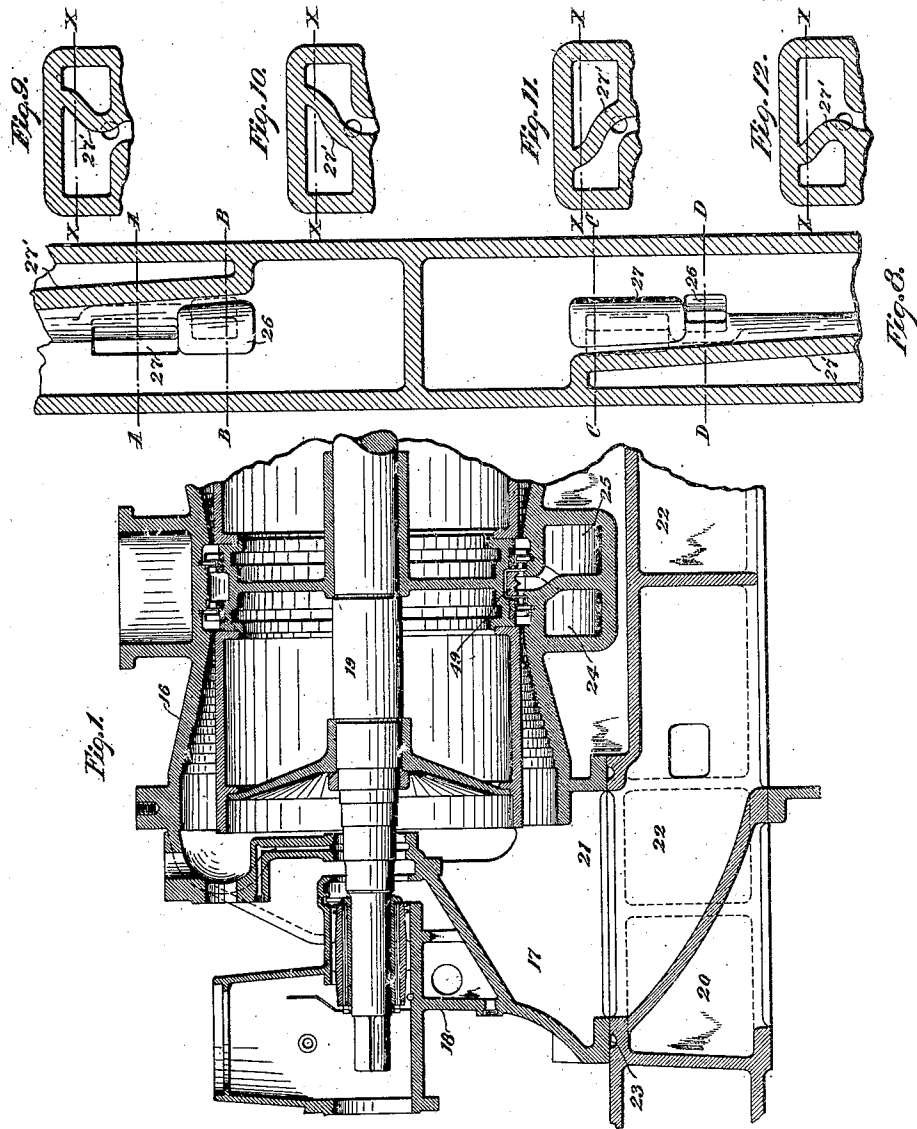


G. WESTINGHOUSE.
 ELASTIC FLUID TURBINE.
 APPLICATION FILED AUG. 6, 1904.

946,749.

Patented Jan. 18, 1910.

5 SHEETS—SHEET 1.



Witnesses.
 G. B. Ryder.
 H. Van Horn

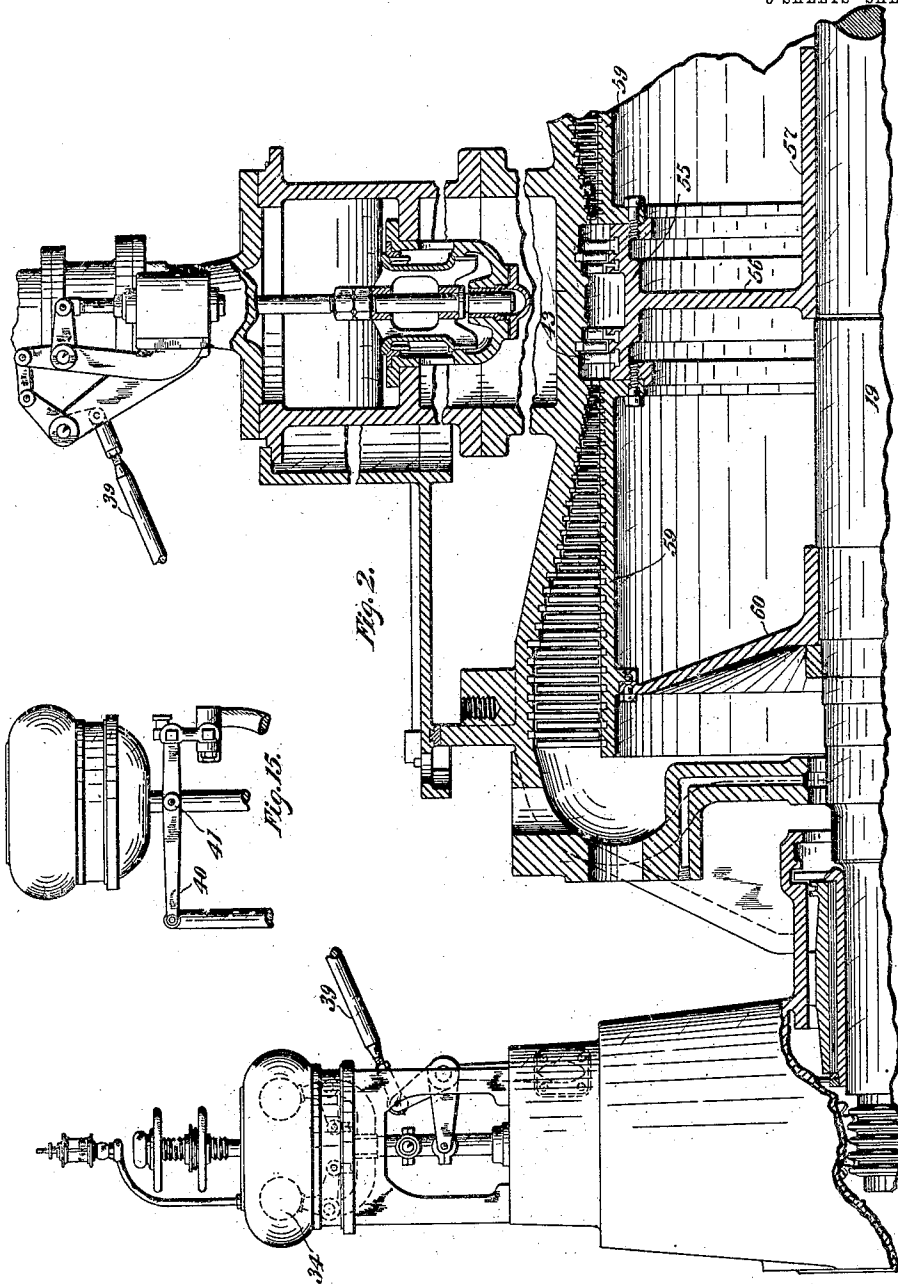
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5 SHEETS—SHEET 2.

946,749.



Witnesses
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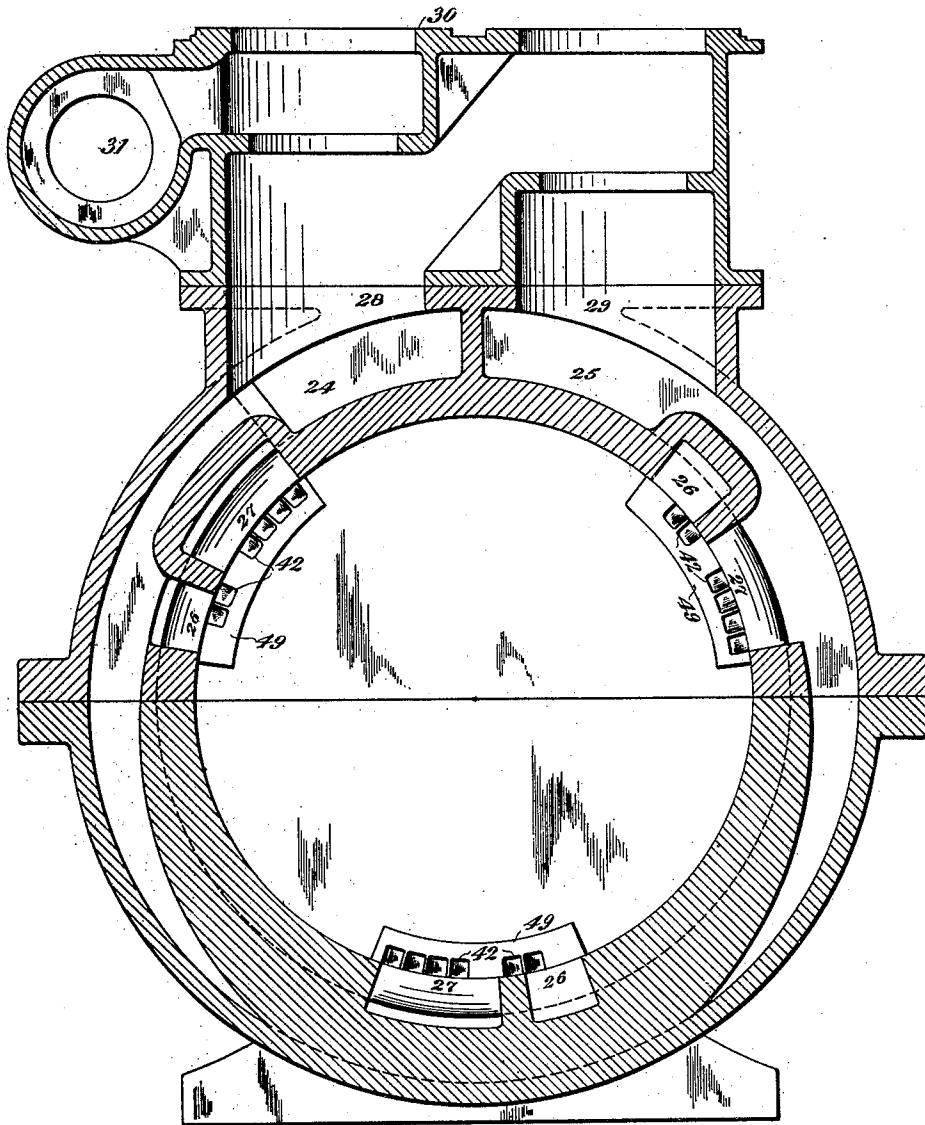
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5 SHEETS—SHEET 3.

Fig. 3.



Witnesses
G. L. Ryder.
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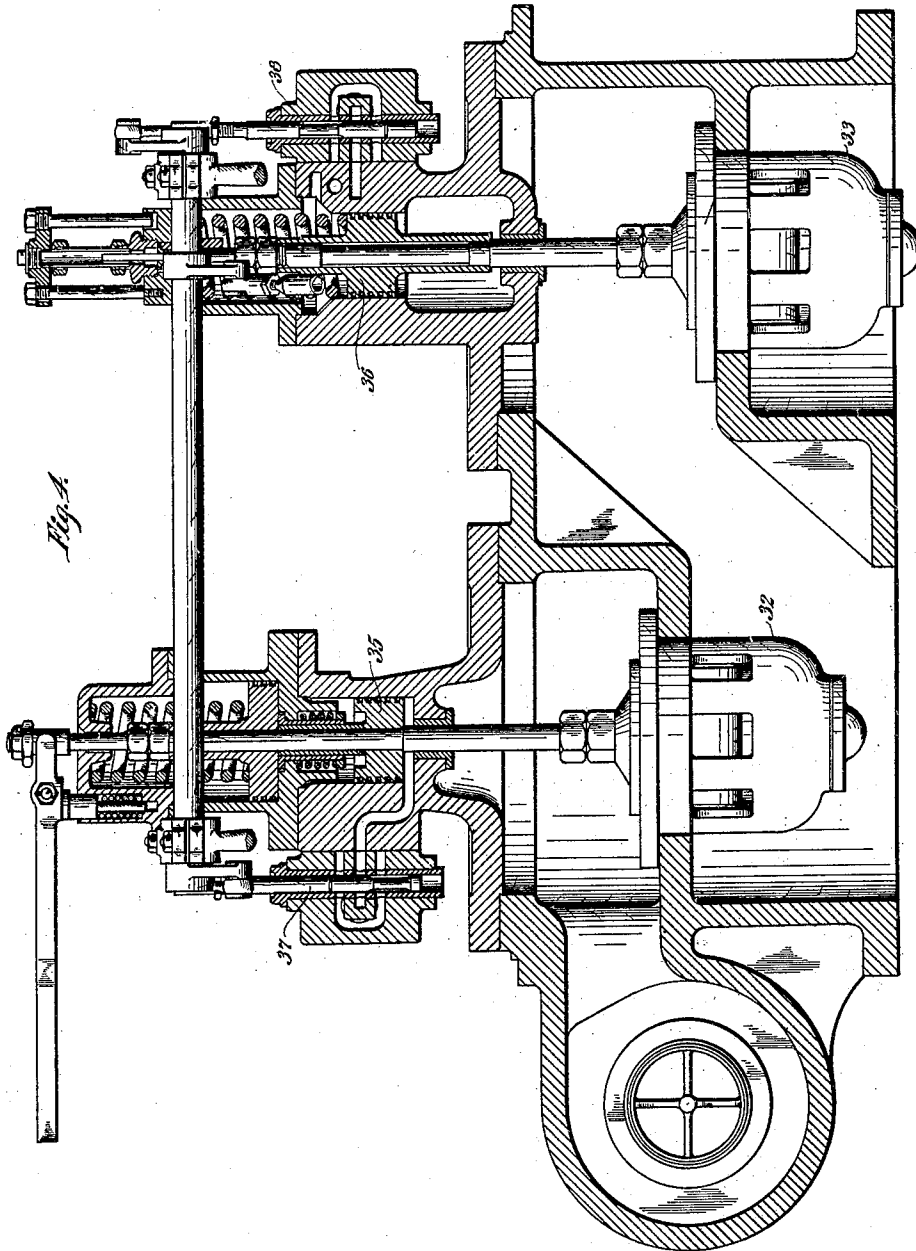
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5 SHEETS—SHEET 4.



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5 SHEETS—SHEET 5.

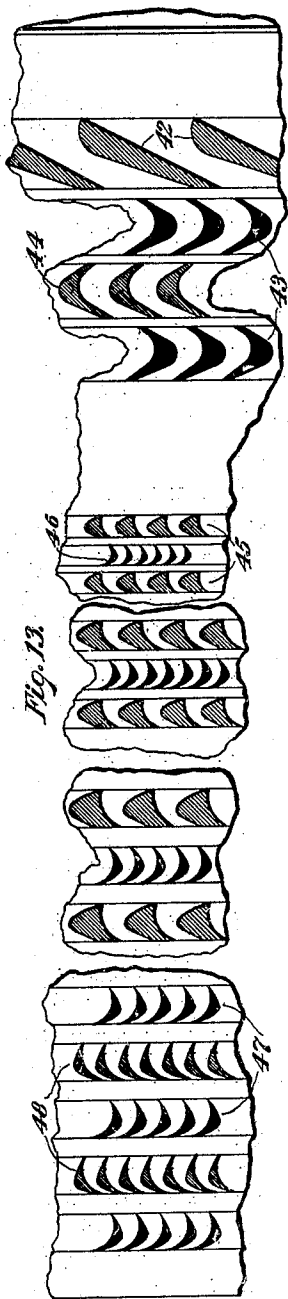


Fig. 13.

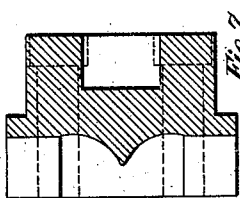


Fig. 2.

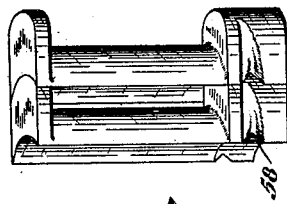


Fig. 14.

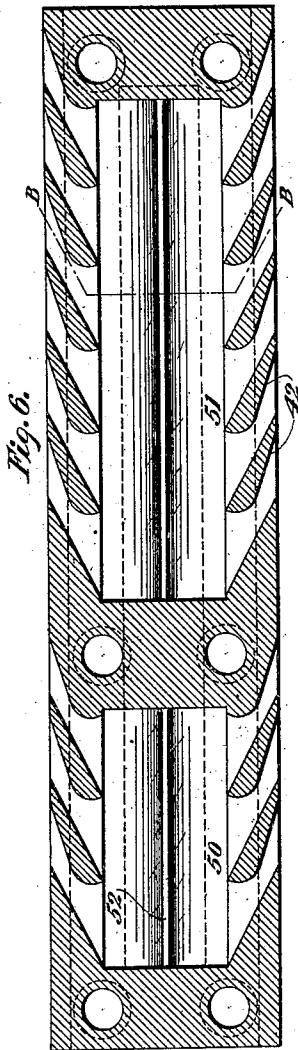


Fig. 6.

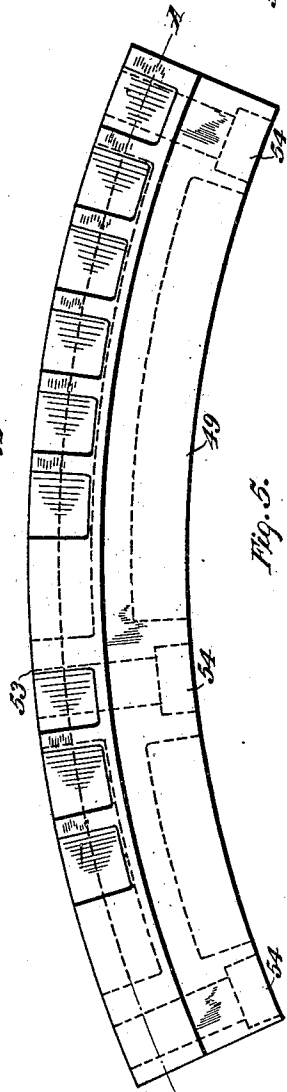


Fig. 5.

Witnesses
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Inventor
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UNITED STATES PATENT OFFICE.

GEORGE WESTINGHOUSE, OF PITTSBURG, PENNSYLVANIA, ASSIGNOR TO THE WESTINGHOUSE MACHINE COMPANY, A CORPORATION OF PENNSYLVANIA

ELASTIC-FLUID TURBINE.

946,749.

Specification of Letters Patent. Patented Jan. 18, 1910.

Application filed August 6, 1904. Serial No. 219,731.

To all whom it may concern:

Be it known that I, GEORGE WESTINGHOUSE, a citizen of the United States, and a resident of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Elastic-Fluid Turbines, of which the following is a specification.

This invention relates to elastic fluid turbines, and more particularly to turbines of the double flow type, although certain principles thereof are equally applicable to single flow turbines.

The space required for double flow turbines of the purely impact and reaction type is prohibitive under certain conditions, and an object of this invention has been to produce a relatively short and yet highly efficient turbine which retains the valuable features of the double flow type.

A further object of this invention has been to simplify the construction, and minimize the labor necessary in the process of manufacture, whereby the cost of manufacture is lowered.

The above and other objects I attain in a turbine embodying in its make-up, the elements constructed, combined and located as will be more fully set forth in the specification, illustrated in the drawings and pointed out in the appended claims.

The device illustrated represents a practical embodiment of this invention and throughout the several views thereof similar elements are denoted by like characters.

The turbine illustrated in the drawings is of the variety in which the working fluid is admitted midway between the ends of the turbine and flows in opposite directions to the exhaust ports which are located at the ends of the turbine. The invention is not, however, limited to this variety, but may be embodied in one in which the fluid is admitted at one end and is exhausted at the other; but when embodied in this type it will be found desirable to employ balancing pistons in order to counter-balance the end thrust, as is now common and well known in the art.

Figure 1 is a fragmentary view in longitudinal section of a turbine embodying this invention and as both ends of the turbine, it being a double flow machine, are substantially alike it has not been deemed necessary

to fully illustrate both ends: Fig. 2 is a fragmentary view partially in elevation and partially in longitudinal section of a portion of the turbine: Fig. 3 is a view in cross section of the turbine casing and fluid chest therefor: Fig. 4 is a sectional view of the valves and valve operating mechanism employed with this turbine: Fig. 5 is a side view in elevation of one of the details: Fig. 6 is a developed section taken on line A—A in Fig. 5: Fig. 7 is a view in cross section taken on line B—B in Fig. 6: Fig. 8 is a developed section taken on lines X—X in Figs. 9, 10, 11 and 12, of the normal and overload fluid channels, which will be hereinafter referred to: Figs. 9, 10, 11 and 12 are views in cross section taken on lines A—A, B—B, C—C and D—D respectively in Fig. 8: Fig. 13 is a diagrammatic view illustrating the nozzles, blades and vanes utilized in this turbine: Fig. 14 is a view in perspective of two blades, the form of which is utilized in one section of the turbine: Fig. 15 is a detail view of a portion of the valve operating mechanism.

The turbine consists of a casing 16 divided on the horizontal plane through its axis, as is now common practice, whereby the upper half may be readily lifted off. The lower half 17 of the casing is provided with pillars 18 carrying bearings within which the shaft 19 of the turbine rotor or spindle is journaled.

One end of the lower half of the casing is rigidly secured to a bed-plate 20, while the other end is free to move longitudinally of said bed-plate, according to the expansions which occur from the temperatures encountered.

Exhaust ports 21 at each end of the lower half of the casing register with a passage or channel 22 formed for that purpose in the bed-plate; said passage or channel 22 connecting both exhausts and with a common condenser, not shown. If desired, the exhaust fluid may be led away from the exhaust port, or ports of a double flow turbine, through a suitable pipe or pipes which are independent of the bed-plate as is now common.

As elastic fluid turbines are generally run condensing, and, as, when so run the exhaust pressure is below that of atmospheric pressure, a joint which will prevent atmos-

pheric air from entering the exhaust is necessary; as this air would tend to destroy the vacuum of the condenser. In order to allow proper movement of one end of the turbine casing and at the same time to form a tight joint between said casing and the bed-plate, I form a channel 23, preferably in the bed-plate, extending around the ports 22, and connected to this channel 23 will be a source of fluid supply, preferably water, whereby a fluid seal is formed, and as the fluid is forced into the exhaust passage by the atmospheric air the fluid supply will fill the channel and maintain the fluid seal. If it is found necessary the walls of this channel 23 and the faces of the casing and bed-plate adjacent thereto may be covered in any suitable manner with a metal which will not rust. If desired this channel may be located in the turbine casing or it may be formed partially in the turbine casing and partially in the bed-plate.

The turbine casing midway between its ends is provided exteriorly with two fluid channels 24 and 25 for the normal load working fluid and the overload working fluid respectively. These channels preferably extend circumferentially of the casing as illustrated in Fig. 3; and are provided with fluid passages 26 and 27 respectively, which extend through the casing and into the interior thereof. These passages are in a line around the casing, and a partition 27' separating the channels proceeds spirally in order to permit said single line. It will be seen that the passages 27 are of twice the area of passages 26 and the three passages 26 supply the normal load fluid, while the three passages 27 are adapted to supply the overload fluid; this difference in passage area is made, for the reason that each of the passages 27 supplies twice as many high pressure fluid nozzles as any of the passages 26 in order to accommodate overloads, as is hereinafter pointed out. If desired these circumferentially extending fluid channels may be omitted and any other suitable fluid channels or pipes may lead the working fluid to the desired points of the turbine.

The fluid channels 24 and 25 terminate at the top of the casing in ports 28 and 29, and a fluid chest 30 is secured to the top of the casing and is provided with passages which register with the ports 28 and 29, and each of said passages is connected with a main fluid supply inlet 31.

A reciprocating valve 32 of the puppet type, is located in the fluid passage above port 28 for supplying the normal load motive fluid to the turbine, and a similar valve 33 is located above the port 29 for supplying the overload motive fluid to the turbine.

The overload valve 33 is normally held to its seat until the speed of the turbine drops below a certain predetermined point by rea-

son of an overload or for other cause; and until said valve 33 is opened the fluid for operating the turbine, which passes through valve 32, is admitted to the turbine through fluid inlets 26.

When the speed of the turbine drops below the predetermined point, valve 33 will be opened, and fluid admitted to the turbine through fluid inlets 27 as well as inlets 26.

The details of the valve construction, the valve operating motors and the connections between the governor and said valve motors are herewith shown only for the sake of illustrating a complete device. For these details specifically, no claims are made in this application as they may form the subject matter of other applications for Letters Patent which may be made later.

It is believed sufficient for the purpose of this application to say that a portion of the valve operating devices are in a manner similar (as will appear to one skilled in the art) to those illustrated in Letters Patent No. 751,510, issued on February 9th, 1904, to Francis Hodgkinson, and, further, that a fly ball governor 34 is made use of, and valves 32 and 33 are caused to reciprocate by means of fluid operated motors 35 and 36 connected to the respective valve stems. These valve motors are controlled in their operations by governing or pilot valves 37 and 38, which receive reciprocation by means of various links and levers connected therewith and to rod 39, which rod is connected to a reciprocating member 40 fulcrumed on the vertically movable governor shaft at 41, and which receives reciprocation indirectly from the main shaft of the turbine.

When the speed of the turbine is at normal, running under full load or below full load and the fulcrum point 41 of the reciprocable member 40 is above or at its mid-position, valve motor 36 will not operate valve 33 to open the same, but will hold the same in a closed position, and valve 32 by means of its motor 35, will be regularly reciprocated and motive fluid admitted to the normal load fluid channel 24 in puffs; the duration of the admissions or puffs, however, will be dependent upon the speed of the turbine, as the governor by changing the fulcrum point 41 varies the point of cutoff of governor valve 37 whereby the valve motor is caused to close the valve 32 in an irregular manner while it is opened regularly or synchronously with the movements of the turbine.

When the speed of the turbine drops below normal and the governor balls move inward and fulcrum point 41 moves below mid-position, the plane of reciprocation of governor valve 38 is changed so that valve motor 36 is thrown into operation and caused to open valve 33 synchronously with

the movements of the turbine and to admit motive fluid to fluid channel 25. As with valve 32 the closing of valve 33 is made dependent upon the degree of overload, as fulcrum point 41 is common to both of said valves; therefore the puffs of the elastic fluid, operating the turbine through both the normal and overload passages, are of either long or short duration, according to the load.

The motive fluid, which in this turbine after it is admitted through passages 26 and 27, flows in opposite directions, it being a double flow turbine, is worked in a manner which to me appears to be novel. The fluid first passes through divergent nozzles 42 adjacent to the inlet passages 26 and 27, which nozzles are preferably rectangular in cross section and formed for partially expanding the fluid and converting a portion of its pressure into velocity, which portion may be varied as desired in different turbines. Adjacent to the outlets of these nozzles two annular rows of moving blades 43 are carried by the rotor, between the operative point of which stationary guide vanes 44 are situated. These moving blades and stationary vanes are adapted to transform the velocity so obtained from the nozzles into rotary motion.

For receiving the fluid from the last row of moving blades 43, a plurality of alternate rows of stationary vanes 45 and moving impulse blades 46 are employed. The cross sectional contour of these stationary blades is such that the fluid received from the primary stage has its pressure abstracted, and this is fractionally done in each of the stationary rows, down to a predetermined point or pressure. The fluid issuing from between the stationary vanes contacts with the alternate rows of impulse blades and thereby is converted into rotary motion. It will be understood that practically no pressure drop occur between the annular rows of stationary vanes in this section; and the pressure on each side of each row of impulse blades in its chamber, formed by two rows of stationary vanes, is the same.

In the turbine illustrated about 39 rows of these pressure abstracting passages and impulse blades are illustrated, but it will be understood that the number utilized will depend upon the pressure drop or rotor speed desired. The fluid after passing through this section of the turbine, in which its pressure is fractionally abstracted, enters a section in which the remaining fluid pressure and velocity is converted into rotary motion, and this is accomplished by employing a plurality of rows of moving blades 47 alternating with stationary vanes 48, and these moving blades and stationary vanes are of such a form that the fluid is fractionally expanded and the energy obtained by impact

and reaction, or by impulse and reaction. This last section including the blades and vanes 47 and 48 might be termed "Parsons blading", and it may be desirable to have the fluid entering this section at about atmospheric pressure and to work on the fluid through this section from atmospheric pressure to the pressure of the exhaust or condenser, although this is not necessary as the turbine may be run non-condensing. It will be seen that by utilizing these different styles of blades and vanes, a shorter and more compact turbine is obtained than is possible with pure impact and reaction blades, of the "Parsons type".

The divergent nozzles 42, before referred to, are formed in the circular segments 49, each of which segments, (of which there are three in number in the turbine illustrated) is preferably cast with a normal load fluid space 50 and an overload fluid space 51, each of which fluid spaces is provided with an outwardly extending central divider 52 for dividing the entering fluid and oppositely directing it. The nozzles 42 which are preferably rectangular in cross-section and divergent, but not necessarily so, are milled or otherwise formed in the opposite walls of the fluid spaces 50 and 51, and the outward face 53 of each segment is machined to conform to the inner periphery of the turbine casing directly below it or inside of the annular fluid passages 24 and 25; and to the inner periphery of the casing the segments are preferably secured by means of suitable screws or bolts passing through openings 54 therefor formed in the segments, so that the centers of the three segments are preferably 120 degrees apart.

The fluid spaces 50, from which nozzles for the normal load discharge, register with the openings 26 leading from channel 24, while the fluid spaces 51 from which the overload nozzles discharge register with passages 27 leading from channel 25. It will be seen that this makes a very cheaply constructed and easily assembled series of divergent nozzles, and as the partitions or walls between the several nozzles extend to the top or outer face 53 of the segments the inner periphery of the casing which is bored out, forms the tops or one wall of the nozzles.

It will be evident that, if this invention is utilized in a single flow turbine, oppositely discharging nozzles will not be necessary, but the nozzles will only be formed in one side of each of the segments, or nozzle members.

Moving blades 43 adjacent to the nozzles are carried by a drum 55 having a central web 56 which supports it on a hub 57 carried by the turbine shaft 19. These blades are preferably formed, as shown in Fig. 14, with rearwardly extending top and bottom portions on their convex side, which form

a shroud and spacer respectively. This construction allows the concave faces of the blades to be readily machined from top to bottom so as to provide a smooth impact surface. The sides of the base portions are preferably rabbeted or cut away, as shown at 58, forming channels which dovetail with the walls of suitably formed grooves in the drum 55.

Each of the supporting drums 59 for the remainder of the blades is bolted or otherwise secured to drum 55 at one end and has its other end supported by means of a hubbed web 60 carried on the turbine shaft adjacent to the end of the drum 59, and by means of this construction a relatively cheap yet extremely rigid motor is obtained.

It will be apparent that this type of turbine either as a single or double flow machine may be readily utilized for driving the propeller shafts of marine vessels, and of course when so utilized no governor, in the ordinary sense of a governor, will be necessary; but if desired, the amount of motive fluid admitted to the turbine may be varied by throttling, and both the normal and overload valves operated manually.

Having now set forth the objects of this invention and a form of construction embodying the principle thereof, and having described such construction, its functions, and mode of operation, what is claimed as new and useful and sought to be secured by Letters Patent is:

1. In a double flow elastic fluid turbine, in combination with the casing provided with its two exhausts, a bed plate provided with a passage connecting said exhausts, and a fluid seal between said plate and casing.

2. In a double flow elastic fluid turbine in combination with the casing provided with its two exhausts, a bed plate provided with a passage connecting said exhausts, a fluid seal between said plate and casing and a source of fluid supply communicating with said seal.

3. In an elastic fluid turbine, in combination with its casing provided with its exhaust port, a bed plate provided with a fluid passage substantially registering with said exhaust port and a fluid seal between said plate and casing.

4. In an elastic fluid turbine, in combination with the casing provided with its exhaust port, a bed plate provided with a passage substantially registering with said exhaust port, a channel in said bed plate surrounding said passage, and a source of fluid supply communicating with said channel whereby a fluid seal is maintained between said plate and casing.

5. In an elastic fluid turbine, an annular fluid channel extending around the turbine casing, ports leading from said channel to the interior of the casing, and a segment

secured against the inner periphery of the casing and provided with radially extending members forming nozzles.

6. In an elastic fluid turbine, an annular fluid channel extending around the turbine casing, ports leading from said channel to the interior of said casing and a segment secured against the inner periphery of the casing and provided with radially extending members forming divergent nozzles.

7. In an elastic fluid turbine of the double flow type, an annular fluid channel extending around said casing, ports leading from said channel to the interior of said casing, and a plurality of segments secured against the inner periphery of said casing, each segment provided with a row of oppositely discharging divergent nozzles.

8. In an elastic fluid turbine of the double flow type, an annular fluid channel extending around said casing, ports leading from said channel to the interior of said casing, and a plurality of segments secured against the inner periphery of said casing, each segment provided with a row of oppositely discharging nozzles.

9. In an elastic fluid turbine, a fluid channel extending circumferentially of the turbine casing, ports leading from said channel to the interior of the casing, a segment formed with outwardly extending parts bearing against the inner periphery of said casing whereby divergent nozzles are formed.

10. In an elastic fluid turbine, a fluid channel extending circumferentially of the turbine casing, ports leading from said channel to the interior of the casing, a segment formed with outwardly extending parts bearing against the inner periphery of said casing whereby oppositely discharging divergent nozzles are formed.

11. In an elastic fluid turbine, a fluid channel extending circumferentially of the turbine casing, ports leading from said channel to the interior of the casing, a segment formed with outwardly extending parts bearing against the inner periphery of said casing whereby oppositely discharging nozzles are formed.

12. In an elastic fluid turbine, a fluid channel extending circumferentially of the turbine casing, ports leading from said channel to the interior of the casing, a segment formed with outwardly extending parts bearing against the inner periphery of said casing whereby nozzles are formed.

13. In an elastic fluid turbine, a normal load fluid channel, an overload fluid channel, and a spirally extending partition between said channels.

14. In an elastic fluid turbine, a normal load fluid channel extending circumferentially of the turbine casing, a similarly located overload fluid channel and a spirally extending partition between said channels.

15. In an elastic fluid turbine provided with oppositely discharging fluid nozzles and alternate rows of stationary and moving vanes and blades, a shaft, a central supporting web mounted on said shaft and provided with a blade supporting drum, a secondary blade supporting drum secured to each side of said primary drum and two outer webs on said shaft each supporting the outer end of one of said secondary drums.
16. In an elastic fluid turbine, a casing, a normal load fluid channel extending exteriorly to and circumferentially of said casing, an overload fluid channel located and extending similarly to said normal load channel, a single line of fluid ports extending from both of said channels to the interior of the casing, a partition between said channels, and a valve for each of said channels.
17. In combination with the casing of an elastic fluid turbine having a fluid passage leading thereto, a member provided with a face conforming to and secured against the inner periphery of said casing adjacent to said fluid passage, a fluid space in said member communicating with said fluid passage, and fluid discharge nozzles formed in one face of said member.
18. In combination with the casing of an elastic fluid turbine having a fluid passage entering the same, a member provided with a face conforming to and secured against the inner periphery of said casing, a fluid space in said member communicating with said fluid passage and fluid discharge nozzles rectangular in cross section and formed in one face of said member.
19. In combination with the casing of an elastic fluid turbine having a fluid passage entering the same, a member provided with a face conforming to and secured against the inner periphery of said casing, a fluid space in said member communicating with said fluid passage and divergent fluid discharge nozzles rectangular in cross section formed in one face of said member.
20. In combination with the casing of an elastic fluid turbine having a fluid passage leading thereto, a member provided with a face conforming to and secured against the inner periphery of said casing adjacent to said fluid passage, a fluid space in said member communicating with said fluid passage, and fluid discharge nozzles formed in opposite faces of said member.
21. The combination with the casing of an elastic fluid turbine having a fluid passage entering the same, of a member provided with a face conforming to and secured against the inner periphery of said casing, a fluid space in said member communicating with said fluid passage and fluid discharge nozzles rectangular in cross section and formed in opposite faces of said member.
22. In combination with the casing of an elastic fluid turbine having a fluid passage entering the same, a member provided with a face conforming to and secured against the inner periphery of said casing, a fluid space in said member communicating with said fluid passage and divergent fluid discharge nozzles rectangular in cross section formed in opposite faces of said member.
23. In an elastic fluid turbine of the double flow type, a turbine casing provided with fluid passages extending into the interior thereof, and a plurality of segments secured against the inner periphery of said casing each of which is provided with a row of oppositely discharging nozzles.
24. In an elastic fluid turbine of the double flow type, a turbine casing provided with fluid passages extending into the interior thereof, and a plurality of segments secured against the inner periphery of said casing each of which is provided with a row of oppositely discharging divergent nozzles.
25. In an elastic fluid turbine of the double flow type, a turbine casing provided with fluid passages extending into the interior thereof, and a plurality of segments secured against the inner periphery of said casing each of which is provided with a row of oppositely discharging rectangular nozzles.
26. In combination in an elastic fluid turbine, a casing provided with a fluid delivery port, a bedplate provided with a port adapted to register with the port of said casing, and a liquid seal between said casing and said plate.
27. In combination in an elastic fluid turbine, a casing provided with a fluid delivery port, a bedplate provided with a fluid delivery passage and a port communicating therewith and registering with the port of said casing, and a liquid seal between said casing and said plate and extending around said ports.
28. In combination in an elastic fluid turbine, a fluid delivery channel extending circumferentially around the casing of the turbine and provided with two fluid supply ports, and a spiral partition dividing said channel into two compartments, each of which communicate with one of said ports.
29. In an elastic fluid turbine, a fluid delivery channel extending around the casing of the turbine and provided with two fluid supply ports and a plurality of circumferentially aligned delivery ports leading from said channel to the interior of said casing, a partition dividing said channel into two passages, one of which communicates with one of said supply ports and a number of said delivery ports, and the other of which communicates with the other supply port and the rest of the delivery ports.
30. In combination in an elastic fluid tur-

bine, a fluid supply channel extending around the turbine casing and provided with two fluid supply ports, communicating with the source of motive fluid, and circumferentially alined delivery ports leading through said casing to the working passages of the turbine and divided into two groups, and a partition located within said channel and dividing the interior thereof into two passages, each of which communicates with one of said supply ports and one group of said delivery ports.

31. In combination in an elastic fluid turbine, a fluid supply channel extending around the turbine casing and provided with two fluid supply ports, communicating with a source of motive fluid, and a plurality of delivery ports leading through the casing to the working passages of the turbine, a segment secured to the inner face of said casing and communicating with said delivery ports, and a partition dividing said channel into two passages, each of which communicates with one of said supply ports.

32. In combination in an elastic fluid turbine, a fluid supply channel extending around the turbine casing and provided with a normal and an overload fluid supply port and a group of normal and a group of overload fluid delivery ports leading through the casing to the working passages of the turbine, a segment secured to the inner face of the casing and provided with normal and overload fluid nozzles communicating respectively with the normal and overload delivery ports, and a partition dividing said channel into two passages, one of which

communicates with the normal supply and delivery ports, and the other of which communicates with the overload supply and delivery ports.

33. In an elastic fluid turbine, a fluid delivery channel provided with a fluid supply port, and a plurality of circumferentially alined fluid delivery ports leading from said channel to the interior of the turbine, and a partition dividing said channel into two passages, one of which communicates with a number of the fluid delivery passages and the other of which communicates with the rest of said delivery passages.

34. In combination in an elastic fluid turbine, a fluid supply channel extending around the turbine casing and provided with a fluid supply port and a group of circumferentially alined delivery ports leading through the casing to the working passages of the turbine, a partition dividing said channel into two passages, one of which communicates with a number of the fluid delivery ports and the other of which communicates with the rest of said ports, and a segment secured to the inner face of the casing and provided with separate groups of nozzles which communicate with the separate groups of fluid delivery ports.

In testimony whereof, I have hereunto subscribed my name this 21st day of July, 1904.

GEO. WESTINGHOUSE.

Witnesses:

H. C. TENER,
WM. H. CAPEL.