

Feb. 16, 1937.

G. A. JESSOP ET AL

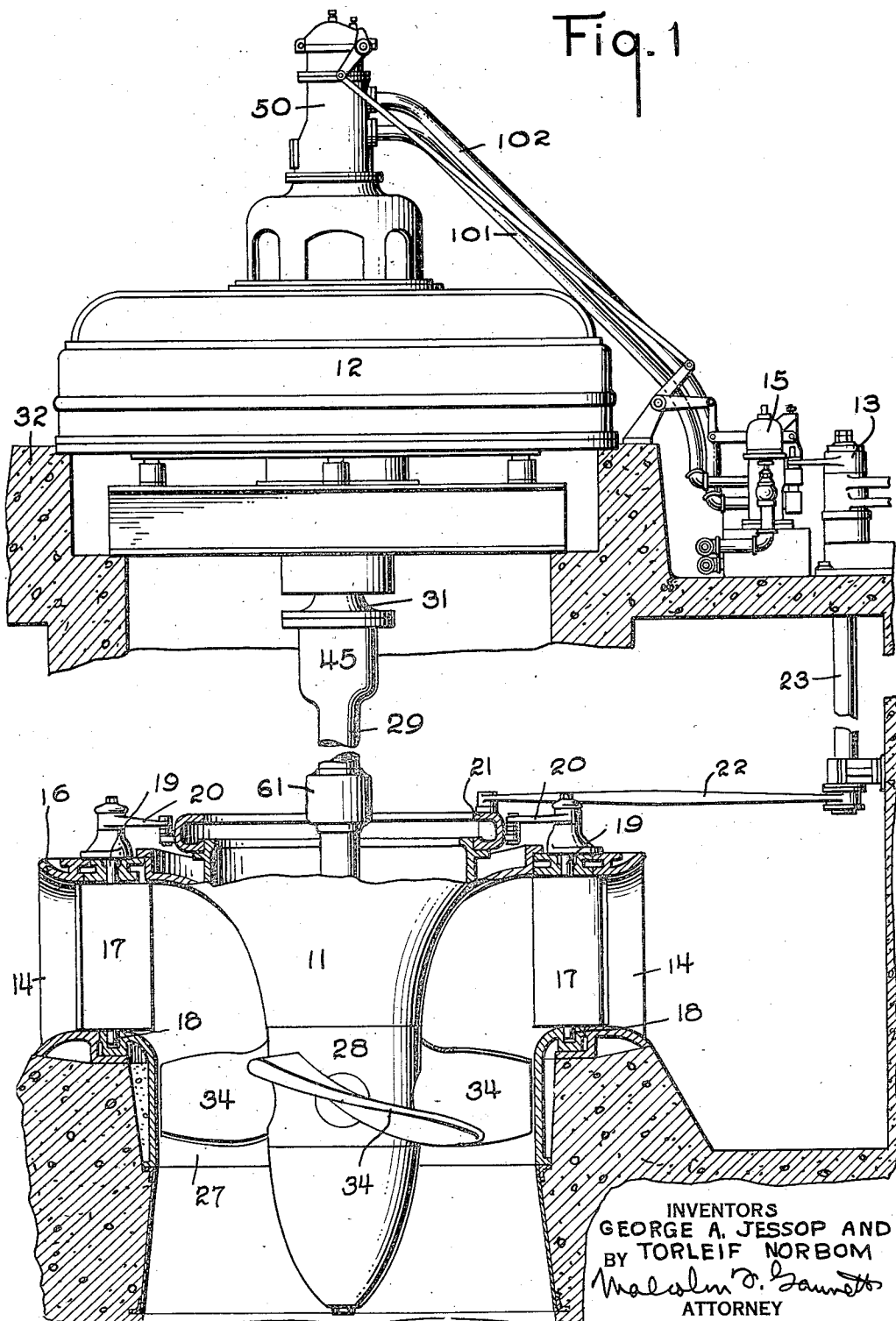
2,070,601

HYDRAULIC MACHINE

Filed Aug. 22, 1935

2 Sheets-Sheet 1

Fig. 1



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Fig. 2

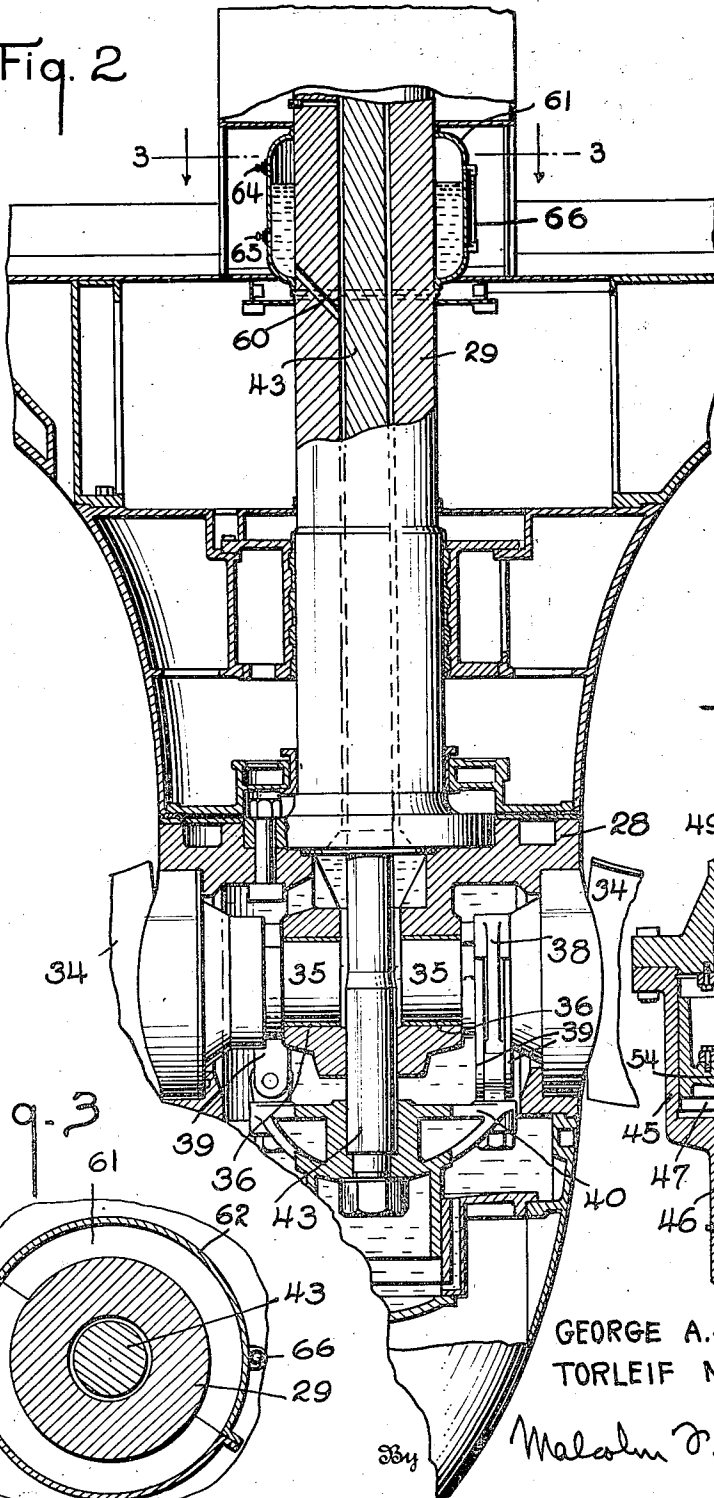


Fig. 4

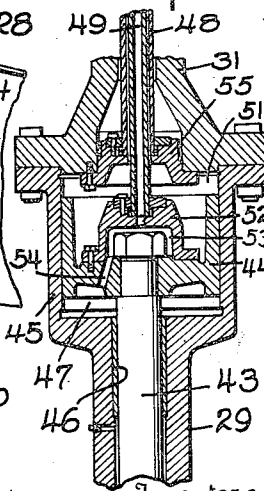
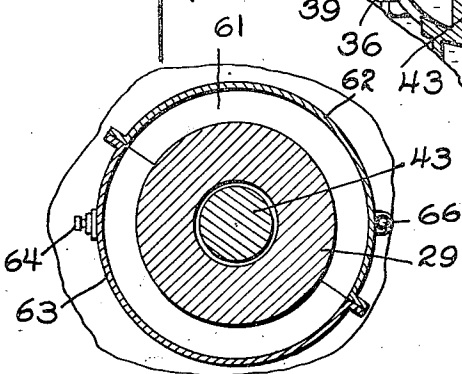


Fig. 3



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HYDRAULIC MACHINE

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4 Claims. (Cl. 253—117)

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 for supplying oil under pressure to the hub of the runner from a suitable reservoir carried by the shaft of the hydraulic machine.

An object of the invention is to provide improved means for maintaining a predetermined pressure of lubricating oil in the runner hub of adjustable blade hydraulic machines.

Another object of the invention is to provide an improved means for maintaining the lubricating oil in the runner hub of an adjustable blade hydraulic turbine at a predetermined pressure by means of compressed air.

Another object of the invention is to provide an improved lubricating system for hydraulic machines of the character mentioned, which is simple in construction, and reliable and exact in function under all conditions of service.

The invention also comprises certain new and useful improvements in the construction, arrangement and combination of the several parts of which it is composed, as will be hereinafter more fully described and claimed.

In the accompanying drawings:—

Figure 1 is a view 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 runner of the turbine shown in Fig. 1;

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

Fig. 4 is an enlarged 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 casing 16 which forms a peripheral water inlet in which are mounted an annular series of wicket gates 17 and guide vanes 14.

Projecting from the lower ends of the wicket gates 17, are trunnions 18 which are journaled in the adjacent portion of the casing.

Likewise, stems 19 project upwardly from the wicket gates 17 and terminate a suitable distance thereabove. The stems 19 are rotatably mounted in the upper portion of the casing 16.

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 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 16 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 Figs. 1 and 4.

Any suitable type of setting may be used for the turbine installation, a concrete setting 32 being shown in the present instance. The elec-

trical generator 12 may rest on top of the setting 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 journaled 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 different blades to a cross head 40 fixed to the lower end of an operating rod 43 which extends upwardly through the hollow runner shaft 29.

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 the point where the runner shaft is joined to the generator shaft 31.

The servomotor piston 44 may be contained in a cylinder which may be formed as an enlargement of the runner shaft 29, the upper portion of said cylinder being closed by the lower portion of the generator shaft 31, as shown in Fig. 4.

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 thereof for the purpose of operating the same 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 cuts 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 valve device 15 of the governor mechanism 13 through pipes 101 and 102, respectively. As fully explained in Patent 1,937,772 above referred to, through the action of the governor 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 same 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 of the runner 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 through 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 turbine, 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 servomotor 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 interior of the hub through a port or passage 60 in runner shaft 29. This port or passage 60 may be located at any convenient place in the runner shaft 29 between the top of the runner and the bottom of servomotor 45. In the present instance it is shown disposed slightly above the upper portion of the turbine casing 16.

Surrounding the runner shaft 29 and enclosing the outer end of port or passage 60 is a closed chamber 61 formed preferably of two sections 62 and 63, suitably secured together in the manner shown in Fig. 3.

Chamber 61 constitutes a closed, air tight reservoir for containing a suitable supply of heavy lubricating oil for the mechanism within the hub of the runner 28, and in order to pro-

vide means whereby oil may be supplied thereto from time to time in order to replenish the amount contained therein, the wall of the chamber 61 is formed with two openings which are normally closed by screw plugs 64 and 65, respectively. As shown in Fig. 2, the openings may be superposed, one being disposed near the bottom of chamber 61 and the other near the top.

Chamber 61 is also provided with a sight glass or other element 66 by which the level of the oil within the chamber will be indicated.

Heretofore it has been the practice to employ an open oil reservoir which was located on the revolving runner shaft at a distance below the servomotor. The maximum level of the heavy lubricating oil in the hub was therefore a considerable distance below the servomotor.

In installations where the head is relatively high the pressure of the water on the runner blades is for the most part of the operating range higher than the oil pressure in the hub. Since the pressure of water in the runner hub is undesirable, and since it is practically impossible to keep the packings of the runner blade trunnions absolutely tight, it is necessary, in order to prevent water leakage, to keep the pressure of the oil within the runner hub higher than the maximum pressure of the water outside of the hub. To do this it is necessary to maintain the pressure of the lubricating oil within the runner hub sufficiently high, so that the natural oil level is higher than the elevation of the servomotor. However, since this is not possible to do, by the present invention, it is proposed to increase the pressure of the lubricating oil within the runner hub and maintain the oil under increased pressure by means of compressed air supplied to the oil chamber 61.

With compressed air in the chamber 61 the pressure of the oil within the hub of the runner can be such that the lubricating oil will have a natural level equal to the elevation of the part of the turbine oil head which supplies the oil to the chamber 47 on the underside of the servomotor piston 44, and still not have a tendency for the heavy hub oil to leak into the light governor oil with which the servomotor is operated.

In filling the runner hub with heavy oil, sufficient oil is used so that the chamber 61 is approximately half filled with oil. Then compressed air is introduced into chamber 61 and the pressure raised to the desired point. This pressure can be the equivalent to the pressure which would be obtained if the free level of the hub oil extended up to the part of the oil head of the turbine which feeds the bottom chamber 47 of the servomotor 45, or to any elevation desired between the servomotor and said point in the oil head. The pressure of the governor oil in chamber 47 of the servomotor 45 is always substantially the equivalent to the static head of oil between the oil head and the bottom of the servomotor cylinder. If the pressure in the chamber 61, therefore, does not exceed the limit as described above, there will never be any tendency for leakage of the heavy lubricating oil into the light governor oil. In the event that, through the process of governing, high pressure is introduced below the servomotor piston 44, then, of course, there will be a tendency for the light oil to leak into the heavy oil.

The vertical operating rod 43 moves up and down to operate the runner blades. When rod 43

moves down oil must be displaced out of the hub of the runner 28 up through the space between the rod 43 and the main shaft 29 and into the chamber 61. This will, of course, raise the pressure in cylinder 61. When the rod 43 is raised, oil must be supplied to the hub of the runner 28 from chamber 61, thus reducing the pressure in chamber 61. Chamber 61, therefore, should be large enough and should contain sufficient compressed air, so that the variation in pressure at the extreme oil levels will be small, and so that in any event the oil pressure maintained is sufficient to prevent leakage of water into the hub of the runner around the joints between the trunnions of the runner blades and the hub.

The chamber 61, which revolves with the main shaft 29 of the turbine, should be fastened to shaft 29 in such a way that the chamber 61 is tight against oil leakage on the bottom and air leakage on the top. Chamber 61 should be balanced so that there will be no unbalanced revolving load on the shaft 29. It is necessary to have means, such as provided by the opening closed by plug 64, so that an instrument can be attached to the chamber 61 to check the pressure therein at any time the apparatus is shut down and also by which additional air under pressure can be introduced into chamber 61. The lower opening which is normally closed by plug 65 provides a connection whereby oil can be introduced into or removed from chamber 61.

Mechanisms of the type herein described, when installed in hydro-electric power plants, have to be shut down from time to time for the purpose of lubrication, inspection and adjustment. When the mechanisms are being inspected, it is customary to remove the plug 65 and replenish the supply of oil in chamber 61. After the supply of oil has been replenished, it is then customary to remove plug 64 and insert in the opening closed by plug 64 a hose leading from a source of supply of compressed air and thus supply additional air under pressure to chamber 61 to bring the pressure of air in said chamber up to the desired amount, after which the air hose is removed and the plug reinserted in its opening.

By designing the hydraulic and mechanical balance of the runner blades in such a way, that it is always necessary to maintain some pressure underneath the servomotor piston 44 in order to keep the servomotor from moving downwards, it is possible to maintain an oil pressure in the hub of the runner 28 so that the normal level of the oil will be higher than the elevation of the oil head and still not have a tendency for the heavy oil to leak into the light governor oil.

It should be noted that the oil connection from chamber 61 to the passage around the blade operating rod 43, provided by port or passage 60, connects to chamber 61 at or near the bottom of said chamber. This is done so that the air in the chamber 61 is positively trapped and can never enter the oil space around operating rod 43 as long as there is oil in the chamber 61.

Having thus described our invention what we claim is:—

1. 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, said hub and said shaft containing oil for lubricating the blade operating mechanism within the hub, and means for maintaining the pressure of the lubricant in the hub a predetermined amount, comprising a fluid tight oil cham-

ber surrounding the runner shaft and rotatable therewith, and means connecting the interior of said chamber with said shaft, said chamber containing air under pressure for increasing the static pressure of the lubricating oil in the hub.

2. 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, said hub and said shaft containing oil for lubricating the blade operating mechanism within the hub, and means whereby the pressure of the oil in the hub may be maintained a predetermined amount, comprising a fluid tight oil chamber surrounding the runner shaft and rotatable therewith, a passage connecting said chamber and said shaft, means formed on said chamber whereby oil may be supplied to the chamber, and means formed on said chamber above said oil supply means whereby air under pressure can be supplied to said chamber.

3. A device of the class described comprising a runner having a hollow hub containing lubricating

oil, a hollow shaft connected to said hub, a fluid tight chamber rotatably carried by said shaft and in communication with the interior thereof, and means whereby air under pressure may be supplied to said chamber for maintaining the static pressure of the oil in said hub a predetermined amount.

4. A device of the class described comprising a runner having a hollow hub containing lubricating oil, a hollow shaft connected to said hub, a fluid tight chamber rotatably carried by said shaft and surrounding the same for containing a supply of lubricating oil, a passage connecting the bottom of said chamber with said hollow shaft, means whereby oil may be supplied to said chamber, said chamber being adapted to be only partly filled with oil, and means located above the normal level of oil in said chamber whereby air may be introduced under pressure into said chamber to increase the static pressure of the oil in the hub.

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