

W. J. A. LONDON.
BALANCING MEANS FOR ELASTIC FLUID TURBINES.
APPLICATION FILED AUG. 8, 1907.

1,011,826.

Patented Dec. 12, 1911.

3 SHEETS—SHEET 1.

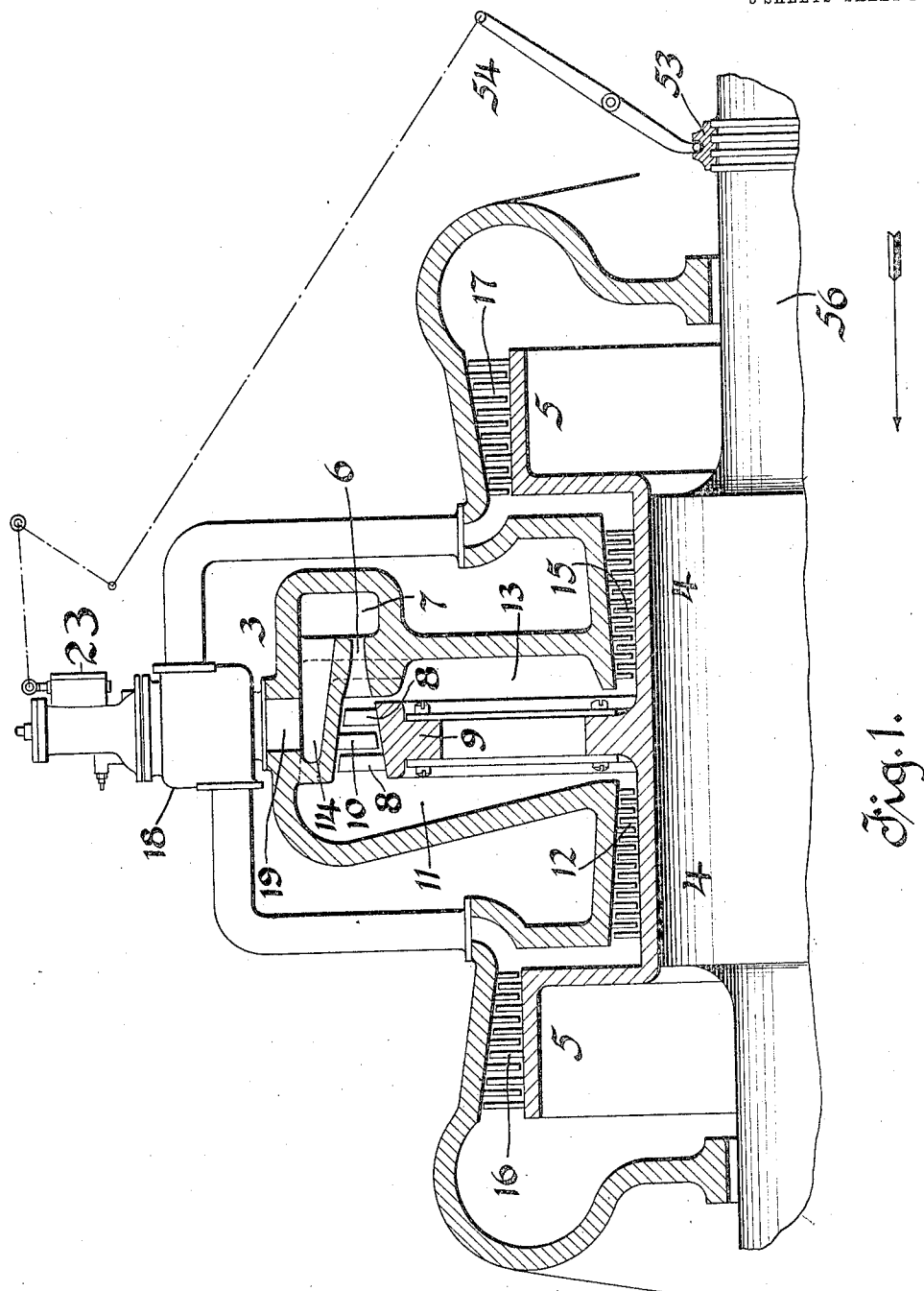


Fig. 1.

WITNESSES:

[Signature]
E. M. Ballister.

INVENTOR.
William James Albert London.
BY *[Signature]*
ATTORNEY IN FACT.

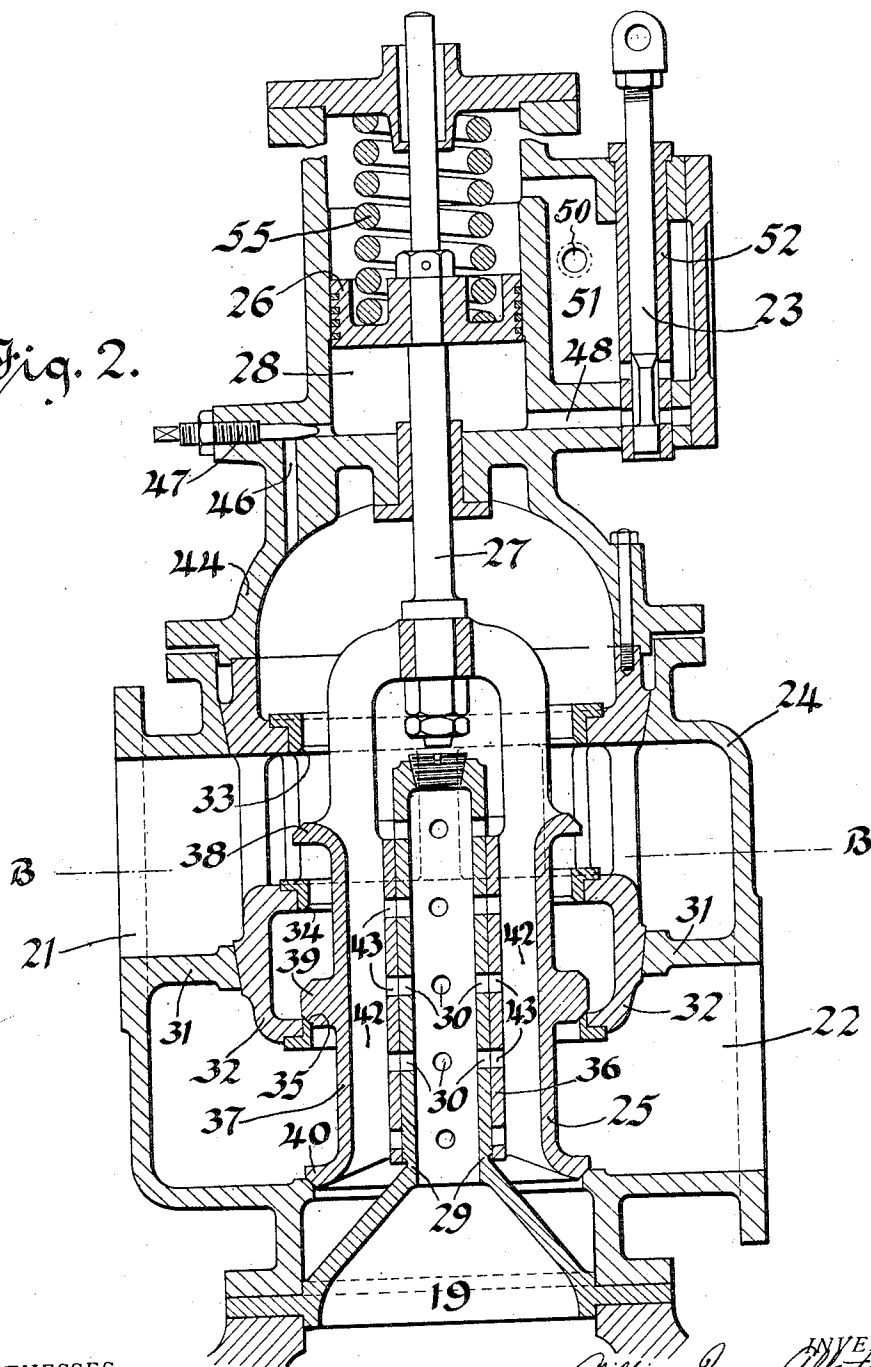
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3 SHEETS—SHEET 2.

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Fig. 2.



WITNESSES:

W. J. A. London
E. M. W. Hallister

INVENTOR.
William James, Albert London.
BY *W. S. Green.*
ATTORNEY IN FACT.

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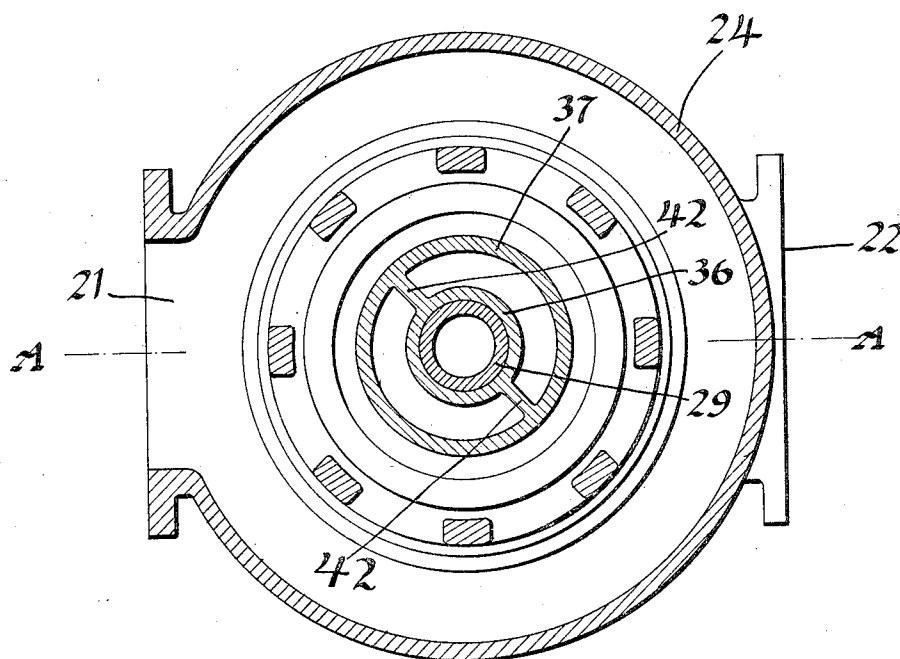


Fig. 3.

WITNESSES:

W. J. A. London
E. W. McCallister

INVENTOR.
William James Albert London
BY *J. S. Deen*
ATTORNEY IN FACT.

UNITED STATES PATENT OFFICE.

WILLIAM J. A. LONDON, OF EDGEWOOD PARK, PENNSYLVANIA, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE COLONIAL TRUST COMPANY, TRUSTEE, OF PITTSBURGH, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA.

BALANCING MEANS FOR ELASTIC-FLUID TURBINES.

1,011,826.

Specification of Letters Patent.

Patented Dec. 12, 1911.

Application filed August 8, 1907. Serial No. 387,661.

To all whom it may concern:

Be it known that I, WILLIAM J. A. LONDON, a subject of the King of Great Britain, and a resident of Edgewood Park, in the county of Allegheny and State of Pennsylvania, have made a new and useful Invention in Balancing Means for Elastic-Fluid Turbines, of which the following is a specification.

This invention relates to elastic fluid turbines and more particularly to means for automatically balancing the inherent fluid thrust and any external end or longitudinal thrust that may be imposed upon the turbine rotor.

My invention is particularly applicable to marine and other turbines which are subjected to varying end thrusts due to external forces, such, for example, as the propeller thrust in marine turbines and the impeller thrust in turbines directly connected to rotary pumps or compressors.

An object of my invention is to produce automatic means for proportioning the delivery of motive fluid to the different working passages of the turbine in such a manner that any end or longitudinal thrust on the turbine rotor is balanced. I accomplish this by providing a valve which operates automatically in response to variations in position of the turbine rotor, to proportion the delivery of motive fluid to the different sections of a multistage turbine and to thereby counterbalance by fluid pressure any unbalanced thrust on the turbine rotor.

In the drawings accompanying this application and forming a part thereof: Figure 1 is a sectional view of a turbine embodying my invention; Fig. 2 is a sectional elevation of a valve forming a detail of my invention, a section being taken along the line A—A of Fig. 3; and Fig. 3 is a section along the line B—B of Fig. 2.

The turbine illustrated as embodying my invention is ordinarily termed a "semi-double flow" turbine and comprises a primary stage 3, through which the motive fluid flows in one axial direction, a double flow intermediate stage 4 receiving motive fluid from the primary stage and a double flow final or low pressure stage 5, which receives motive fluid from the intermediate stage and which communicates with the turbine exhaust.

The primary stage is located midway between the ends of the turbine and receives motive fluid from a suitable source of supply through a valve controlled inlet port (not shown). The amount of fluid admitted to the turbine is proportioned by the valve controlling the inlet port in accordance with the load, through the agency of a speed-responsive governor, which is not shown, but is of the ordinary type. The primary stage is provided with one or more expanding nozzles 6, which are located in the turbine casing and which communicate with the admission port through a passage 7 formed in the casing of the turbine.

The nozzles 6 expand the motive fluid a predetermined amount and discharge it into a row of rotating blades 8 mounted on a wheel 9 which is secured to and forms a part of the turbine rotor. The blades 8 are adapted to abstract by impact a portion of the velocity energy rendered available by the expansion of the motive fluid and to deliver the flow of fluid to a row of stationary vanes 10, which are mounted on the turbine casing and which redirect the flow of fluid and deliver it to a second row of blades 8, which are also mounted on the wheel 9. The primary stage 3 is purely impulse and consequently imposes no end or longitudinal thrust upon the turbine rotor.

The motive fluid discharged from the final row of blades in the primary stage is received by a chamber 11, which is formed between the wheel 9 and the turbine casing and which communicates directly with one section 12 of the intermediate stage. A chamber 13 is formed between the other side of the wheel 9 and the turbine casing and communicates through passages 14, formed in the turbine casing adjacent to the nozzles 6, with the chamber 11 and directly with a section 15 of the intermediate stage.

Both sections of the intermediate stage are provided with a plurality of alternate rows of moving blades and stationary vanes mounted respectively on the rotor and casing of the turbine. The motive fluid delivered by the primary stage is divided and flows through the two sections of the intermediate stage in opposite axial directions. The rotating blades and stationary vanes of the intermediate stage cooperate in fractionally abstracting by impact and reaction a

portion of the pressure energy of the motive fluid. Since the intermediate stage is bi-laterally symmetrical, the longitudinal thrust of one section is balanced by the equal and opposite longitudinal thrust of the other section.

The final or low pressure stage, like the intermediate stage, is divided into two sections 16 and 17, each of which is provided with alternate rows of moving blades and stationary vanes mounted respectively on the rotor and casing of the turbine. The blades and vanes of the final stage, like the blades and vanes of the intermediate stage, cooperate in fractionally expanding the motive fluid and abstract by impact and reaction the velocity energy rendered available by the expansion. The sections 16 and 17 of the final stage are located at each end of the turbine and receive motive fluid respectively from the sections 12 and 15 of the intermediate stage. The two stages are bi-laterally symmetrical and since the motive fluid flows through them in opposite axial directions the final stage occasions no inherent end thrust and consequently the turbine rotor is balanced for all loads and fluid pressures.

A valve 18 is mounted on the turbine casing and communicates with the chambers 11 and 13 of the primary stage by means of a port 19. The valve is provided with ports 21 and 22, which respectively communicate through suitable piping with the sections 16 and 17 of the final stage. The valve is capable of delivering motive fluid from the primary stage direct to one of the sections 16 or 17 of the final stage and operates in response to variations in position of the turbine rotor. The turbine rotor is capable of shifting longitudinally through its bearings in response to an unbalanced thrust and controls, through the agency of a pilot valve 23, the operation of the valve 18. The valve, as described, operates to vary the distribution of motive fluid to the working passages of the turbine and to cause the fluid pressure in the working passages to preponderate in one direction and to exert a thrust equal and opposite to the thrust disturbing the longitudinal equilibrium of the rotor.

The valve comprises a casing 24, which is mounted on the turbine casing, a piston 25, which controls the delivery of motive fluid through the valve ports and a controlling piston 26, which is mounted on the stem 27 of the piston valve 25 and which is located within a cylinder 28. The admission port 19 is located at the bottom of the valve and delivers motive fluid to the interior of the valve through a vertically extending tubular portion 29, which is provided with a series of delivery ports 30. The outlet ports 21 and 22 of the valve are separated by a diaphragm 31, which is formed integrally with the casing and which supports a cage 32.

The cage 32 surrounds the piston 25 and is provided with valve seats 33, 34 and 35, which cooperate with the piston valve 25 in controlling the delivery of motive fluid through the ports 21 and 22. The piston valve 25 is provided with a cylindrical sleeve 36, which is slidably mounted on the tubular portion 29 and a cylindrical portion 37, located concentrically therewith, which is provided with annular projections 38, 39 and 40, which cooperate with the valve seats of the cage 32. The sleeve 36 and the cylindrical portion 37 are secured together by means of ribs 42, which extend above the sleeve to form a yoke to which the valve stem 27 is secured. The admission of motive fluid to the interior of the valve is controlled by means of apertures or ports 43, which are provided in the sleeve 36 and which are adapted to register with the ports 30 of the tubular portion 29 for certain positions of the piston 25.

The cylinder 28 is formed integrally with a cover portion 44 of the valve, which is secured to the casing 24 and through which the stem 27 extends. A passage 46 formed in the cover portion 44 connects the steam space above the piston 25 with the cylinder 28 below the piston 26 and an adjusting valve 47 located within the passage is adapted to permit of a restricted flow of motive fluid through the passage. A passage 48 connects the lower portion of the cylinder 28 with a chamber 51, which is formed integrally with the top portion 44 and which is exposed to atmospheric pressure through an aperture 50. The passage 48 is of sufficient size to discharge the motive fluid admitted to the cylinder 28 by the passage 46, but is controlled by the pilot valve 23, which is arranged to open and close communication between the cylinder 28 and the chamber 51. The pilot valve is located within a valve casing 52, which is provided with suitable ports and which extends through the chamber 51 and is mounted on the walls thereof. A collar 53 is loosely mounted on shaft 56 of the turbine and is adapted to transmit the longitudinal motion of the turbine rotor to the pilot valve through a system of links and levers which are adapted to magnify the motion sufficiently to give an accurate operation of the valve. The collar 53 and system of links and levers 54 are so arranged that the motion of the rotor in one direction operates the pilot valve to close the passage 48 to the atmosphere, thereby piling up pressure in the cylinder 28 under the piston 26 and raising the piston valve 25 against the pressure of a spring 55, which is located above the piston 26 and which surrounds the valve stem 27. Movement of the rotor in the opposite direction will actuate the pilot valve to open the passage 48 to the atmosphere and thereby exhaust the motive fluid from the

cylinder 28 and permit the spring 55 to move the piston valve 25 downwardly. Under normal conditions, that is, when the turbine rotor is not subjected to an external thrust, it is adapted to occupy an intermediate position between the limits of its longitudinal travel and the pilot valve 23 is so adjusted that, under such conditions, the valve 18 will not deliver motive fluid through either of its ports 21 or 22. When the rotor is exposed to a thrust which moves it in the direction of the arrow in Fig. 1, the pilot valve 23 is moved, as has been described, to close the passage 48 to the atmosphere and thereby cause the piston valve 25 to be moved upwardly against the spring 55 and open communication between the port 19 of the valve and the port 22. Under such conditions, motive fluid is delivered directly from the primary stage to the section 17 of the final stage. Consequently the fluid pressure at the admission end of the section 17 of the final stage is greater than the fluid pressure at the admission end of the section 16 and, therefore induces a preponderating thrust in a direction opposite to the external thrust on the rotor. If now for any reason the external thrust on the rotor is reversed in direction the rotor moves in a direction opposite to that indicated by the arrow in Fig. 1 and the pilot valve 23 operates to open the passage 48 to the atmosphere and thereby permit the spring 55 to force the piston valve 25 down to close the port 22 and open the port 21. With the port 21 open, motive fluid is delivered directly from the primary stage to the section 16 of the final stage and consequently the thrust upon the rotor caused by the fluid pressure preponderates in the direction indicated by the arrow or in the opposite direction to the thrust imposed upon the rotor. The shifting of the rotor automatically adjusts the position of the valve 18 until the steam pressure delivered to either one or the other sections of the final stage of the turbine and by-passed around the intermediate stage is just sufficient to counterbalance the disturbing force and, consequently, the turbine rotor will take slightly different positions for different disturbing forces. When the turbine rotor is relieved of the shifting force the preponderating fluid pressure moves it back to the normal position and thereby operates the pilot valve to shut off the flow of motive fluid through the by-pass valve 18 to the final stage. By by-passing steam around the intermediate stage to the low pressure stage, the power delivered by the turbine is increased, but the automatic speed governor operates to decrease the amount of steam delivered to the turbine and therefore maintains the speed of the turbine constant.

It will be apparent to those skilled in the art that various apparatus may be utilized

for operating the valve 18; for instance, the pilot valve as disclosed may be replaced by an electrical relay which will respond to very slight longitudinal motion of the rotor.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

What I claim is:

1. In combination with a turbine and its rotor, a double flow working stage and means dependent on the longitudinal position of the rotor for varying the volume of motive fluid delivered to the sections of said double flow stage.

2. In combination in a turbine, a longitudinally shiftable rotor, a plurality of working stages, and means, dependent on the rotor for proportioning the delivery of motive fluid to said stages and thereby balancing the end thrust on said rotor.

3. In combination in a turbine a high pressure stage, a plurality of low pressure stages, and means for proportioning the delivery of motive fluid from the high pressure stage alternately to the low pressure stages respectively to balance the thrust on the rotor of said turbine.

4. In combination in a turbine, a plurality of working stages, and means, dependent on the longitudinal thrust on the rotor of said turbine, for proportioning the delivery of motive fluid to the different stages to counterbalance said thrust.

5. In combination with a turbine and its rotor, a plurality of working stages arranged with reference to the turbine rotor so as to counterbalance one another, and means responsive to variations in the longitudinal position of the rotor for varying the delivery of motive fluid to said stages to cause the fluid pressure to preponderate in one direction on said rotor.

6. In combination in a turbine, bi-laterally symmetrical working stages arranged so as to counterbalance the inherent thrust on the turbine rotor, a valve responsive to unbalanced longitudinal thrust on the rotor for controlling the delivery of motive fluid to said working stages and for maintaining the turbine rotor in longitudinal equilibrium.

7. In combination in a turbine, a plurality of double flow and longitudinally balanced working stages, a valve responsive to unbalanced thrust on the rotor of the turbine for delivering motive fluid to one section of a working stage of said turbine and thereby causing the thrust of the motive fluid to preponderate in one direction and counterbalance said unbalanced thrust.

8. In combination with a turbine, a valve casing provided with a fluid inlet port communicating with a stage of said turbine and two fluid outlet ports communicating with
5 separate sections of the turbine, a piston valve located within said casing and provided with means for controlling the flow of fluid through said inlet valve, and means for opening one or the other of said inlet
10 ports to deliver fluid to one or the other of the sections of said turbine.

9. In combination with a turbine, a valve casing provided with an inlet port receiving motive fluid from a stage of said turbine
15 and two outlet ports communicating with separate sections of the working portion of said turbine, a valve operating within said casing to control the delivery of fluid to said inlet port and for closing communication
20 between one and opening communication between the other of said outlet ports and said inlet port, and means, comprising a fluid controlled piston, for operating said valve.

10. In combination with a double-flow
25 turbine, a valve casing provided with an inlet port and two outlet ports, each of which communicates with one section of said turbine, a valve located within said casing, and means controlling the operation of said
30 valve to deliver motive fluid to one or the other of said sections to counterbalance the longitudinal thrust of the turbine.

11. In combination, a valve casing provided with a fluid inlet port and two fluid
35 outlet ports, means for controlling the delivery of fluid to said inlet port, comprising a tubular portion receiving motive fluid from said port and provided with a plurality of fluid delivery apertures and a
40 sleeve provided with ports which, for certain positions of said valve, register with the apertures of said tubular portion, and means for establishing communication between one or the other of said outlet ports
45 and said inlet port.

12. In combination, a valve casing provided with two fluid outlet ports and a fluid inlet port, a valve operating within
50 said casing which, in one position, establishes communication between one and closes communication between the other out-

let port and said inlet port, and for a second position closes communication between the one and establishes communication between the other outlet port and said inlet port,
55 and means for establishing communication between said inlet port and the interior of said valve casing when said valve moves to fully open either of said outlet ports, and for closing communication between the inlet
60 port and the interior of said valve casing for all intermediate positions of said valve.

13. In combination in a turbine, a plurality of working sections, a valve for varying the delivery of motive fluid to said sections and means responsive to variations in
65 the longitudinal position of the turbine rotor for controlling the operation of said valve.

14. In combination with a turbine and its
70 rotor, a plurality of working stages and a valve for proportioning the delivery of motive fluid to said stages, and means dependent on the longitudinal position of the rotor of the turbine for controlling the operation
75 of said valve.

15. In a double flow turbine two symmetrical sections and a valve for proportioning the delivery of motive fluid to said sections to balance the longitudinal thrust of the
80 turbine.

16. In combination with a turbine and its rotor, a plurality of working stages, and means dependent on the longitudinal position of the rotor for proportioning the delivery of motive fluid to the stages and thereby balancing the end thrust on the
85 rotor.

17. In combination with a turbine and its rotor, a plurality of working stages, and
90 means dependent on the longitudinal thrust encountered by the rotor for proportioning the delivery of motive fluid to the stages, whereby the fluid pressure is caused to preponderate in one direction on the rotor.

In testimony whereof, I have hereunto subscribed my name this 6th day of August, 1907.

WILLIAM J. A. LONDON.

Witnesses:

CHARLES W. MCGHEE,
R. P. MCINTYRE.