F. HODGKINSON.

END THRUST APPARATUS FOR FLUID PRESSURE TURBINES.

APPLICATION FILED JAN. 20, 1904. RENEWED SEPT. 14, 1907.

953,530. Patented Mar. 29, 1910.

4 SHEETS—SHEET 1.

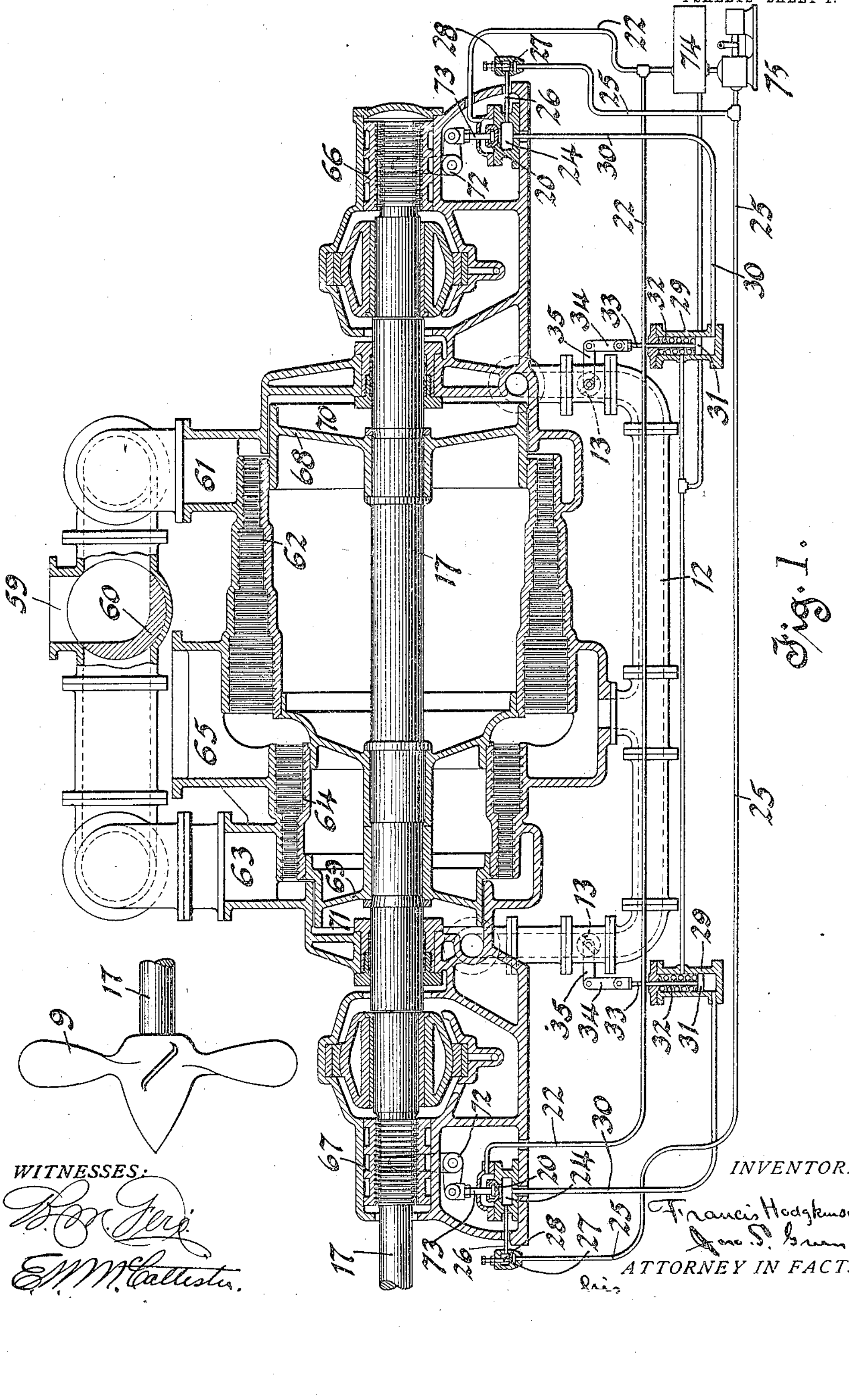

Fig. 1.

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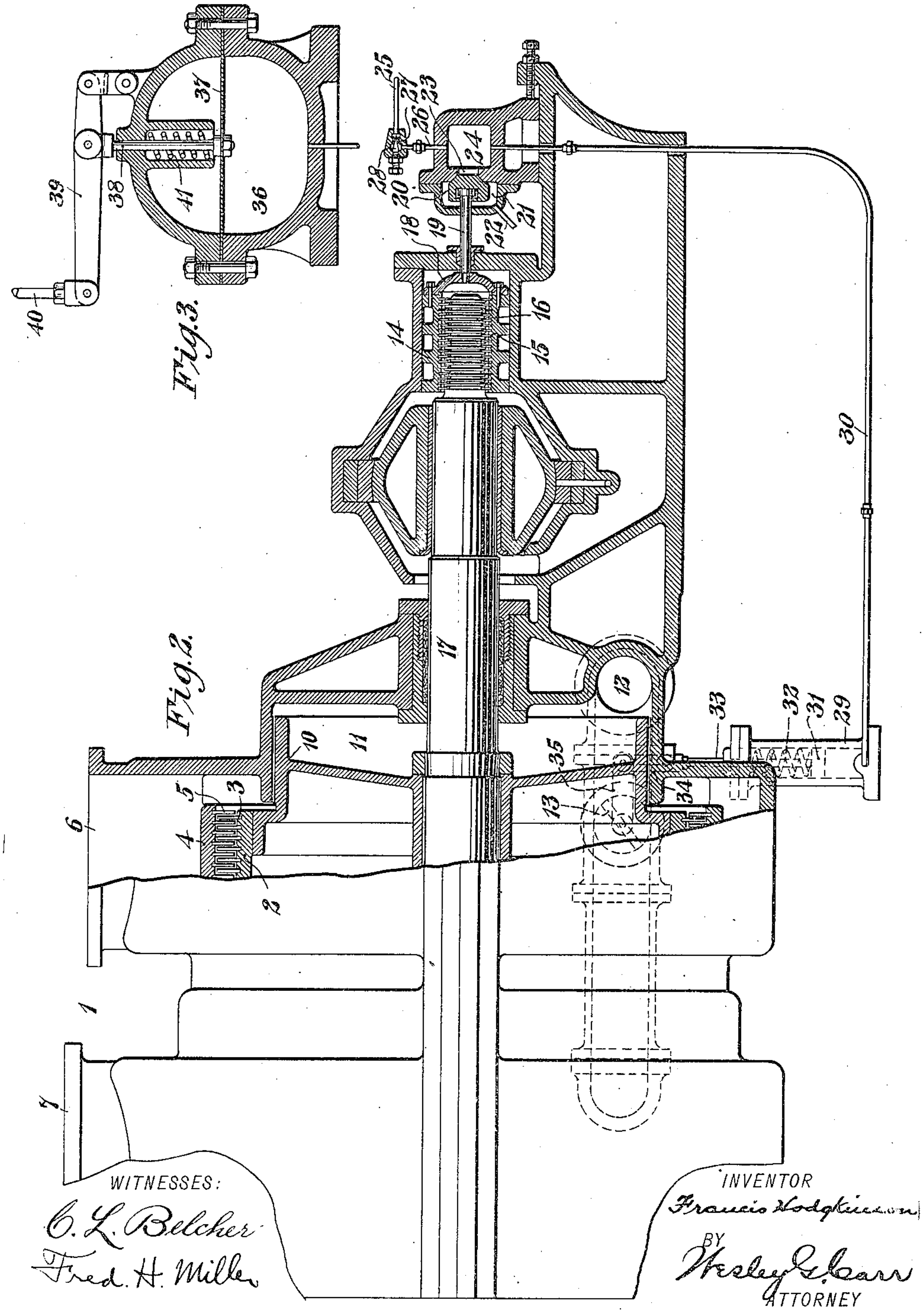

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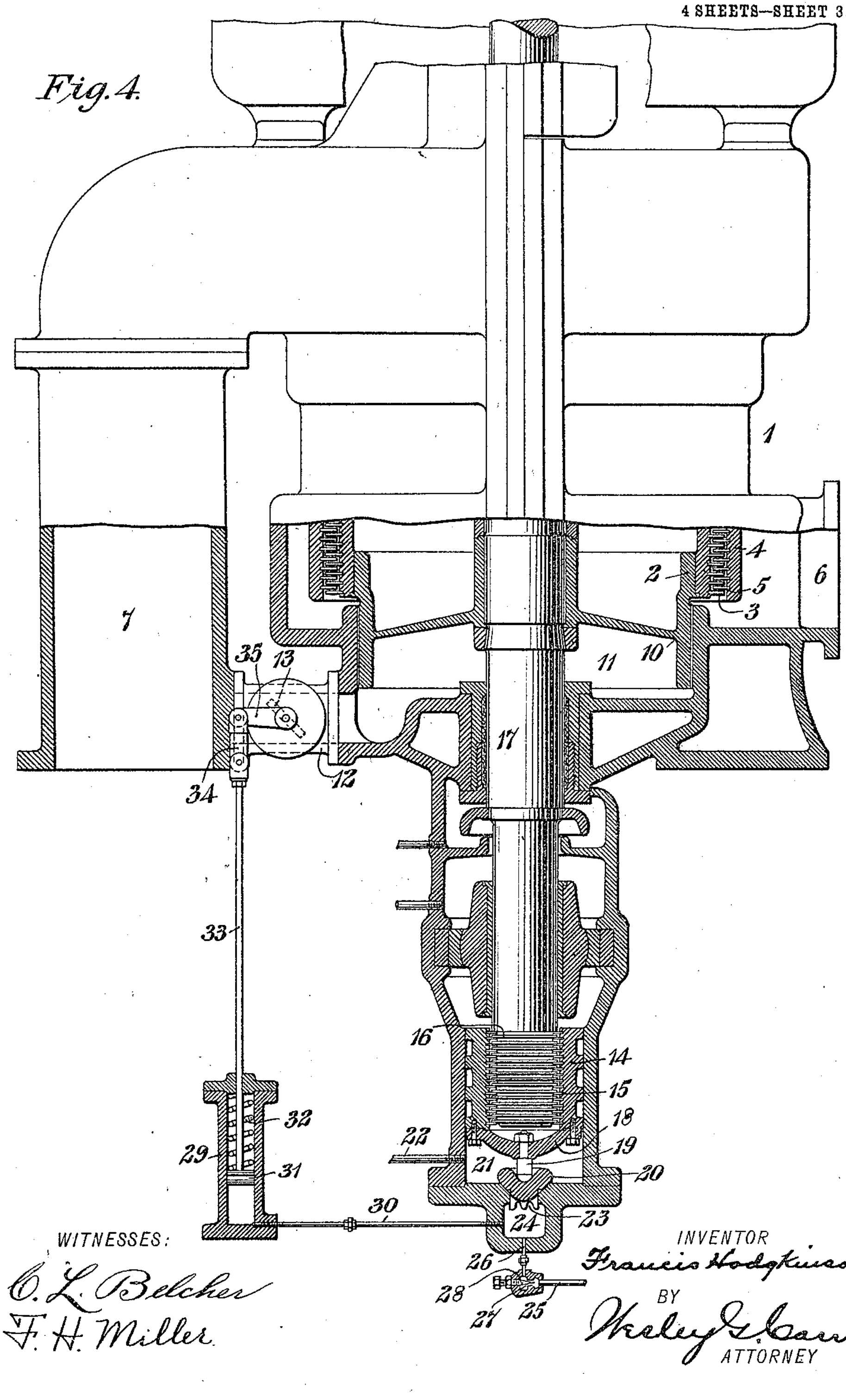

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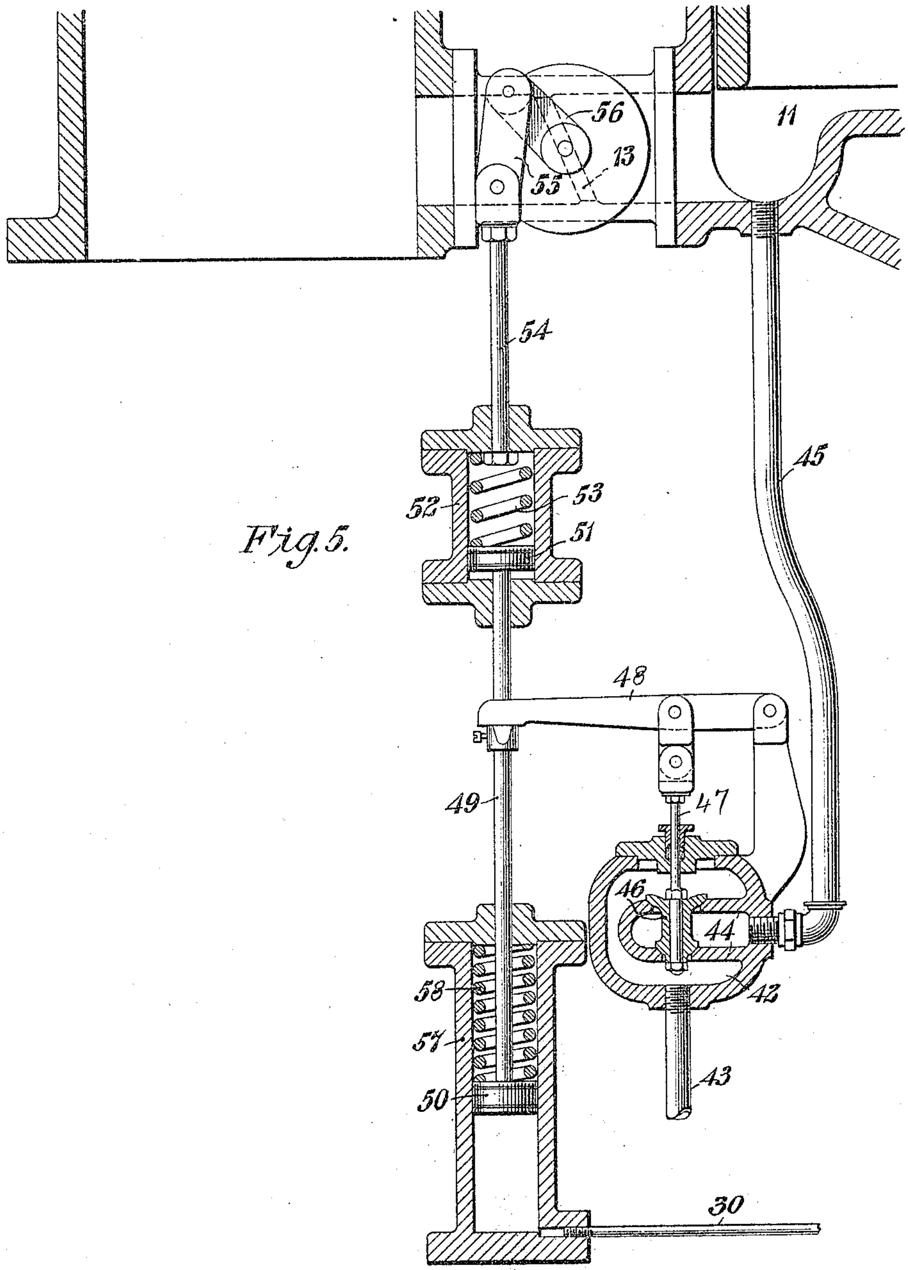

Fig. 5.

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END-THRUST APPARATUS FOR FLUID-PRESSURE TURBINES.

953,530. Specification of Letters Patent. **Patented Mar. 29, 1910.**

Application filed January 20, 1904, Serial No. 189,897. Renewed September 14, 1907. Serial No. 392,822.

To all whom it may concern:

Be it known that I, FRANCIS HODGKINSON, a subject of the King of Great Britain and Ireland, residing at Edgewood Park, in the county of Allegheny and State of Pennsylvania, United States of America, have invented a new and useful Improvement in End-Thrust Apparatus for Fluid-Pressure Turbines, of which the following is a specification.

My invention relates to fluid-pressure turbines, and particularly to such as operate against considerable pressures exerted as end thrusts upon their shafts, and it has for its object to provide means for counter-balancing such end thrusts in a simple and effective manner and to such a degree as to promote satisfactory operation of the engine as a whole.

Figure 1 is a longitudinal sectional view of a reversing turbine constructed in accordance with my invention. Fig. 2 is a view, partially in side elevation and partially in section, of a portion of one of the turbines shown in Fig. 1. Fig. 3 is a sectional, detail view of a modification of one of the parts of the end thrust counter-balancing mechanism. Fig. 4 is a view, partially in elevation and partially in section, of a vertical turbine equipped with my invention. Fig. 5 is a vertical, sectional view of a modified form of my invention as adapted to a vertical turbine.

In the operation of horizontal steam turbines for driving electric generators and for similar purposes, it is obvious that there is no material end thrust upon the turbine shafts except in cases where the turbines are of the single-flow type; that is, in which the steam is introduced at one end and exhausted at the other, and in such cases, it has been usual to provide a piston to balance the end thrust produced by the pressure of the steam against the rotating drum of the turbine. In the use of turbines for driving the propellers of marine vessels, however, it is obvious that the end thrust due to the propeller action is considerable and that some means should be provided to counter-balance it. The end pressure thus exerted may, of course, be taken by an ordinary form of thrust bearing, such as is commonly employed in marine practice, but such bearings are subject to considerable wear and large frictional losses. I therefore propose to provide a means which will automatically balance the end thrust caused by the propellers throughout all the limits of regular operation.

As here shown, the turbine 1 is of the multi-cellular or Parsons type, in which the main rotating member or drum 2 is provided with a series of annular sets of blades or buckets 3 and the casing 4 is provided with a corresponding series of annular sets of guide-vanes 5, which alternate in position with the blades or buckets 3, the steam being introduced through an inlet port 6 and exhausted, at the other end of the turbine, through an exhaust port 7.

Referring now more particularly to Fig. 2, the drum 2 is provided, at its forward end, with a piston 10, which is shown as having the form usually adopted for balance pistons and as of less diameter than the main portion of the drum. If the balance piston is of less diameter than the main portion of the drum, as indicated, the pressure of steam acting upon the said main portion will exert an end thrust which will, to a greater or less extent, counter-balance the thrust of the propeller. The balance piston may, however, be made of the same mean diameter as the main portion of the drum, and if such is the case, there will be no counter-balancing end thrust which is incident to the normal operation of the turbine. The space 11 in front of the piston 10 is connected with the exhaust chamber of the turbine by means of a pipe 12 in which is located a valve 13. As the high-pressure steam entering the inlet port 6 leaks, to a greater or less extent, around the piston 10 and into the space or chamber 11, the pressure exerted in this space and against the piston depends upon the position of the valve 13. If this valve is completely closed, the steam pressure will obviously accumulate in the space 11 until it becomes approximately equal to the pressure of the steam received at the inlet port 6, and for any other position of the valve 13, the pressure in the space 11 will be correspondingly reduced, so that this end pressure may be varied in order to counter-balance the end thrust of the propeller blades. In order that this steam pressure in the space 11 may be varied automatically in accordance with the propeller end thrust, I provide a thrust bearing 14 in the form of a cylinder, the inner periphery of which is provided with a set of rings or collars 15 which intermesh and make lateral engagement with corresponding rings or collars 16 on the engine shaft 17, this thrust bearing being of such dimensions as to take a very small portion only of the thrust. Bolted to the outer end of the thrust bearing cylinder 14, is a cap 18, from which projects a stem 19 having, at its outer end, a valve 20. The valve 20 is located in a chamber 21 having a drain pipe outlet 22 and communicating, by means of an opening 23, with a chamber 24, communication between the chambers 21 and 24, through the opening 23, being controlled by the valve 20. Oil or any other suitable fluid, under pressure obtained from any suitable source, is introduced into the chamber 24 through pipes 25 and 26 so connected as to provide a small orifice 27 for the passage of the fluid, this orifice in the present instance being shown as adjustable by means of a needle-valve 28.

The chamber 24 is connected to the bottom of a cylinder 29 by means of a pipe 30, and in the cylinder 29, is a piston 31 between which and the upper end of the cylinder is located a coil-spring 32. The piston 31 is connected, by means of a rod 33, a link 34 and a lever-arm 35, with the valve 13 which is located in the pipe 12 and controls the flow of steam from the chamber 11 to the exhaust chamber of the engine.

The operation of the mechanism thus far described is as follows: In case the end thrust due to the action of the propellers becomes greater than a predetermined amount, according to the proportioning of the apparatus, the thrust bearing will exert a greater pressure on the valve 20, thus raising the fluid-pressure in the chamber 24 and this pressure will be exerted, through the pipe 30 and the cylinder 29, against the piston 31, which will be therefore raised against the action of the spring 32 and will partially or wholly close the valve 13, according to the degree of end thrust, and thus cause steam pressure to accumulate in the space 11 and thus exactly counter-balance the end thrust due to the propellers. It will, of course, be generally convenient and desirable to have the spring 32 of such strength as to maintain some definite pressure upon the thrust bearing 14 and in the chamber 24. It is to be also understood that the degree of fluid-pressure at the orifice 27 should be sufficient, when fully exerted against the piston 31, through the channels provided for it, to so compress the spring 32 as to completely close the valve 13.

The construction and arrangement of mechanism for effecting the desired result may be varied considerably within the scope of my invention and, while I shall not attempt to illustrate or describe all of the parts, modifications and variations of such mechanism, I have illustrated in Fig. 3 a substitute for the cylinder 29 and the piston 31 which may be conveniently utilized, if desired. This modification comprises a chamber 36 having a flexible diaphragm 37 which is connected, by means of a rod 38, to a lever-arm 39, the free end of the latter being connected to the lever-arm 35 for operating the valve 13 by means of a rod 40. The diaphragm 37 may be normally held in its lowest position by means of a coil-spring 41 and be moved upward to effect movement of the valve 13 by fluid-pressure introduced into the space in the chamber 36 below the diaphragm through the pipe 30 from the chamber 24. Any other suitable form of valves and connecting link and lever mechanism may, of course, be utilized in practice.

In the case of vertical turbines utilized for driving dynamo electric generators, the rotary members of the generators are generally mounted upon and supported by the rotating members of the turbines which drive them and the turbine shafts are therefore subjected to an end thrust which must be taken care of by some suitable means. I propose to utilize my present invention for this purpose and, in Fig. 4, have illustrated a modification which is adapted therefor. Since the essential parts of the mechanism which have to do with my present invention do not differ materially from those already described, I have given the said parts the same reference numerals as the preceding figures and the description heretofore given may be therefore read in connection with Fig. 4, making it unnecessary to repeat such description.

Since it sometimes occurs that the steam pressure at the inlet will be but slightly higher than the exhaust pressure, as, for example, when the dynamo is operating under very light load, although the pressure in the chamber 11 might be raised to such initial pressure, it would be insufficient to counter-balance the dead weight of the rotating parts of the dynamo and turbine. In order to meet the conditions thus imposed, I may employ the modified apparatus shown in Fig. 5, which embodies an additional valve chamber 42 into which live steam is admitted through a pipe 43. The valve chamber 42 is provided with a double diaphragm 44, the space between which communicates with the space 11 by means of a pipe 45. A valve 46, which normally closes the ports in the double diaphragm 44, is connected, by means of a stem 47 and a lever-arm 48, to the stem 49 of a piston 50 which corresponds to the piston 31 of Figs. 1, 2 and 4. The upper end of the stem 49 is provided with a piston 51 which operates in a cylinder 52 against the action of a coil-spring 53, and the cylinder 52 is provided with a rod 54 which is connected to the valve 13 by means of a link 55 and an arm 56. A cylinder 57 and its spring 58, which correspond, respectively, to the cylinder 29 and spring 32 of Figs. 1, 2 and 4, are of greater longitudinal dimensions than the corresponding parts in the other figures, so that the piston 50 has a greater range of movement. It follows, therefore, that after the said piston has moved a sufficient distance to close the valve 13, it may still continue its movement, under the action of fluid-pressure, and compress the spring 53 in the cylinder 52 and, at the same time, move the lever 48 a sufficient amount to raise the valve 46 and thus admit live steam, through the pipe 45, to the chamber 11 in sufficient quantity to counter-balance the dead weight of the rotating parts.

In Fig. 1 which shows a general view of a turbine embodying my invention the steam inlet port 59 is provided with a reversing valve 60, which may be turned, by means of any suitable device or mechanism, (not shown), to direct the steam to either the admission port 61 of that end of the turbine having the blades and vanes 62 for running ahead or to the admission port 63 for that portion of the turbine provided with the blades and vanes 64 for running astern, both the ahead and astern turbine sections having a common exhaust outlet 65. When either turbine is operating under steam pressure, the other will be operating in a vacuum, and the losses due to this idle operation will be very small, as is well known to those skilled in the art.

The ahead turbine and the astern turbine might be entirely separate machines, if desired, instead of being parts of a single structure, as here illustrated. The single shaft of the complete reversing turbine, as here shown, is provided with two thrust bearings 66 and 67 and with two balance pistons 68 and 69, a chamber 70 being provided behind the balance piston 68 and a similar chamber 71 being provided behind the balance piston 69, the structure and function of these parts being substantially the same as those already described in connection with what is shown in the preceding figures.

When the vessel is running ahead, the thrust due to the propellers will be exerted toward the thrust bearing 66 and, consequently, the bell crank lever 72, one arm of which is connected to the thrust bearing and the other arm of which is connected to the valve stem 73, will hold the valve 20 to its seat and thus permit the fluid-pressure which is produced by a pump 75 and is transmitted to the cylinder 29 through the pipes 25 and 30 and the chamber 24, to be exerted, in the manner already described to close the valve 13 in the pipe 12 leading from the chamber 70 to the exhaust port.

When the steam is turned off from the inlet port 61, by means of the valve 60, and is admitted to the astern turbine through the port 63, the thrust due to the propellers will be reversed and thus exerted toward the thrust bearing 67, in which case the apparatus at that end of the turbine, corresponding in structure and function to that above referred to in connection with the thrust bearing 66, will operate to counterbalance the propeller thrust. At the same time, the pressure will obviously be relieved from the thrust bearing 66, and the fluid in the corresponding chamber 24, the cylinder 29 and the pipe connecting them will be permitted to escape, by reason of the lifting of the valve 20 to a greater or less degree, and will flow out, through the pipe 22, into the tank 74.

The fluid utilized in this apparatus is drawn from the tank 74 and forced, under the desired pressure, through the pipes and chambers by means of the pump 75, which may be driven by any suitable outside source of power or may be driven by the turbine itself, as may be desired.

It is, of course, apparent that there will be some lateral motion of the turbine and that the whole rotating element will move longitudinally some small amount in going from one thrust bearing to the other; that is, if it is operating ahead, the position of the thrust bearing 66 will be such as to maintain the correct adjustment of the balance piston 68. When, however, the thrust is reversed, the rotating element will move bodily lengthwise a small amount before the thrust is taken by the thrust bearing 67, and this, in turn, is so adjusted as to position that when the thrust of the shaft is taken by this bearing, the balance piston 69 will have the proper adjustment for the most effective packing.

In view of the fact that Fig. 1 is more or less diagrammatic no attempt has been made to describe in detail all of the controlling devices applicable in connection with a reversing turbine, as it is believed that such a description would tend to confuse rather than to elucidate the understanding of the subject matter herein involved.

I claim as my invention:

1. In combination with an elastic fluid turbine, a piston carried at one end of its rotor, a chamber behind said piston into which steam passes from the inlet end of the turbine, a passage between said chamber and the turbine exhaust port, a valve in said passage, a fluid pressure actuated device for operating said valve and means dependent upon the rotor end thrust for controlling said device.

2. The combination with the stationary and rotatable members of a fluid-pressure turbine and a chamber at one end of the rotatable member into which steam leaks from the turbine inlet, of a passage between said

chamber and the turbine exhaust port, a valve in said passage, fluid-pressure actuated means for operating said valve and a governing valve operatively connected to the turbine shaft and serving to vary the fluid-pressure utilized for operating the first-named valve in accordance with the end thrust upon the turbine shaft.

3. In a steam turbine, the combination with a piston attached to and forming a part of the turbine drum and a chamber behind the piston that is in communication with both the inlet and exhaust ports of the turbine, of a valve for controlling the exhaust passage from said chamber, a spring for normally holding said valve open, means for applying fluid-pressure in opposition to the spring to close the valve and a valve operatively connected to the turbine shaft to govern the application of said fluid-pressure in accordance with the end thrust upon the shaft.

4. The combination with the stationary and rotatable members of a steam turbine and a chamber at one end of the rotatable member into which steam is admitted from the inlet port, of a passage from said chamber to the exhaust port, a valve in said passage, a spring tending to normally open said valve, a piston against which said spring acts, means for applying fluid-pressure to said piston in opposition to the spring and a governing valve operatively connected to the turbine shaft and serving to regulate said fluid-pressure in accordance with the end thrust upon the shaft.

5. In a turbine, a rotor, a plurality of bearings therefor, a balancing chamber near each bearing, a piston in each balancing chamber and means for connecting each balancing chamber with the exhaust passages of said turbine.

6. In a turbine, a rotor, a plurality of bearings therefor, and a pressure balance piston near each bearing.

7. In a turbine, a rotor, a plurality of bearings therefor, a balancing chamber near each bearing, a piston within each chamber and means, dependent on the longitudinal thrust on the rotor, for varying the balancing effect of one or the other of said pistons.

8. In a turbine, the combination of a rotor, a casing therefor, a balancing chamber at each end of said casing and means, controlled by the longitudinal motion incident to unbalanced end thrust on said rotor, for varying the pressure in one or the other of said chambers for the purpose of balancing said rotor.

9. In combination with an elastic fluid turbine, a piston carried at one end of the rotor element of said turbine, a chamber provided behind said piston within the casing of the turbine and into which steam passes from the inlet end of the turbine, a passage between said chamber and the turbine exhaust, a valve located within said passage, a fluid actuated mechanism controlling the operation of said valve and a relay device actuated by the turbine rotor and dependent upon the rotor end thrust for controlling the operation of said valve operating mechanism.

10. In combination with the rotor and stator elements of an elastic fluid turbine, a piston carried by the rotor element of the turbine, a chamber provided behind said piston and within said stator, a passage located between said chamber and the exhaust of the turbine, a valve controlling the delivery of fluid through said passage, a fluid actuated mechanism for said valve and a relay device actuated by the longitudinal motion of the rotor for controlling the operation of said valve actuating mechanism.

11. In combination in a turbine, a rotor element, a stator element surrounding said rotor, a piston carried at one end of the rotor, a chamber located behind said piston and within said casing, a passage between said chamber and the exhaust of the turbine, a valve controlling the delivery of fluid through said passage, a fluid actuated mechanism for controlling the operation of said valve, and a relay device actuated by the longitudinal motion of the turbine for controlling the delivery of fluid to said fluid actuated mechanism.

In testimony whereof, I have hereunto subscribed my name this 28th day of December, 1903.

FRANCIS HODGKINSON.

Witnesses:

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J. A. MacMurchy.