Aug. 17, 1937. A. W. ANDREWS 2,090,093

HYDRAULIC TURBINE

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Fig. 1

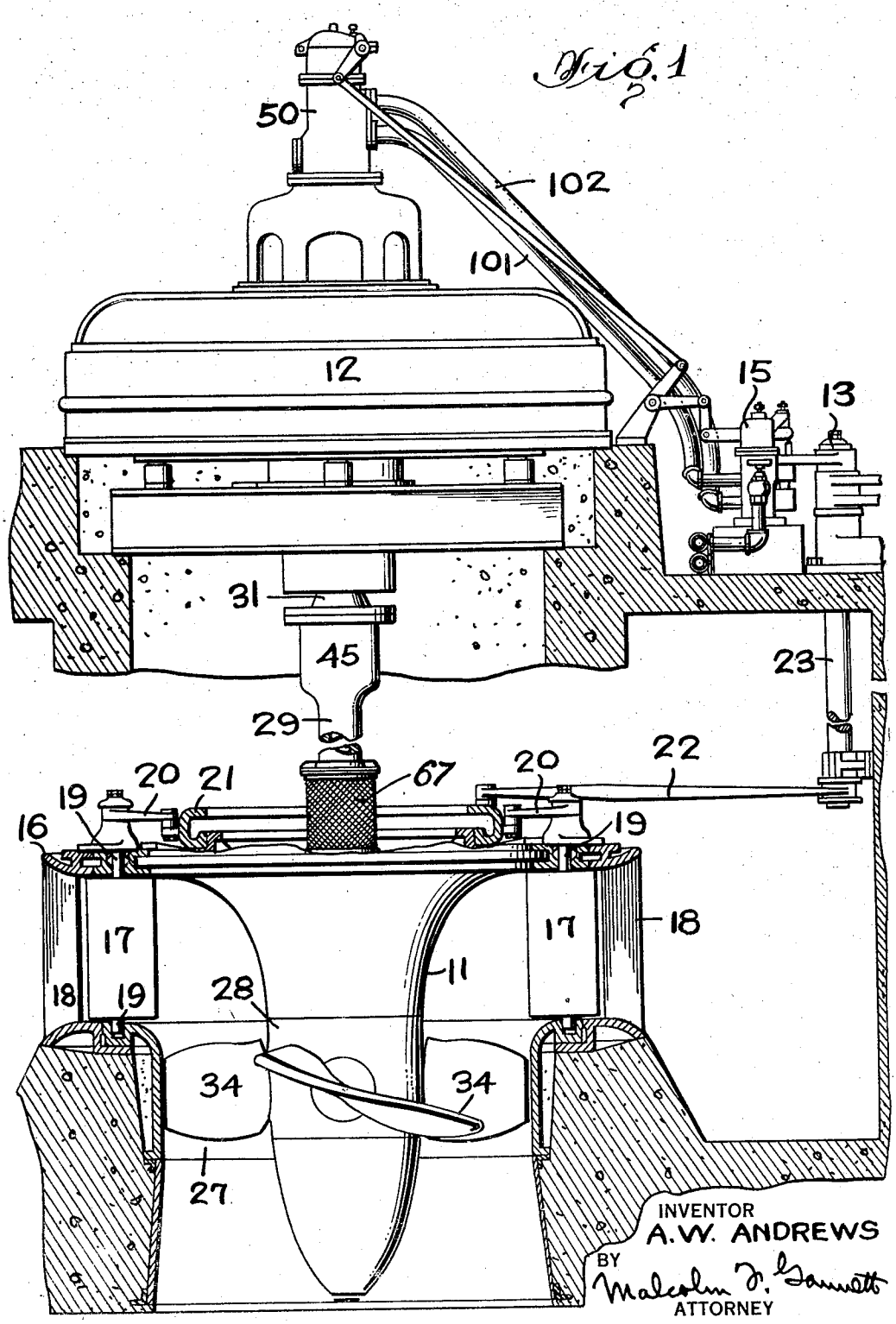


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Fig. 2

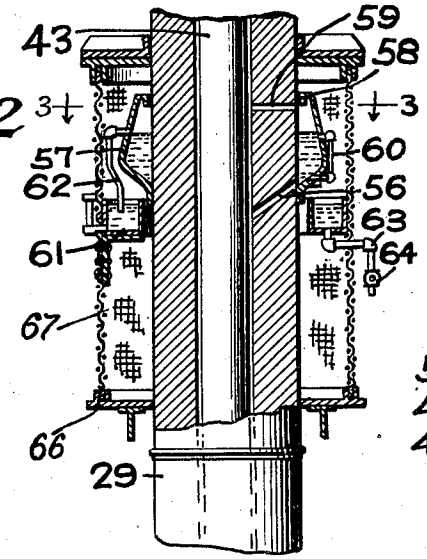
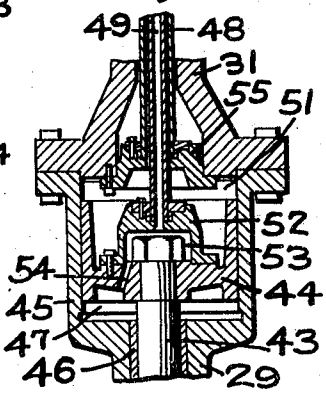



Fig. 4



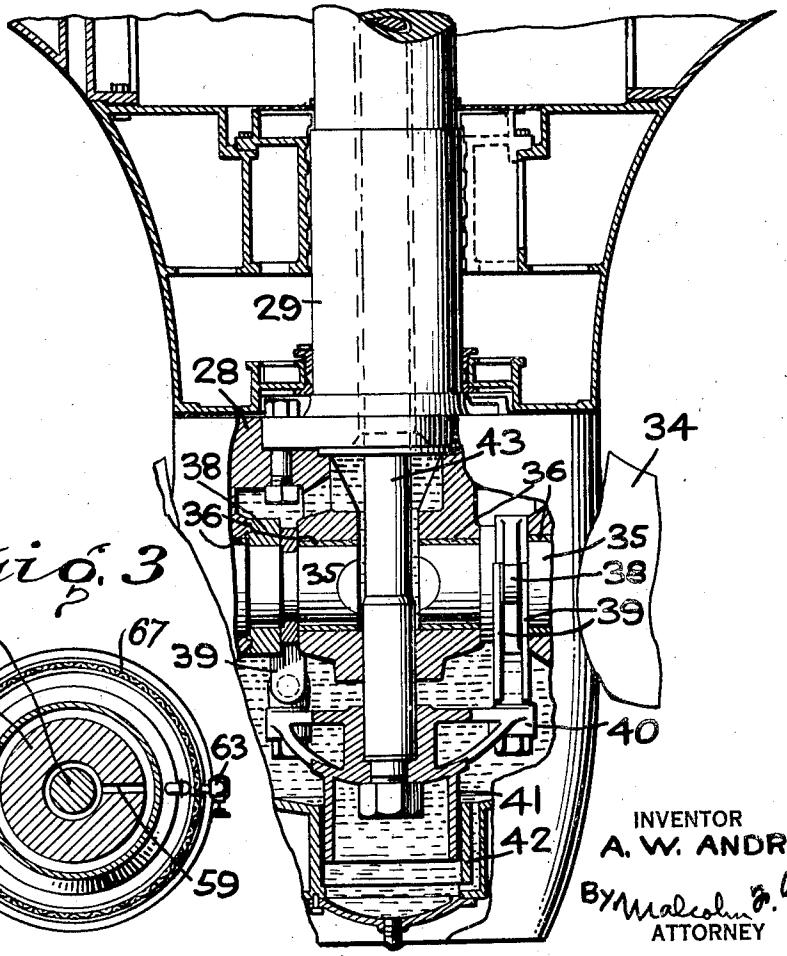




Fig. 3

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# UNITED STATES PATENT OFFICE

2,090,093

## HYDRAULIC TURBINE

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Application November 6, 1936, Serial No. 109,457

1 Claim. (Cl. 253—148)

This invention relates to hydraulic machines, such as hydraulic turbines, pumps and the like, and more particularly to the type of hydraulic machines having runners with movable or adjustable blades.

The hubs of the runners of the above type of hydraulic machines are filled with oil for lubricating the blade operating mechanism within the runner hub, and the present invention relates more particularly to specific mechanical details of construction by which the desired quantity of lubricating oil is maintained in the runner hub.

An object of the invention is to provide improved means for automatically draining oil from the lubricating system of adjustable blade hydraulic machines when the quantity of lubricating oil exceeds a predetermined amount.

Another object of the invention is to provide improved means for maintaining a predetermined quantity of lubricating oil for the blade operating mechanism of a hydraulic machine having adjustable blades.

With the foregoing and other objects and advantages in view, the invention consists in the construction and arrangement of the several parts which will be hereinafter more fully described and claimed.

In the accompanying drawings:—

Figure 1 is an elevation partly in section of an adjustable blade hydraulic turbine embodying the present invention;

Fig. 2 is an enlarged vertical section of a portion of the structure shown in Fig. 1;

Fig. 3 is a horizontal section taken on the line 3—3 of Fig. 2; and

Fig. 4 is a vertical section of the servomotor for operating the runner blade adjusting mechanism.

Referring to the drawings, wherein the turbine is shown connected to an electric generator for the purpose of operating the same, the complete generating unit may comprise a hydraulic turbine 11, an electrical generator 12, and a governor mechanism 13.

As is well known in the art, the governor 13 is adapted to automatically control the operation of the turbine, so that the turbine will operate at a substantially uniform speed, irrespective of the variations of the load.

The turbine 11 has a runner which is made with adjustable blades, the angular positions of which are adapted to be varied according to the load, so that the turbine will operate at its highest efficiency at all times.

In mechanisms falling within the scope of the present invention, the controlling fluid is generally oil, means being provided for controlling the oil in such a manner that when the governor 13 operates to adjust the angles of the wicket gates of the turbine, the runner blades will be caused to rotate in a similar direction so as to effect a corresponding adjustment in the angles or positions thereof. In this way the parts of the turbine will be simultaneously adjusted so that all of the parts will at all times retain their correct relationship with each other and the turbine will operate with maximum efficiency and smoothness and with minimum vibration.

For the purpose of controlling the actuation of the runner blade operating mechanism, a control device 15 may be employed. This control device may be operatively connected with the governor 13 and function in the manner shown and described in McCormack patent No. 1,937,772, granted December 5, 1933 for Hydraulic turbine.

The turbine 11 may comprise a speed ring 16 which forms a peripheral water inlet in which are mounted an annular series of wicket gates 17 and guide vanes 18.

The wicket gates 17 are each provided with a stem or shaft 19 which is mounted in suitable bearings carried by the speed ring.

The wicket gates 17 are adapted to be simultaneously rotated into different angular positions to control the flow of water into the turbine in the usual manner, and for this purpose the upper ends of the stems or shafts 19 are usually provided with gate operating arms 20 which are fixed to said stems and connected by links to a gate adjusting ring 21. The gate adjusting ring 21 is connected by link means 22 to a shaft 23 of the governor mechanism 13.

The lower portion of the turbine casing forms an axially directed chamber 27 in which the runner 28 operates.

The hub of the runner 28 is fixed to the lower end of a hollow or tubular shaft 29. The upper end of shaft 29 is connected to the shaft 31 of the generator 12, as shown in Fig. 1.

A suitable number of blades 34 are rotatably supported in the hub of the runner 28 and project radially therefrom.

The inner end of each blade 34 is formed with a trunnion 35 which is journalled in bearings 36 supported in the hub.

Means are provided for simultaneously rotating all of the blades 34 and for maintaining them in equal angular relationship, such means comprising preferably an arm 38 rigidly fixed on the

trunnion 35 of each blade and links 39 which connect the arms on the several blades to a cross head 40 fixed to the lower end of an operating rod 43 which extends through the hollow runner shaft 29.

The cross head 40 is formed with an annular downwardly extending portion 41 which is mounted in a correspondingly formed guide 42 mounted in the lower portion of the runner hub. The guide 42 provides a sump for the bottom of the hub of the runner, and in this sump collects any water which may seep into the hub of the runner. Since the sump is located at a considerable distance below the blade operating mechanism within the hub, any water which collects in the sump will thus be prevented from mixing with the lubricating oil in the main portion of the hub.

As shown in Fig. 4 the upper end of the operating rod 43 is fixed to the piston 44 of a servomotor 45 which is mounted in the runner shaft 29 adjacent to the point where the runner shaft is joined to the generator shaft 31.

The upper portion of the operating rod 43 passes through a bushing 46 mounted in the runner shaft 29, and this bushing besides forming a bearing for the operating rod 43, provides means for closing the chamber 47 on the lower side of piston 44.

The servomotor piston 44 is double acting, and in order to supply oil to both sides of said piston for the purpose of operating the piston in both directions, two tubes or pipes 48 and 49 are employed.

The pipes 48 and 49 are mounted within the hollow generator shaft 31 and rotate therewith, said pipes extending from the servomotor upwardly through the shaft 31 to a head 50 which is mounted on top of the generator 12, as shown in Fig. 1.

The lower end of pipe 49 is in communication with chamber 47 on the lower side of the servomotor piston 44, and the lower end of pipe 48 is in communication with chamber 51 on the upper side of piston 44.

The lower end of pipe 49 is fixed to a cap 52 carried by the piston 44, and chamber 53 formed within the cap, is connected to piston chamber 47 by means of a passage or port 54 formed in the piston 44, so that oil supplied through pipe 49 will flow into chamber 47.

The lower end of pipe 48 terminates above the cap 52, so as to be in communication with chamber 51 of the servomotor. The lower end of pipe 48 may be secured to the lower end of the generator shaft 31 by means of a member 55 having a peripheral flange which is bolted or otherwise secured to the adjacent portion of the generator shaft 31. The member 55 provides means for closing the lower end of the hollow generator shaft 31 and thereby cut off communication from the chamber 51 to the space within said shaft exteriorly of the pipes 48 and 49.

Pipes 48 and 49 are connected to the control device 15 of the governor 13 through pipes 101 and 102, respectively. As fully explained in Patent 1,937,772, heretofore referred to, through the action of the governor 13 in accordance with variations in load, oil will be supplied to the chambers on the opposite sides of the servomotor piston 44 to operate the servomotor and thereby effect rotation of the runner blades.

The mechanism within the hub of the runner 28 requires thorough lubrication. Therefore, it has been customary to fill the hub with some suitable heavy lubricating oil, since the comparatively light oil used in the governor mechanism for operating the servomotor 45 does not possess sufficient lubricating properties for satisfactorily lubricating the blade operating mechanism within the runner hub.

With two kinds of oil thus used in the turbine, several problems have been confronted in actual practice. One of these problems has been the provision of suitable means for preventing the two oils from becoming mixed together to such an extent as to prove ruinous to the proper functions of either, i. e., to provide means whereby the light oil supplied to the servomotor 45 is prevented from flowing down the hollow turbine shaft 29 and mixing with the heavy lubricating oil in the hub of the runner 28. Another problem has been to provide suitable seals around the joints where the trunnions 35 of the adjustable blades 34 enter the hub of the runner, so as to prevent leakage of the lubricating oil in the hub outwardly through these joints and the entrance of water, sand and other impurities inwardly through these joints.

It is almost impossible to provide a seal which will entirely prevent leakage of the governor oil from the bottom of the servometer 45 into the hollow runner shaft 29 leading downwardly to the runner hub. It is much better to have any oil leakage which occurs here to be in the direction such that the light governor oil passes to the heavy lubricating oil, rather than have the heavy oil mix with the light oil. This is because of the delicacy of the governor 13 which would have its functions interfered with if any substantial quantity of the heavy oil should become mixed with the light governor oil. On the other hand the blade operating mechanism within the hub of the runner is much more rugged and it can withstand some mixture of light oil with the heavy lubricating oil within the hub. The light oil in any event usually passes to the heavy oil at a slow rate and becomes mixed therewith at an elevation slightly below the bottom of the servomotor 45, so that some time is required for the light governor oil to mix with the heavy lubricating oil to such an extent as to deteriorate the quality of the oil in the hub and substantially reduce its viscosity.

As shown in Fig. 4, rod 43 fits snugly in bushing 46 and the latter functions to close the upper end of the hollow runner shaft 29 and thus prevent oil in chamber 47 from entering the hollow runner shaft 29 in appreciable quantities.

According to the present invention the heavy lubricating oil for the hub of the runner 28 is supplied to the interior of the hub, through a port or passage in the runner shaft. This port or passage 56 may be located at any convenient place in the runner shaft 29 between the top of the runner 28 and the bottom of the servomotor 45.

Surrounding the runner shaft 29 and enclosing the outer end of port or passage 56, is a pan 57 for containing a suitable supply of heavy lubricating oil for the mechanism within the hub of the runner 28.

As shown in Fig. 2, the bottom of the oil pan 57 slopes downwardly from the outside wall of the pan inwardly toward the runner shaft 29, and the port or passage 56 also inclines downwardly from a point adjacent to the bottom of the oil pan 57 towards the central opening in the shaft 29 so that oil in the pan 57 can readily flow into the hollow runner shaft 29.

The outer wall of the oil pan **57** is irregular in form, said wall also sloping inwardly upwardly from a point a suitable distance above the bottom of the oil pan, the construction being such that the exterior of the oil pan bulges outwardly at a point slightly below the center of the pan.

Furthermore, the top of the oil pan **57** is open. However, in order to prevent escape of oil from the pan due to centrifugal forces which tend to throw the oil in the pan outwardly and upwardly while the runner is in motion, the top outer edge of the oil pan is bent inwardly, as shown in Fig. 2, to provide a downwardly extending lip **58**. This lip surrounds the runner shaft **29** and is spaced a suitable distance therefrom.

At a point in the shaft **29** adjacent to the lower edge of the lip **58**, there is a vent hole **59**. This vent hole extends from the chamber provided by the oil pan **57** inwardly of the shaft **29** to the central bore formed therein for the operating rod **43**.

The oil pan **57** is provided with a sight glass **60** by which the level of oil within the pan will be indicated. When the supply of oil in the pan is low, additional oil can be introduced into the pan through the open top thereof.

In filling the runner hub with heavy oil, sufficient oil is used so that the oil pan **57** is approximately half filled with oil when the parts of the blade operating mechanism within the hub are in intermediate position. When the servomotor **45** is at its topmost position there is only a small quantity of oil in the pan **57**. Then, when the servomotor moves downwardly, thereby moving the rod **43**, cross head **40** and associated parts downwardly, a volume of oil equal to the volume of the rod **43** which enters the hub is forced into the pan **57**. The difference in oil head or pressure between the top and bottom of the operating rod stroke is thus reduced to a minimum. If there was not a substantial reservoir the difference in oil pressure would be very large, as the volume of the space between the operating rod **43** and the bore of the shaft **29** is small.

During the operation of the turbine the level of the oil in the pan **57** may increase for two reasons: First, there is some leakage of the governor oil from the chamber **47** to the inside of the runner shaft **29**; second, there may be some leakage of water into the hub. On the other hand, there may be also some leakage of oil outward from the hub.

When the leakage inward of the hub exceeds leakage outward from the hub, if it is desired to maintain a turbine in service for a long period of time without shutting the turbine down, it frequently happens that the level of oil in the pan **57** rises to such an extent until oil overflows out of the top of the pan **57**. When this happens the oil is thrown outward into the turbine pit. This loss of oil will continue until such time as the turbine can be shut down and the pan **57** drained.

Therefore, in order to provide means whereby oil in excess of a predetermined amount can be removed from the pan **57** while the turbine is in operation, a stationary circular tank **61** is mounted in the turbine frame at a point beneath the revolving oil pan **57**. The tank **61** surrounds the runner shaft **29** so as not to interfere with the operation thereof.

As shown in Fig. 2, the tank **61** is U-shaped in cross section, being open at its top.

Mounted in the outer wall of the oil pan **57** and adapted to rotate with said pan, is a pipe **62**. The pipe **62** extends downwardly and terminates in the tank **61**.

When the level of the oil in pan **57** reaches the level in said pan to which the pipe **62** is connected to the pan, the oil will flow outwardly from the pan **57** into the stationary tank **61**. Surplus oil can be drained from the tank at any time through pipe **63** having a drain valve **64**.

In turbine installations of the type herein shown and described, it is customary to construct a structural steel floor **66** (Fig. 2) at a convenient level above the runner.

In order to provide means for enclosing the oil pan **57** and its associated parts, so as to prevent attendants and others from coming in contact therewith during operation of the turbine, a tubular member **67**, preferably constructed from heavy screen material, is mounted upon the floor **66** and extends upwardly therefrom a suitable distance, (Figs. 1 and 2).

In actual practice the tubular screen member **67** has been used for supporting the stationary tank **61**, as shown in Fig. 2.

Having thus described my invention, what I claim is:—

In a hydraulic machine, a runner having a hollow hub, a plurality of blades rotatably mounted in said hub, mechanism within the hub for rotating said blades, a hollow shaft connected to the hub, an operating rod in said hollow shaft and operatively connected to said blade operating mechanism, means for reciprocating said operating rod, said hub and said shaft containing oil for lubricating the blade operating mechanism, an oil pan surrounding the runner shaft and rotatable therewith, a passage connecting the bottom of said pan with the interior of the hollow shaft, said pan being adapted to contain lubricating oil for maintaining a predetermined amount of oil in said runner hub and shaft, said pan being adapted to receive surplus oil displaced from said hollow shaft when the operating rod is reciprocated therein, a stationary tank disposed beneath said oil pan, and means connecting the oil pan with said tank whereby surplus oil from the pan is delivered to said tank.

ALBERT W. ANDREWS.