No. 824,547.

PATENTED JUNE 26, 1906.

O. JUNGGREN.

REGULATING MECHANISM FOR TURBINES.

APPLICATION FILED APR. 6, 1904.

2 SHEETS—SHEET 1.

Fig. 1.

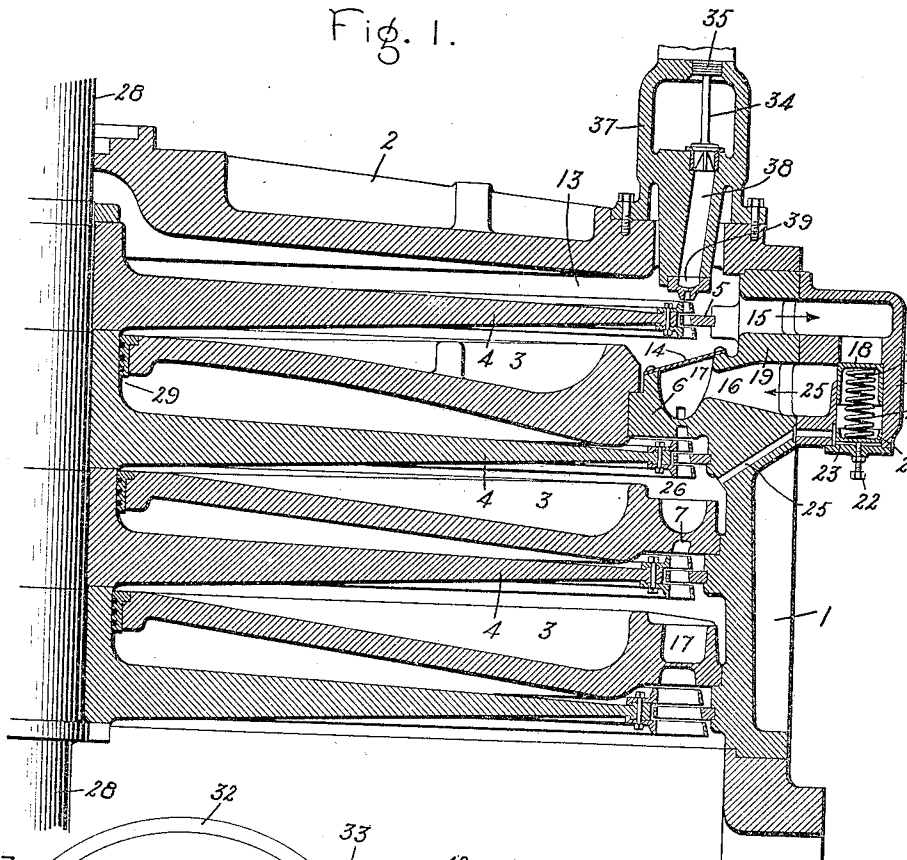


Fig. 3.

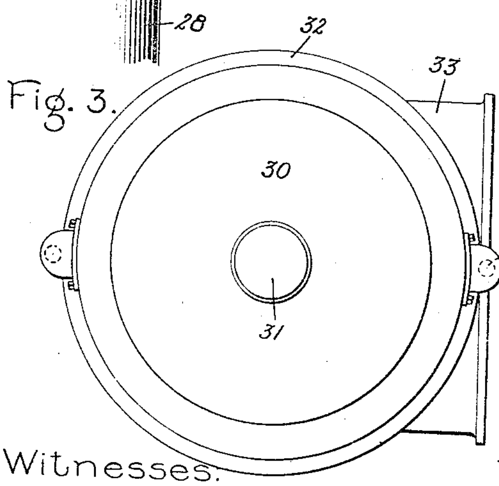
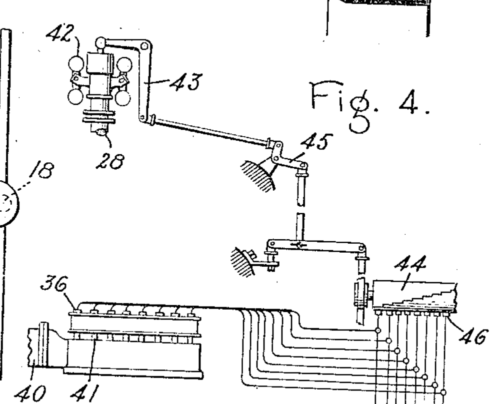


Fig. 4.



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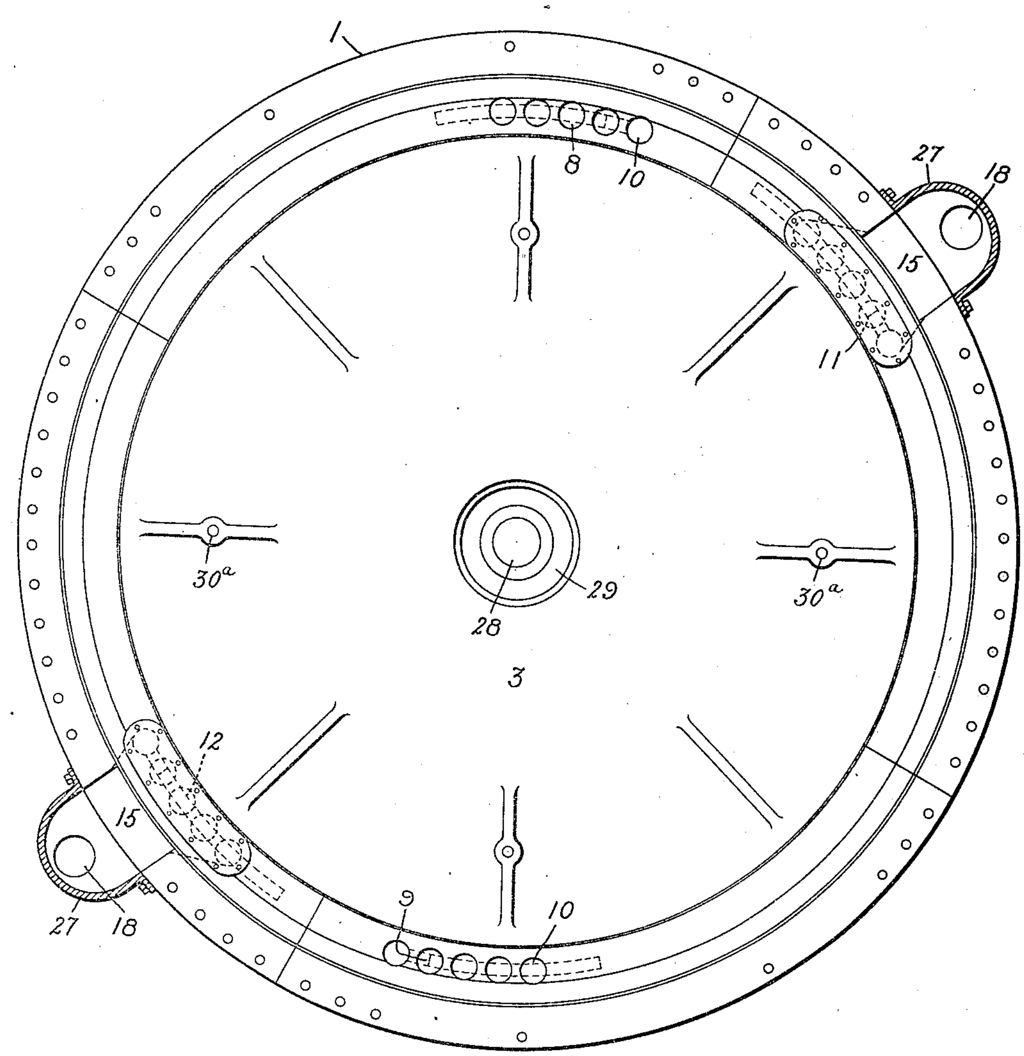
2 SHEETS—SHEET 2.

Fig. 2.



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UNITED STATES PATENT OFFICE.

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REGULATING MECHANISM FOR TURBINES.

No. 824,547. Specification of Letters Patent. Patented June 26, 1906.

Application filed April 6, 1904. Serial No. 201,860.

To all whom it may concern:

Be it known that I, OSCAR JUNGGREN, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Regulating Mechanism for Elastic-Fluid Turbines, of which the following is a specification.

The object of the present invention is to provide a regulating mechanism for elastic-fluid turbines operating by stage expansion which is simple in construction and reliable and efficient in operation.

The turbine is divided by diaphragms into as many stages as are desired, and motive fluid is admitted to the first or high-pressure stage by a plurality of nozzles or nozzle-sections controlled by separately-actuated valves, the said valves being under the control of a device responsive to load changes. The said device may be directly or indirectly driven by the main shaft. As an example, I may use a governing mechanism for the first stage of the character described and claimed in my pending application, Serial No. 121,110, filed August 26, 1902. Under normal running conditions one or more of the valves will be open and one or more of the valves will be closed and one valve will be doing the regulating. In other words, the volume of steam delivered by a given number of nozzles or nozzle-sections is seldom the right amount to maintain a constant speed of the bucket-wheel. Hence one nozzle-valve has to keep opening and closing, and the interval of time that the valve is open or closed depends upon how nearly a given number of nozzles can handle the load. In order to control the passage of steam or other motive fluid through the nozzles or discharging devices between stages and to maintain constant or substantially constant stage-pressures, separately-actuated valves are provided, which to distinguish them from the admission-valves are called "stage" or "by-pass" valves. This feature of the invention is an improvement over the construction shown in the United States Patent to Dwight D. Book, No. 714,094, which broadly covers the idea of varying the number of active stage-nozzles in a turbine having two, three, or more stages by valve mechanism responsive to variations in stage-pressure. Book employs a single piston-valve of large dimensions for controlling each stage. This construction while satisfactory in many instances is limited in its application for various reasons, among which are the inertia of the heavy moving parts, the difficulty of connecting nozzles located at different points around the wheel-buckets with a single valve-casing, and the large amount of space required, and the consequent increase in dimensions of the turbine as a whole.

In order to overcome the objections above referred to, a plurality of individual and relatively small valves are provided between one stage and another, which are located in close proximity to the stage nozzle or nozzles controlled thereby in order that the fluid-conveying passages may be as short as possible. The valves can with advantage be located in casings which are bolted or otherwise secured to the wheel-casing adjacent to the stage-nozzles, since by reason of this construction the valves may be readily inspected, adjusted, mounted in place, or repaired. The valves may be weighted in any suitable manner and may be arranged to operate simultaneously or successively, as desired. I prefer to have them operate successively, since by so doing a more nearly even pressure will be preserved in the wheel-compartment. The motive fluid in order to prevent its effect being lost when the valve opens is discharged into a succeeding shell or compartment of lower pressure. This discharge is preferably into the adjacent shell of lower pressure in order to effectively utilize the fluid; but it can take place into a shell which is more remote, if desired. This discharge can take place directly into the shell, in which case it does no useful work in passing; but it is preferable to discharge it through what I term "auxiliary" or "stage" nozzles that are normally inactive and are prevented from receiving fluid directly from the main steam-space of the compartment. In this way the excess steam from one shell or wheel-compartment is made to do useful work in passing to a shell or shells of lower pressure.

The stage-valves are so arranged that they open one after the other as the pressure in a given stage increases and close in reverse order as the pressure falls, thereby increasing or decreasing the number of active stage-nozzles. Other things being equal, an increase in pressure will cause one or more stage-nozzles to be put in service until an equilibrium is again established. On the other hand, a fall in stage-pressure will cause one or more stage-nozzles to be cut out of service one after the other until an equilibrium is again established. In other words, the successively-acting valves tend to hold the pressure of a given stage constant. The construction and action of the stage-valves is the same in each case whether for a high or low pressure stage.

The first stage or shell is provided with suitable nozzles or fluid-discharging devices and a governor of any approved type to compensate for load changes, but preferably the one disclosed in my pending application above referred to. One or more of the stages or shells of lower pressure are provided with as many main nozzles or discharging devices as are necessary for average load conditions, which nozzles may be in permanent open communication with the shell and receive steam directly therefrom, or they may be valved, as desired. In addition to these nozzles there are auxiliary or stage nozzles which are closed to the steam-space of the shell and receive steam only through the weighted stage or by-pass valves. These valves are set to open under a predetermined increase in stage or what is sometimes called "shell" pressure. The weights on the valves differ, so that they operate successively. In other words, the auxiliary or stage nozzles are in a connection or conduit from one stage to another and are controlled in their action by automatic valves.

To reduce the strain on the parts and also to simplify the construction, the main and auxiliary stage-nozzles are separate structures, and for certain types of turbine, especially large sizes, it will be found advantageous to form the main nozzles on one part of a segmental bucket-wheel shell or casing and the auxiliary nozzles in a separate part or segment of the same shell. They may, however, be supported in a different manner, if desired. Each of the by-pass or stage valves may be mounted in a separate casing, that is attached to the exterior of the main casing or shell, in which case it is readily accessible. One or more rows of wheel-buckets may be provided for each stage, depending upon the character of the nozzles or fluid-distributing devices.

In the accompanying drawings, which illustrate one embodiment of my invention, Figure 1 is a partial vertical section of a two-wheel-per-stage turbine. Fig. 2 is a horizontal section of the same, taken on a plane just above the upper diaphragm. Fig. 3 is a plan view of the turbine, and Fig. 4 is a detail view of the first stage or supply valves.

1 represents the casing of the machine, which is provided with a top or cover 2 and one or more walls or diaphragms 3. Between the cover and the upper diaphragm and between adjacent diaphragms are bucket-wheels 4 for fractionally abstracting the velocity of the fluid stream due to the nozzles. In the present illustration two rows of wheel-buckets are provided for each stage, with a row of intermediate buckets 5 between each pair of wheel-buckets. The function of these intermediate buckets is to receive steam from one row of wheel-buckets and after changing its direction discharge it properly against the adjacent row of wheel-buckets. The upper diaphragm 3, owing to the high pressure to which it is subjected, is made smaller than the other diaphragms. Situated below and supporting the diaphragm 3 is an overhanging projection 6, formed on a segment of the wheel-casing. In the projection is formed a nozzle which is composed of a plurality of closely-associated sections or passages. The nozzle may be of the expanding or non-expanding type. The lower-pressure diaphragms are mounted on small shoulders formed on the inside of the casing and are provided at one or more points near their peripheries with nozzles 7, which are preferably of the sectionalized type and may or may not expand between the receiving and discharge orifices, as is desired.

Referring to Fig. 2, the arrangement of the second-stage nozzles will be seen. The casing 1 is divided into sections. In the present illustration four of these sections are shown, and the lines of division between sections are in radial planes. 8 and 9 represent the main stage-nozzles for supplying elastic fluid to the bucket-wheel of the second stage, it being understood that the first stage has been removed in this figure for the purpose of illustration. Each of these nozzles is of the sectionalized type and is composed of five sections, each section being provided with a suitable bowl 10, which delivers steam or other elastic fluid to the nozzle-orifice. The nozzles are situated diametrically opposite and are of sufficient capacity to handle a given or normal load on the turbine. The nozzles for the subsequent stages are designed to handle the increased volume of steam at the reduced pressure. Situated at suitable points with respect to the main nozzles are auxiliary stage-nozzles 11 and 12. These nozzles are formed in sections of the casing separate from those sections which carry the main stage-nozzles. The object of this arrangement is to prevent the weakening of any one of the casing-segments by cutting away a considerable mass of metal, as would be the case if all of the nozzle-sections were formed therein. The main stage-nozzles 8 and 9 are in permanent communication with the upper wheel-chamber 13, Fig. 1.

The auxiliary stage-nozzles are permanently covered by a plate or other suitable means 14, and adjacent thereto the wheel-casing is cut away to form a passage 15, which forms a part of a valve-controlled connection. Situated below the passage 15 is a second passage 16, Fig. 1, which discharges fluid into all of the bowls 17 of the auxiliary or stage nozzles.

In order to control the passage of fluid from one wheel-chamber to the next and to relieve the pressure on the diaphragm, an automatic by-pass or stage valve is provided, comprising a piston-like portion 18, which engages with a conical seat on the partition 19. The piston is weighted or held against its seat by a coiled compression-spring 20. The lower end of the spring is supported in the cup-shaped abutment 21, that may be adjusted by a screw 24. The screw is carried by a detachable plate 23, and when it is desired to remove the valve for the purpose of inspection or repair this plate, together with the abutment and spring, is removed, and by inserting a screw-threaded rod in the projection 24 the piston can be withdrawn, it being understood that this piston makes a close fit with its inclosing cylinder. The valve does not open until the pressure exceeds a certain amount, and when once opened it remains so until there is a predetermined decrease in steam-pressure. By reason of the beveled end of the valve the effective area of the valve when closed is somewhat less than when open. In order that the pressures on the piston may be in a measure balanced, a passage 25 is provided, which opens the cylinder-space back of the piston to the wheel-chamber 26. Under normal conditions the valve is in the position shown; but when the pressure within the upper wheel-chamber 13 exceeds a predetermined amount the by-pass or stage valve opens and motive fluid is permitted to flow through the passages 15 and 16 into the auxiliary nozzles, the latter being arranged to effectively discharge the fluid against the bucket-wheel mounted in the wheel-chamber 26. Two or more of these by-pass or stage valves may be provided for a given stage. I find it convenient in the present embodiment of my invention to provide two such valves and to adjust them differently, so that they will operate successively.

Referring to Fig. 2, it will be seen that the stage-valves and their casing 27 are situated diametrically opposite, and the latter are bolted to the main casing, so that they can readily be attached and removed. 28 represents the main shaft, and 29 a packing, which prevents motive fluid from escaping from one wheel-chamber to the next without performing useful work. 3 represents the upper diaphragm, which is provided with suitable strengthening-ribs, some of which are provided with screw-threaded holes 30^a to receive eyebolts, the latter being used in assembling and taking down the machine.

In Fig. 3 is shown a plan view of the turbine with a dynamo or other load 30 mounted thereon. In the center of the dynamo is a dome 31, which incloses the speed-responsive device that is mounted on the main shaft. Situated at diametrically opposite points on the casing and suitably inclosed are valves 18, responding automatically to changes in stage-pressure. The turbine is supported by a base 32, which is provided with a conduit 33, that carries off the exhaust. The base may contain a condenser or be connected to a condenser or atmosphere, as desired.

In order to supply fluid to the turbine, a plurality of separately-actuated valves 34 are employed, each valve being operated by a motor 35 of suitable construction. In the present instance each valve is operated by a fluid-motor which is under the control of an electromagnet 36. The valves are mounted in a valve-chest 37, which is common to them all. Extending from the chamber in the valve-chest is a plurality of fluid-carrying passages 38, each of which is provided with a valve which opens into one or more passages in the first-stage or supply nozzles 39. Steam or other elastic fluid is admitted to the valve-chest by the conduit 40. The magnets 36 for controlling the motors 35 are supported by the valve-chest, but are separated therefrom by a small space to permit of the circulation of air for cooling purposes. Each magnet acts on the stem of a relay-valve which controls the motor. Mounted on the main shaft 28 is a speed-responsive device 42, which is connected to a bell-crank lever 43, that is mounted in the dome 31. The lever 43 is connected to the stepped contact-cylinder 44 through a system of levers 45 in such manner that the cylinder can be oscillated in response to speed changes. Engaging with the contact-cylinder is a plurality of contact-brushes 46, which are connected to a source of current-supply and to the magnets 36. As shown, all of the magnets are energized, which means that all the supply or first-stage valves are open. If the load decreases, the speed-responsive device will move the contact-cylinder in a direction to cut out one or more of the brushes, which will permit one or more of the magnets 36, and consequently one or more of the nozzle-valves, to close. Under ordinary running conditions one or more of the valves are closed, one or more of the valves open, and at least one valve is doing the governing by opening and closing. As the load increases the speed drops slightly, causing one or more admission-valves to open, thereby increasing the pressure in the first stage. When the increase in stage-pressure reaches a certain predetermined amount, one of the stage-valves will open, and upon a still further increase another stage-valve will open, and so on until all of the stage-valves are open. The increasing of the pressure in the first stage is accompanied by an increase in pressure in the second and subsequent stages, due to the opening of the stage-valves and the putting in service of what I have termed "auxiliary" or "stage" nozzles. Conversely, when the admission-valves are closed one after the other a temporary fall in pressure takes place in the first stage, which permits one or more stage-valves to close, the latter cutting off one or more auxiliary nozzles and causing a temporary drop in pressure in the second and succeeding stages until a state of equilibrium is reëstablished. This action takes place in each stage provided with these stage-valves.

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 believe to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is merely illustrative and that the invention can be carried out by other means.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In an elastic-fluid turbine operating by stage expansion, means controlling the supply of fluid to the first stage, and individual automatic stage-pressure-controlled valves located at different points around the turbine for supplying fluid to the succeeding stage or stages.

2. In an elastic-fluid turbine operating by stage expansion, valves controlling the supply of fluid to the first stage, and a series of valves controlling the supply of fluid to a succeeding stage which are automatically operated by relatively different variations in the preceding stage-pressure.

3. In an elastic-fluid turbine operating by stage expansion, individual and successively-operating valves controlling the supply of fluid to the first stage, and automatic stage-pressure-controlled valves admitting fluid to the succeeding stage or stages.

4. In an elastic-fluid turbine operating by stage expansion, means controlling the admission of fluid to the first stage, passages disposed around the turbine for delivering the fluid to a succeeding stage, and valves which are automatically and successively opened or closed under the control of the preceding stage-pressure.

5. In a turbine operating by stage expansion, a plurality of passages for discharging fluid-pressure from a stage, and successively-acting valves under the control of a stage-pressure which regulate the volume of fluid exhausted from said stage.

6. In an elastic-fluid turbine operating by stage expansion, independently and successively acting valves controlling the supply of fluid to the first stage, valves between the stage-compartments adapted to maintain stage-pressures therein, which are automatically actuated by the pressure in the stage which they control acting against a substantially constant resistance tending to move said valves in opposition to said stage-pressure.

7. In an elastic-fluid turbine, operated by stage expansion, the combination of a plurality of separately-actuated valves controlling the supply of fluid to the first stage, a speed-responsive device, and automatic stage-pressure-controlled valves supplying fluid to the succeeding stage or stages.

8. In an elastic-fluid turbine operated by stage expansion, the combination of a plurality of valves controlling the supply of fluid to the turbine, a speed-responsive device for regulating the action of the valves, and a series of individual valves controlling the supply of fluid to a succeeding stage, which are automatically operated by variations in the preceding stage-pressure.

9. In an elastic-fluid turbine operated by stage expansion, the combination of a plurality of individual and separately-actuated valves, a speed-responsive device for controlling the valves, and automatic stage-pressure-controlled valves admitting fluid to a succeeding stage or stages.

10. In an elastic-fluid turbine operated by stage expansion, the combination of a plurality of separately-actuated valves controlling the admission of fluid to the first stage, a speed-responsive device acting on said valves to regulate them, and passages delivering fluid to a succeeding stage, which are automatically and successively opened under the control of the pressure in the preceding stage.

11. In an elastic-fluid turbine operated by stage expansion, the combination of individual valves controlling the supply of fluid to the first stage, a speed-responsive device for operating the valves one after the other in predetermined sequence, and valves between the stage or wheel compartments adapted to maintain predetermined pressure therein, said valves being subjected to the pressure of fluid within the stage and also to a substantially constant resistance tending to move said valves in opposition to the stage-pressure.

12. A turbine of the multistage type, in combination with a valve mechanism responding to speed changes for increasing and decreasing the amount of motive fluid ad-

mitted to the turbine, stage nozzles or devices, and successively-operating stage-valves which open and permit more fluid to flow through the stage nozzles or devices when the amount of fluid admitted to the turbine by the governed valve mechanism increases and close one after the other and cut out stage nozzles or devices as the amount of fluid admitted by the governed valve mechanism decreases.

In witness whereof I have hereunto set my hand this 4th day of April, 1904.

OSCAR JUNGGREN.

Witnesses:

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HELEN ORFORD.