

1,180,602.

Fig. 1 is a cross-sectional view of a mechanical device, likely a pump or engine, showing a central shaft (13) passing through a housing (9). The shaft is connected to a crank mechanism (12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28) which is driven by a motor (12). The device includes a large circular component (2) at the top and bottom, and a central chamber (7) with various internal parts (10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28). The housing (9) is shown in cross-section, revealing internal components like a valve (21) and a piston (22). The device is mounted on a base (10) and has a flange (11) at the top.

Fig. 2 is a detailed cross-sectional view of a component, possibly a valve or a piston, showing its internal structure. It includes a central shaft (170) passing through a housing (40). The component has a flange (33) at the top and a base (80). Internal parts include a valve (32), a piston (31), and a spring (35). The component is shown in cross-section, revealing its internal components and the way they are assembled.

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ROTOR-END-THRUST-BALANCING DEVICE.

1,180,602.

Specification of Letters Patent.

Patented Apr. 25, 1916.

Application filed May 7, 1915. Serial No. 27,260.

To all whom it may concern:

Be it known that I, ARNOLD PFAU, a citizen of the Republic of Switzerland, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented a certain new and useful Improvement in Rotor-End-Thrust-Balancing Devices, of which the following is a specification.

This invention relates to improvements in the construction of end thrust balancing devices particularly applicable to the rotors of steam, gas or hydraulic turbines, centrifugal pumps and similar devices.

An object of the invention is to provide a rotor end thrust balancing device which is simple in construction and efficient in operation.

Another object is to provide an end thrust balancing device particularly applicable to rotors having characteristics which make it impossible by simple mechanical construction to provide balancing means on opposite sides of the rotor.

The present invention is an improvement over the device disclosed in prior Patent No. 1,117,699, dated Nov. 17, 1914.

A clear conception of several embodiments of the invention may be had by referring to the drawing accompanying and forming a part of this specification in which like reference characters designate the same or similar parts in the several views.

Figure 1 is a transverse vertical section through a hydraulic turbine having the present invention applied thereto. Fig. 2 is an enlarged fragmentary vertical section through a portion of a hydraulic turbine having another form of the invention applied thereto.

While the invention is disclosed herein as being applied to a Francis type hydraulic turbine of the horizontal inward flow type, it will be understood that the same is equally applicable to any other device in which it is desired to balance end thrusts on a rotating element. In order to make the present invention especially applicable, the rotor should have such characteristics that balancing devices cannot be readily applied to opposite sides thereof, the device disclosed in the prior patent being readily ap-

plicable in cases where such balancing devices are readily applied.

The main turbine casing 1, which is of the spiral type, forms a housing for the pressure supply chamber 2 and has guiding ribs or stationary vanes 3 formed integral therewith. The runner casing 20 is secured to the inner portion of the main casing 1 and forms a housing for the turbine runner 7. The runner 7 is mounted upon the main shaft 8 which is supported in a main bearing 12 and an auxiliary bearing 13. The periphery of the runner 7 communicates with the interior chamber 2 of the casing 1, while an end of the runner 7 is in direct open communication with the draft tube 9.

Communication between the runner and the chamber 2 is controllable by means of the usual guide vanes 4 having operating stems 6 provided with suitable operating arms 21 which are actuable by means of the guide vane actuating ring 5. The ring 5 is operable by means of any of the well known devices of the prior art.

The side of the runner 7 adjacent the main bearing 12 is provided with a rotary balancing piston 22. The casing 20 is provided with a wall 23 which projects inwardly between the runner 7 and the piston 22, approaching the turbine shaft 8. An annular balancing chamber 11 is formed between the end wall of the runner 7 and the wall 23. An annular balancing chamber 10 is formed between the piston 22 and the wall 23. A pressure chamber 17, which during normal operation of the turbine is in constant open communication with the chamber 2 through a relatively wide annular gap or space 18, communicates with the balancing chambers 10, 11, respectively, through annular openings 25, 26 at the periphery of the piston 22 and at the periphery of the end wall of the runner 7, respectively. The annular openings 25, 26, constitute annular inlet spaces of constant cross-sectional area and of substantially constant length located between cylindrical surfaces of the rotor 7 and casing 1. The chambers 10, 11, communicate with a common pressure discharge chamber 24 through gaps 27, 28 formed between spaced opposed surfaces of

the piston 22 and wall 23, and between the end wall of the runner 7 and the wall 23, respectively. The annular pressure relief chamber 24 communicates with an annular relief chamber 14, which in turn communicates with draft tube 9 through a suitable pipe 16 having a control valve 15 therein. Passages 19 may also be formed directly through the end wall of the runner 7 in order to establish a more direct communication between the chamber 24 and the draft tube 9.

In the form of invention disclosed in Fig. 2, the turbine runner 70 has a balancing piston 122 secured to an end thereof, both the runner and piston being secured to the main shaft 80. The runner 70 is housed within the main runner casing 200 and has its periphery connected with the usual pressure chamber 2, the admission being controllable by means of suitable guide vanes 40. The end of the runner 70 is in free communication with the draft tube 90. The casing 200 is provided with an inwardly extending wall 123, between which and the piston 122 a balancing chamber 100 is formed, and between which and the end wall of the runner 70 a balancing chamber 110 is formed. The pressure chamber 170 which is in constant communication with the high pressure chamber at the periphery of the runner 70 through a relatively wide annular gap or space 180, communicates with the balancing chamber 100 through an annular gap 33, and communicates with the balancing chamber 110 through an annular gap 32, these annular gaps 33, 32, constitute inlet spaces of constant cross-sectional area and of substantially constant length located between cylindrical surfaces of the runner 70 and casing 200. The balancing chamber 100 communicates with the common pressure relief chamber 141 through a variable gap 30, while the balancing chamber 110 has similar communication with the chamber 141 through a variable gap 31. The pressure relief chamber 141 communicates directly with the annular relief chamber 140 which may be connected with the draft tube 90 by means of a pipe 16, and which may also communicate more directly with the draft tube 90 through suitable passages 190.

It may be desirable in applying the invention to rotors having certain characteristics, to have a series of balancing chambers for urging the rotor in either direction. Such a device can be produced by providing chambers 101, 111, as shown in dot and dash lines in Fig. 2. The variable gaps 30, 31, would in such a device communicate directly with the chambers 101, 111, respectively, which chambers would communicate directly through variable gaps 36, 35, respectively, with the pressure relief chamber 141.

During the normal operation of the turbine disclosed in Fig. 1, fluid under pressure is admitted to the runner 7 from the pressure chamber 2 past the stationary guide vanes 3 and the movable guide vanes 4. As the high pressure fluid passes through the runner 7, it delivers energy to the shaft 8, the spent fluid being discharged at a greatly reduced pressure through the draft tube 9. Some of the fluid under pressure at the periphery of the runner 7 passes through the annular space 18 and fills the pressure chamber 17 with high pressure fluid. A small amount of the high pressure fluid is constantly flowing through the annular gap formed between the periphery of the piston 22 and the adjacent surface of the casing 20 directly to the pressure relief chamber 14. A small amount of fluid is also entering each of the balancing chambers 10, 11, through the annular cylindrical spaces 25, 26 adjacent the peripheries of these balancing chambers. With the runner 7 in mid position, the discharge gaps 27, 28 connecting the balancing chambers 10, 11, with the pressure relief chamber 24, permit escape of fluid from the balancing chambers 10, 11, and maintain the pressures within these two balancing chambers at substantially equal values. If, however, the runner 7 is moved in either direction, say toward the left, the discharge gap 28 leading from the balancing chamber 11 becomes suddenly restricted, while the discharge gap 27 leading from the chamber 10 is suddenly widened. This variation in the sizes of the respective discharge gaps 27, 28 leading from the balancing chambers, causes the pressure within the balancing chamber 11 to suddenly increase, while that within the balancing chamber 10 is suddenly reduced, thus tending to urge the runner 7 toward the right. If for any reason end pressure is applied to the runner 7, causing it to move toward the right, the pressure within the balancing chamber 10 is suddenly increased, while that within the chamber 11 is suddenly decreased, thus tending to move the runner 7 toward the left. It will thus be noted that the balancing chambers 10, 11, automatically tend to maintain the runner 7 in mid position, taking care of all end thrusts in either direction which are applied to the runner.

The action of the device disclosed in Fig. 2 is analogous to that of the device disclosed in Fig. 1, the only difference between these devices being structural. In the form disclosed in Fig. 2, the balancing chambers are of equal area and of substantially equal diameters. Such construction also permits more ready application of the series of balancing chambers disclosed in dot and dash lines. When the two series of balancing chambers 100, 101, and 110, 111, are applied, the fluid under pressure is dis-

charged from the balancing chambers 100, 110, through the gaps 30, 31, respectively, to the chambers 101, 111, respectively, from which chambers the fluid is discharged through the gaps 36, 35, respectively, to the chamber 141. If the runner 7 is moved toward the left, the gaps 31, 35, are restricted, while the gaps 30, 36, are simultaneously enlarged, thus tending to increase the pressures within the chambers 110, 111, and to simultaneously release the pressures from the chambers 100, 101. This state of affairs produces a pressure tending to return the runner 70 toward the right. Upon application of an end thrust in the opposite direction, the pressure within the chambers 110, 111, is simultaneously released, thus tending to return the runner 70 to its mid position.

It will thus be seen that if the rotor of either of the structures disclosed, is moved in either direction from its normal or mid position, the balancing device automatically returns the same to its mid position. The balancing devices disclosed are readily applicable to one side of the rotor, thereby making them especially applicable to rotors in which mechanical difficulties prevent ready application of a balancing device to each side of the rotor. By making the means of pressure communication from the common supply to the balancing chambers of constant cross section and substantially constant length, the rate of pressure supply to the balancing chambers for a constant pressure in the supply chamber 17, 170, is substantially constant irrespective of the position of the runner. By forming the means of pressure discharge from the balancing chambers as spaced opposed surfaces having variable gaps between them, the pressures within the balancing chambers are quickly affected to produce a rapid return of the runner to its mid position.

The form of the invention disclosed in dot and dash lines in Fig. 2 is particularly applicable to rotors in which high pressures are utilized for balancing purposes, but its utility is not limited to such devices.

It should be understood that it is not desired to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

It is claimed and desired to secure by Letters Patent,—

1. In combination, a casing, a rotor within said casing, pressure chambers on one side of said rotor, means of pressure communication directly from a common supply to said chambers, said means being of constant cross section and substantially constant length, and means of pressure discharge from said chambers, said means comprising spaced opposed surfaces of said rotor and said casing.

2. In combination, a casing, a rotor within said casing, pressure chambers on one side of said rotor, means of pressure communication to said chambers, said means being of constant cross section and of substantially constant length, and means of pressure discharge directly from said chambers to a common relief chamber, said means comprising spaced opposed surfaces of said rotor and said casing.

3. In combination, a casing, a rotor within said casing, pressure chambers on one side of said rotor, means of pressure communication directly from a common supply to said chambers, said means being of constant cross section and of substantially constant length, and means of pressure discharge directly from said chambers to a common relief chamber, said means comprising spaced opposed surfaces of said rotor and said casing.

4. In combination, a casing, a rotor within said casing, a plurality of pressure chambers at one side of said rotor, said chambers having annular inlet spaces of constant cross sectional area and substantially constant length located between cylindrical surfaces of said rotor and said casing, and said chambers having annular outlet spaces of variable cross sectional area.

5. In combination, a casing, a rotor within said casing, a plurality of series of balancing pressure chambers at one side of said rotor, means of pressure communication directly from a common supply to each of said series of chambers, said means being of constant cross section and substantially constant length, and means of pressure discharge from said series of chambers and of pressure communication between the chambers of each of said series, said means of discharge and of communication each comprising opposed surfaces of said rotor and casing.

6. In combination, a casing, a rotor within said casing, a series of balancing pressure chambers at one side of said rotor, means of pressure communication to said series of chambers, said means being of constant cross section and of substantially constant length, means of pressure discharge from said series of chambers and of pressure communication between the chambers of said series, said means of discharge and of communication each comprising spaced opposed surfaces of said rotor and casing, and means located on the same side of said rotor for subjecting the same to a counterbalancing pressure.

7. In combination, a casing, a rotor within said casing, a plurality of series of balancing pressure chambers on one side of said rotor, means of pressure communication to each of said series of chambers, said means being of constant cross section and of substantially constant length, means of pressure

discharge from each of said series and of pressure communication between the chambers of each of said series, said means of discharge and of communication each comprising spaced opposed surfaces of said rotor and said casing.

8. In combination, a casing, a rotor with in said casing, pressure chambers on one side

of said rotor, means of pressure communication directly from a common supply to said chambers, and means of pressure discharge directly from said chambers to a common relief chamber. 10

In testimony whereof the signature of the inventor is affixed hereto.

ARNOLD PFAU.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."