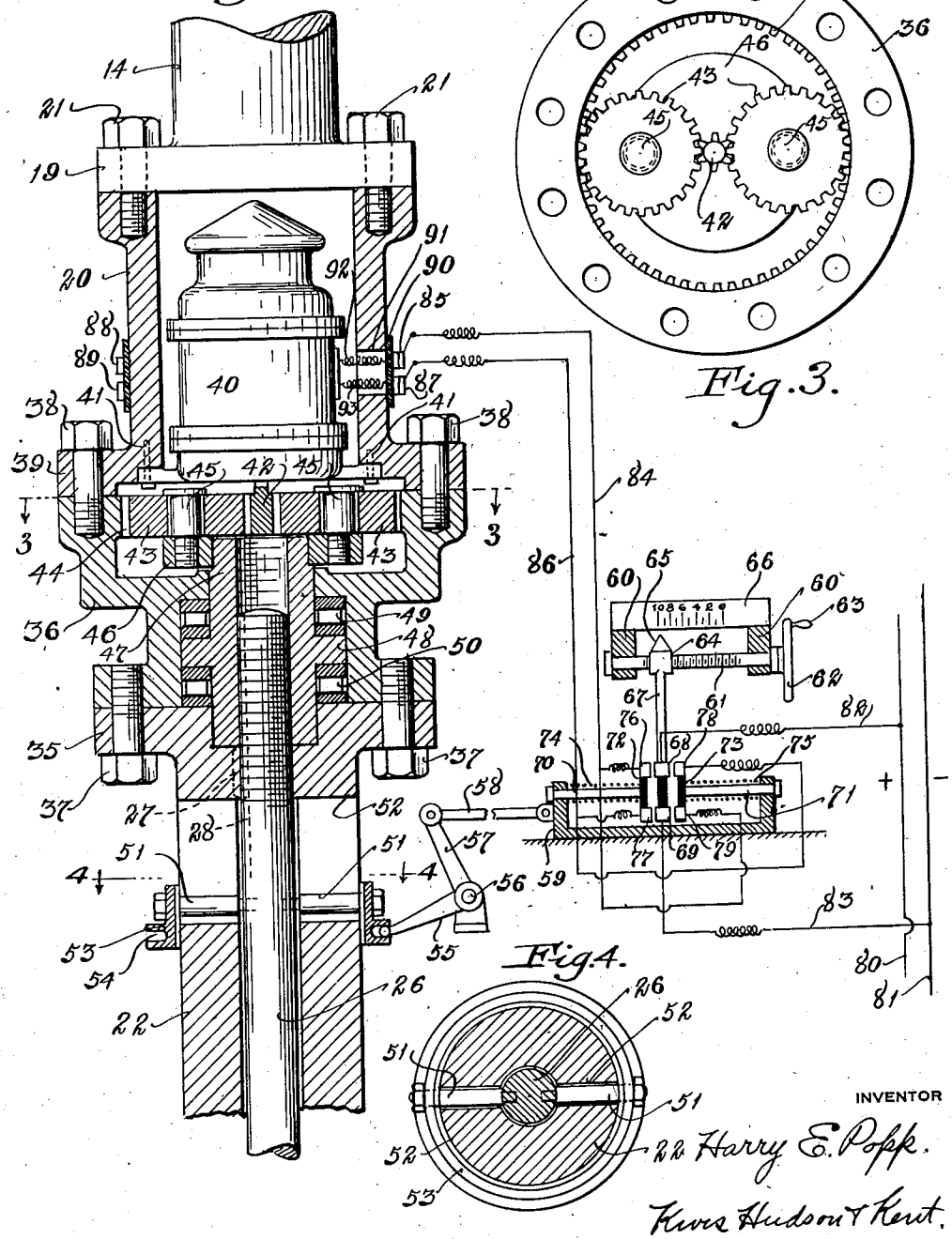


Fig. 3.

Fig. 4.

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UNITED STATES PATENT OFFICE

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ADJUSTABLE VANE HYDRAULIC TURBINE

Application filed July 5, 1928, Serial No. 290,433. Renewed January 13, 1932.

This invention relates to improvements in adjustable vane hydraulic turbines and particularly to electrically operated adjustment means, the control for the same being situated wherever convenient.

One of the objects of the invention is the provision of simple and effective means for securing any desired adjustment of the runner vanes while the turbine is in motion.

Another object is the provision of vane adjusting means in which electrical energy serves as the motive power.

Another object is the provision of adjusting means that is self locking in all positions, that is to say, one which is not reversible by the action of the load imposed upon the runner.

A further object is the provision of mechanism of the character stated, embodying reduction gearing between the electric motor and the vane adjusting elements, the gearing being carried by the shaft and being symmetrically arranged about the axis of the shaft so as to prevent any appreciable unbalance during operation.

Another object is the provision of adjustment control means, readily adapted to remote manual control or to automatic control, which will automatically cause the runner vanes to move to definite positions corresponding to definite positions upon an indicator mechanism which may be manipulated manually or which may be moved automatically to respond, for example, to variations in speed or to variations in the height of the water head, or which may may be connected up for movement simultaneously with some other control mechanism, as for instance, a wicket gate control.

Other objects and features of novelty will appear as I proceed with the description of that embodiment of the invention which, for the purposes of the present application, I have illustrated in the accompanying drawings, in which:

Figure 1 is a view partially in elevation and partially in central, vertical section showing a hydraulic turbine embodying my invention.

Fig. 2 is a vertical, central section of the upper portion of the runner shaft showing a portion of the vane adjusting mechanism, and illustrating diagrammatically remote control mechanism for the electric motor which drives the adjusting mechanism.

Fig. 3 is a horizontal sectional view, taken substantially on the line 3—3, of Fig. 2.

Fig. 4 is a horizontal sectional view taken substantially on the line 4—4, Fig. 2.

In the drawings the cylindrical wall of a pit is indicated at 10. The water as it leaves the runner is discharged through a draft tube 9. The generator to be driven by the hydraulic turbine is not shown in the drawings, but the lower end of its shaft appears in Fig. 1 at 11. On this lower end there is a flange 12 which is bolted to a flange 13 on the upper end of the shaft 14 which constitutes the upper portion of the turbine shaft. Upper and lower speed rings are represented at 15 and 16, and are joined by a series of fixed guide vanes 17 which not only direct the course of the incoming water but also act as structural members, tying the two rings 15 and 16 together. The crown plate which directs the incoming water downwardly is shown at 18, being supported at its periphery by a flange on the ring 15.

The lower end of shaft 14 merges into a cover 19 for a cylindrical housing 20 to which it is secured by screws 21 or the like. The housing 20 constitutes the upper end portion of the hollow shaft 22 which, in effect, is a continuation of the shaft 14. The lower end of shaft 22 is enlarged and has suspended therefrom a hub 23 which is hollow and has an outer surface that is spherical throughout a considerable portion of its extent. Somewhat above its lower end the shaft 22 is journaled in bearing strips 24 mounted in a bearing support 25, the latter being carried in any convenient manner upon the crown plate 18. Above the bearing strips 24 I mount a packing gland 8.

Within the hollow shaft 22 there is slidably mounted a rod 26 which is threaded upon its upper end for a purpose which will hereinafter appear. A key 27 mounted in the shaft 22 is slidable with respect to a groove 28 in the rod 26, whereby the latter

is slidably but non-rotatably connected with the shaft. At its lower end the rod 26 carries four radial arms 29 having reduced ends upon which are pivoted the upper extremities of four links 30 that are pivoted at their lower ends to four cranks 31 on the inner ends of trunnions 32 which are mounted in radial bearings in the hub 23. These trunnions are integral with runner vanes 33, also four in number. It is not my intention, however, to limit the invention to a runner having four vanes, as a greater or even a lesser number might be employed, the number of cranks and links 31 and 30 respectively being modified accordingly.

The inner ends of the vanes from their discharge edges to a position slightly in advance of the trunnions 32 are cut on a circle to correspond with the curvature of the spherical surface of the hub 23, just sufficient clearance being allowed to prevent undue friction when the trunnions 32 are turned.

At their outer ends the vanes 33 are curved in a circle which is concentric with the curvature of the inner ends of the vanes and which corresponds to the curvature of a surrounding spherical surface that is formed partly upon the ring 16 and partly upon a ring 34 which is removable in order to permit the removal of the vanes 33 upwardly. The usual clearance is maintained between the vanes 33 and the adjacent surfaces of the rings 16 and 34, and owing to the fact that these surfaces are spherical this clearance is maintained regardless of the adjusted positions of the vanes.

At the upper end of the section 22 of the hollow shaft there is a flange 35 upon which is supported an annular casting 36, these two parts being fastened together by screw 37 or the like. At its upper end casting 36 is secured by screws 38 to an annular flange 39 on the lower extremity of the cylindrical housing 20. Hence the parts 20, 36 and 22 are rigidly connected and together form the hollow shaft of the turbine.

An electric motor 40 is rigidly mounted, as by screws 41, in the cylindrical housing 20, with its axis coincident with the axis of the cylinder. On the shaft of the motor 40 there is a pinion 42 which meshes with a pair of planet gears 43, the latter gears running upon an internal gear 44 cut into the wall of the casting 36. The gears 43 turn upon spindles 45 which have constricted end portions threaded into a ring 46 that is keyed onto an elongated nut 47, the latter being threaded to receive the threaded end of rod 26. The nut 47 may have an integral collar 48 adapted to take thrust in either direction through two thrust bearings 49 and 50.

Below its threaded upper end the rod 26 carries a pair of axially aligned pins 51 which extend through vertical slots 52 in the shaft 22. On their outer ends these pins carry a ring 53 which slides vertically upon the shaft 22 whenever the rod 26 moves with respect to the shaft. This ring 53 is provided with a groove 54 that has operative engagement with one arm 55 of a bell crank lever pivoted at 56 to any suitable support carried by a fixed part of the turbine. The other arm 57 of the bell crank lever is pivotally connected with a link 58 that is attached to a slide 59 mounted in a convenient position outside the turbine. While for the sake of simplicity I have illustrated herein a single link 58, it will be understood that in practice I may substitute any mechanical connection capable of transmitting sliding motion to the slide 59 from the swing arm 57 of the bell crank lever. This mechanical connection in practice may embody a number of parts, such as links and levers, in order that the control mechanism of which the slide 59 is a part may be located at some distance from the turbine. In carrying out my invention it is entirely feasible, for instance, to mount the control mechanisms for a series of turbines upon a single control board.

Upon the control board or other suitable support I mount a pair of bearing blocks 60 in which is journaled a shaft 61 which is adapted to be rotated to bring about the adjustment of the runner vanes. The rotation of the shaft may be accomplished in various ways, but in the present instance I have shown it provided with a wheel 62 and a crank 63. The shaft 61 is threaded and has mounted thereon a nut 64 having a pointed portion constituting an indicator 65 cooperating with a scale 66 for indicating the degree of opening of the runner vanes, the scale illustrated herein having ten divisions covering various positions of the vanes from fully closed to fully opened position.

Rigidly attached to the nut 64 there is a bar 67 upon which are mounted two electrical contacts 68 and 69 insulated from each other and from the rod. In the ends of the slide 59 there are slidably mounted two rods 70 and 71 which are headed upon their outer ends to limit the inward movement of the rods. On its inner end each of these rods 70 and 71 carries a cross bar 72 and 73 respectively, against which bear coil springs 74 and 75 respectively tending to hold the rods 70 and 71 in the positions illustrated with respect to the slide 59. The cross bar 72 has mounted thereon and insulated therefrom a contact 76 positioned opposite the contact 68 and a contact 77 positioned opposite the contact 69. The cross bar 73 carries a similar pair of contacts 78 and 79 arranged opposite the contacts 68 and 69 respectively.

While I have illustrated and described

herein a control mechanism in which all of the moving parts have a rectilinear motion, it is obvious that they could as well be so mounted as to move in arcs of circles about a common center without departing from the spirit of the invention.

The positive and negative wires of an electric service line are indicated at 80 and 81. From the wire 80 a conductor 82 leads to the contact 68. The contact 69 is similarly connected by a conductor 83 with the negative wire 81 of the line. The conductors 82 and 83 contain flexible portions permitting the movement of the contacts 68 and 69. Contacts 76 and 79 are connected through flexible wires with a conductor 84 leading to a brush 85. The contacts 77 and 78 are connected through flexible wires with a conductor 86 leading to a brush 87. Brushes 85 and 87 bear upon continuous contact rings 88 and 89 respectively mounted upon an insulating collar 90 carried upon the exterior of the cylindrical housing 20. In the latter there is an opening 91 through which the motor wires 92 and 93 extend, the motor being connected by these wires with the rings 88 and 89.

A turbine having adjustable vanes so shaped, proportioned and mounted as to close the turbine entirely against the flow of water, or to take any position of adjustment intermediate the closed position and the fully opened position of the vanes, is disclosed in my copending application Serial No. 216,514, filed August 31, 1927. In that case, as in the present case, the surface of the hub and of the enclosing casing are spherical so that the small clearance between these surfaces and the ends of the vanes remains constant regardless of the adjustment of the latter. The present invention is directed to a different means for accomplishing the said adjustment during the operation of the turbine.

Operation.—When a different adjustment of the vanes 67 is desired the shaft 61 is rotated, moving the nut 64 until the indicator 65 points to the position on scale 66 which corresponds to the adjustment of the vanes that is desired. In the present case assume that the indicator is caused to travel from one position illustrated to a position opposite the point 6 on the scale, that is from a substantially full open position to one about 60% open. The nut 64 is thus traveling toward the right carries with it the rod 67 and the contacts 68, 69 which engage the contacts 78, 79 and move them also to the right, compressing spring 75 and causing rod 71 to slide in its bearing in the slide 59. As soon as the contacts 68 and 69 engage with contacts 78 and 79, an electric circuit is completed from the positive line wire 82 through contacts 68 and 78, through conductor 86 to brush 87, ring 89 and wire 93 to the motor 40 thence back through wire 92, ring 88, brush 85 and conductor 84 to contacts 79 and 69 and through conductor 83 to line wire 81. The motor is thereby driven in a direction which causes it to function through pinion 42 and planet gears 43 to turn ring 46 and nut 47 in a clockwise direction as viewed from above, whereby the rod 26 is raised, also raising the links 30 and swinging cranks 31 to shift the vanes 33 toward closed position.

As the rod 26 moves upwardly, the pins 51, of course, move upwardly with it, sliding the ring 53 upwardly. Upward motion is thus transmitted to the free end of the arm 55 of the bell crank, and the arm 57 thereof moves toward the right, as viewed in Fig. 2, thereby pushing the slide 59 toward the right. This movement of the slide at first merely reduces the compression of spring 75, but presently the slide engages the head on the outer end of rod 71, and through that rod and the cross bar 73 thereon pulls the contacts 78 and 79 away from the contacts 68 and 69, thereby breaking the motor circuit and terminating the movement of the vanes. If a still further closing of the vanes is desired a similar movement of the nut 64 is brought about, so that the indicator 65 rests for example opposite the point 4 on the scale 66. A similar operation of the motor is then produced causing a similar following movement of the slide 59.

An adjustment toward open position is produced by turning the shaft 61 in the opposite direction, causing contacts 68 and 69 to push contacts 76 and 77 to the left, whereby an electric circuit is completed from line wire 80 through contacts 68 and 76, conductor 84, brush 85, ring 88, wire 92, motor 40, wire 93, ring 89, brush 87, conductor 86, contacts 77 and 69 and conductor 83 back to negative line wire 81. The motor then turns in the opposite direction and the rod 28 is lowered, carrying with it ring 53 and swinging the bell crank lever 55, 57 in a counter-clockwise direction. This pulls on link 58 and moves slide 59 toward the left. The latter movement continues until the head on rod 70 is engaged and caused to pull the contacts 76 and 77 away from the contacts 68 and 69, when the motor circuit is broken and the movement of the adjusting mechanism terminated thereby.

While in the disclosure herein the operation of the threaded shaft 61 is manually effected, it will be understood that its automatic operation as heretofore mentioned, may be readily accomplished, but for the sake of avoiding complications such automatic control is not herein illustrated or described.

Having thus described my invention, I claim:

1. In a hydraulic turbine, a rotating shaft, runner vanes carried thereby and adjustable upon their axes, an electric motor carried by

the shaft, operative connections between said motor and said vanes for turning the latter upon their axes, and means operable during the rotation of the shaft for starting said motor in either direction and automatically stopping the same upon the completion of a predetermined change in runner vane adjustment.

2. In a hydraulic turbine, a rotating shaft, runner vanes carried thereby and adjustable upon their axes, a motor fixed to the shaft above the runner, operative connections between said motor and said vanes comprising a threaded rod arranged parallel to the axis of said shaft and adapted to move longitudinally with respect thereto, and a nut mounted upon said threaded rod and connected with said motor for rotation thereby, said nut being mounted against movement longitudinally of the shaft, and means for controlling the direction and extent of rotation of said motor.

3. In a hydraulic turbine, a rotating shaft, runner vanes carired thereby and adjustable upon their axes, a motor carried by the shaft above the runner, operative connections between said motor and said vanes comprising a threaded rod arranged parallel to the axis of said shaft and adapted to move longitudinally with respect thereto, a nut mounted upon said threaded rod, reduction gearing operatively connecting said motor and said nut, said nut being mounted against movement longitudinally of the shaft, and means for controlling the direction and extent of rotation of said motor.

4. In a hydraulic turbine, a rotating shaft, runner vanes carried thereby and adjustable upon their axes, a motor axially mounted in a fixed position in said shaft, operative connections between said motor and said vanes comprising a threaded rod axially arranged in said shaft and adapted to move longitudinally with respect thereto, a nut mounted upon said threaded rod, said nut being mounted against movement longitudinally of the shaft, reduction gearing symmetrically arranged in the shaft for operatively connecting said motor and said nut, and means for controlling the direction and extent of rotation of said motor.

5. In a hydraulic turbine, a rotating shaft, runner vanes carried thereby and adjustable upon their axes, an electric motor carried by the shaft, operative connections between said motor and said vanes for turning the latter upon their axes, a power circuit for said motor extending to a position outside the shaft, means outside the shaft for perfecting said circuit with a flow of current in a given direction, and mechanical means movable with the said connections for interrupting the flow of current in said circuit when an adjustment of the vanes has been accomplished.

6. In a hydraulic turbine, a rotating shaft, runner vanes carried thereby and adjustable upon their axes, an electric motor carried by the shaft, operative connections between said motor and said vanes for turning the latter upon their axes, a power circuit for said motor extending to a position outside the shaft, an indicator outside the shaft movable to various positions corresponding to adjustments of the runner vanes, means associated with said indicator for perfecting said circuit with a flow of current in a given direction, and means movable with the said connections for interrupting the flow of current in said circuit when the vanes reach the position of adjustment corresponding to the setting of said indicator.

7. In a hydraulic turbine, a rotating shaft, runner vanes carried thereby and adjustable upon their axes, an electric motor carried by the shaft, operative connections between said motor and said vanes for turning the latter upon their axes, a power circuit for said motor extending to a position outside the shaft, an indicator outside the shaft movable to various positions corresponding to adjustments of the runner vanes, a switch element for said circuit carried by said indicator, a slide operatively connected with said vane moving connections, a second switch element for said circuit carried by said slide, whereby the movement of the indicator in a given direction brings the said switch elements into contact to start the motor, and whereby the movement of the slide through the connections stated serves to break the contact between the switch elements when the desired adjustment has been accomplished.

8. In a hydraulic turbine, a rotating shaft, runner vanes carried thereby and adjustable upon their axes, an electric motor carried by the shaft, operative connections between said motor and said vanes for turning the latter upon their axes, a gauge outside the shaft bearing indications of different runner vane adjustments, a control member adapted to be manually positioned at various points along said gauge, and means set in motion by the movement of said control member for starting said motor and stopping the same after the vanes reach a position of adjustment corresponding to the setting of said control member.

In testimony whereof I hereunto affix my signature.

HARRY E. POPP.