G. O. GRIDLEY.

MULTIPLE STAGE TURBINE.

APPLICATION FILED NOV. 7, 1910.

1,108,497.

Patented Aug. 25, 1914.

2 SHEETS—SHEET 1.

Fig. 2.

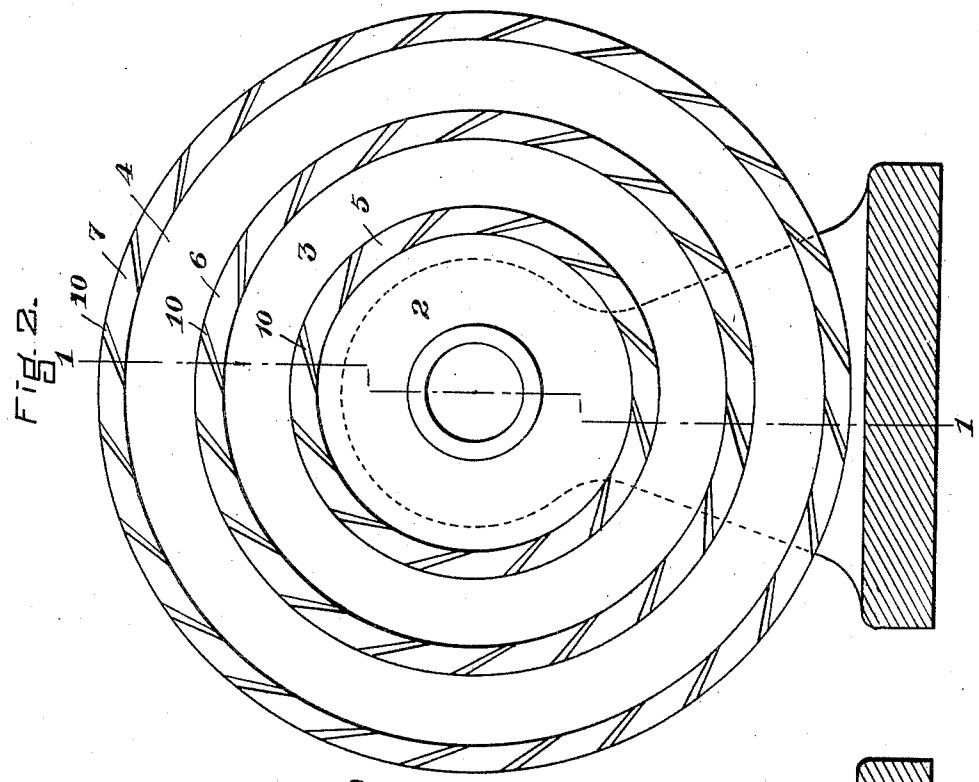
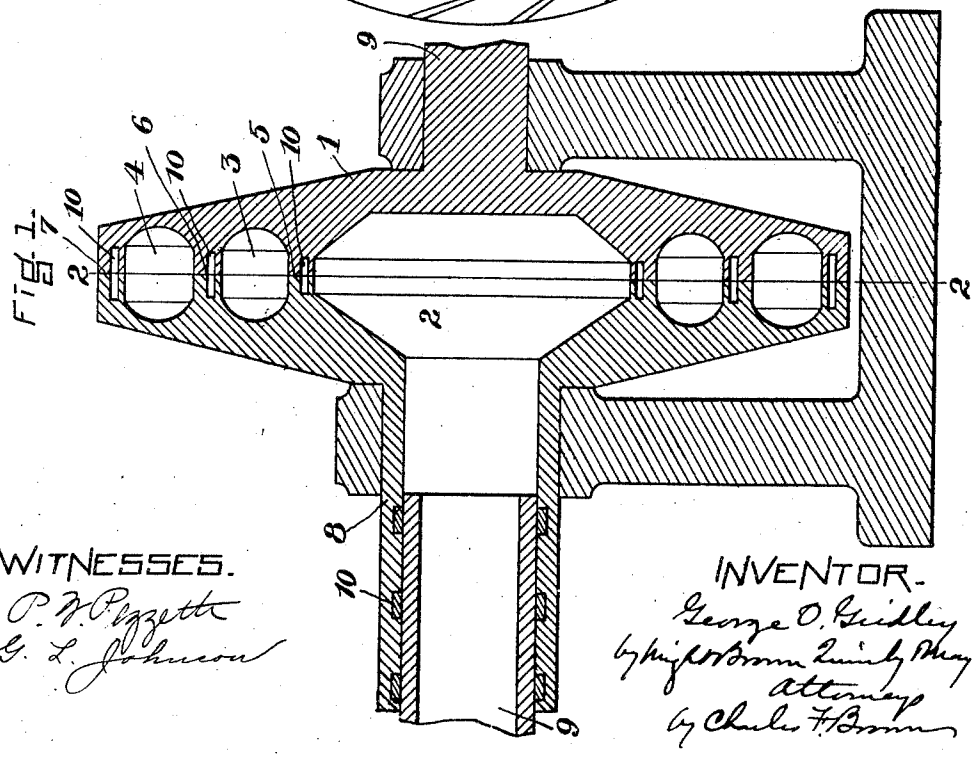


Fig. 1.



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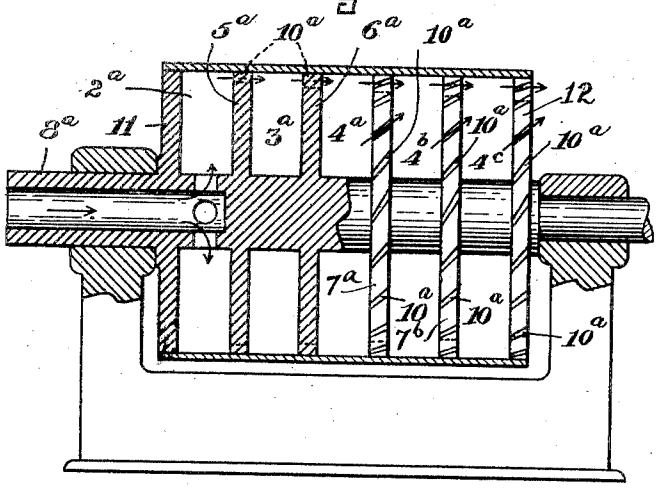
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2 SHEETS—SHEET 2.

FIG. 3.



WITNESSES.

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MULTIPLE-STAGE TURBINE.

1,108,497. Specification of Letters Patent. Patented Aug. 25, 1914.

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To all whom it may concern:

Be it known that I, GEORGE O. GRIDLEY, of Windsor, in the county of Windsor and State of Vermont, have invented certain new and useful Improvements in Multiple-Stage Turbines, of which the following is a specification.

The object of the present invention is to provide a turbine adapted to be driven by steam or other highly expansible elastic fluid at a sufficiently low speed to enable it to be used as a prime mover, without speed-reducing gearing, and to accomplish this result by making the velocity of the steam in its passage through the turbine relatively slow. I accomplish my object by providing a turbine having a number of closed chambers into which the steam may flow successively and by arranging the passages through which the steam flows from chamber to chamber in such directions that the steam exerts a reaction in a direction tending to rotate the turbine. The combined areas of the outlets from the successive chambers are progressively increasing, so that a gradual expansion of the steam in the course of this flow through the turbine occurs, while the plurality of closed chambers provides for the expansion in a number of stages. In other words the object of the invention is to provide a multistage reaction turbine in which the velocities of both the turbine and the working fluid are kept low and the losses incidental to the passage of the working fluid between relatively stationary and moving vanes, or between oppositely moving vanes are eliminated.

The essential features of the invention may be embodied in a turbine wherein the flow of the working fluid is either axial or radial, the principles being the same in both cases. The embodiments of the invention chosen for illustration in this application show types of turbine in which the flow is generally radial, and generally axial, respectively. Many modifications in design of either type, and combinations of the distinctive characteristics of the two types in a single turbine may be made without departing from the spirit or going beyond the scope of the invention.

In the drawings, Figure 1 represents a longitudinal section of a type of turbine embodying my invention, in which the flow of working fluid is generally radial. Fig. 2 represents a cross-section on line 2—2 of Fig. 1. Fig. 3 is a longitudinal section of a form of turbine embodying the invention in which the flow of the working fluid is axial.

The same reference characters indicate the same parts in all the figures.

In this invention the entire turbine is rotatable and constitutes the rotor, there being no stationary casing such as is a feature of all multistage turbines hitherto produced or designed of which I have knowledge. The interior of the turbine is provided with a number of chambers divided from one another by partitions. In the partitions are passages or nozzles which permit the steam or other working fluid to pass from one chamber to the next and are arranged to discharge as nearly opposite to the direction of rotation of the turbine as possible, so that the steam in passing through them exerts a reaction tending to rotate the turbine.

In the type of turbine chosen for illustration in Figs. 1 and 2, the rotor 1 is given a disk-like form and is provided in its interior with chambers, 2, 3 and 4 which are concentric and are divided from one another by partitions 5, 6 and 7 respectively. In this particular embodiment of the invention three chambers and inclosing partitions are shown, but the number is not material to the invention and may be more or less than the number shown.

The rotor is provided with trunnions 8 and 9, one of which is tubular and opens into the central chamber 2, a pipe or coupling 9 being provided to conduct the steam thereto. This pipe or coupling is necessarily stationary, and any form of packing 10 to prevent leakage may be provided between the contacting surfaces thereof and of the tubular trunnion.

In the partitions or walls which inclose the several chambers are passages 10 which pass through the walls on an inclination and are so arranged as to direct the steam at as nearly right angles to the direction of rotation of the turbine as possible, so that the reaction of the steam may exert an impelling force. Preferably also the passages are enlarged in cross-sectional area from their inlet to their discharge ends so as to form expanding nozzles to develop the velocity of the steam in the most efficient manner. In the radial flow type here illustrated the passages are as nearly tangential to the ring-shaped partitions as possible, but in an

axial-flow type where the chambers and partitions are arranged side by side the passages are inclined with respect to the axis. In either case, however, their inclination is such that the steam issues therefrom in a direction as nearly as possible opposite to the path of rotation.

The number of chambers and sets of nozzles may be extended as far as is necessary to secure a gradual step-by-step reduction of the steam pressure from that at which it is delivered from the boiler to the pressure of the atmosphere or in a condenser, and it may be so great that there is a difference of pressure of only a very few pounds between successive chambers. The number of stages, and the area of the nozzles conducting the steam to each stage are designed according to the difference between the initial and exhaust pressures, and the speed at which the turbine is intended to run. These elements will accordingly vary in different turbines according to the conditions governing each case, being so designed in any case as to keep the speed of the turbine down to a relatively slow speed without loss of efficiency, and to carry the steam through as many stages of expansion as may be necessary to develop all of its energy.

In those turbines of the reaction type hitherto designed, either the speed of rotation has been excessive, or where this is not the case, it has been considered necessary to provide a fixed casing with sets of guide vanes projecting between rows of vanes or buckets on the rotor. According to my invention I eliminate the stationary casing and inclose the receiving chambers or spaces between the successive reaction passages wholly in the rotor, thereby wholly preventing wasteful leakage of steam and loss of energy, and design the parts in such manner that the difference in pressure between any two successive stages is so slight that the velocity of the steam in flowing through the passages or nozzles is comparatively low, and therefore the velocity imparted thereby to the rotor is no greater than may be employed without speed-inducing gearing for driving machinery, such, for instance, as an electric generator. As the steam after expanding from stage to stage is increased in volume, the combined area of the nozzles is made successively greater in each succeeding partition either by increasing the number of nozzles or by increasing their cross-sectional area, in order to take care of the proper amount of steam at its increased volume. As, however, in the case of the radial flow type, the linear extent of the outer partitions is greater than that of the inner, greater numbers of passages may be formed in them than in the others without spacing them more closely together. The number and size of passages in each partition is, however, a matter of calculation for each engine and is governed by the speed at which the engine is to run and the amount of expansion in each stage.

As a practical detail of construction, the rotor in the radial-flow type may conveniently be made in two parts in the form of disks, one of which carries the ribs, and the other of which is provided with plane surfaces adapted to fit closely against the ribs and to be bolted to the first disk. The hollow trunnion may be formed upon or attached to either one of the disks and the other may be formed with or secured to a shaft section or trunnion which is coupled to an electric generator or any other piece of machinery which is to be driven.

Fig. 3 shows the embodiment of the same principles in an axial flow turbine. Here the turbine consists of a hub portion having trunnions at its ends mounted in bearings, one of which trunnions as 8^a is provided with an inlet passage for the steam. Surrounding the hub are flanges or disks 5^a, 6^a, 7^a, 7^b, 11 and 12 respectively, which are surrounded by a casing. The latter is for structural reasons a separate piece from the hub and disks, but it is tightly fitted thereto and when in place forms with the latter a unit structure. The partitions divide the space inclosed between the hub and casing into chambers 2^a, 3^a, 4^a, 4^b and 4^c respectively, which are entirely closed from each other except for the passages or nozzles 10^a in the disk partitions. The steam or other working fluid which is admitted first to the chamber 2^a passes through the passages or nozzles in the partition disk 5^a into the chamber 3^a and thence successively into the receiving chambers 4^a, 4^b and 4^c until it finally passes through the nozzles in the endmost disk 12 into the atmosphere or a condenser. The passages 10^a are preferably formed in this case also as expanding nozzles to enable the same to expand in passing from one stage to the next and convert its pressure energy into velocity. Increasing areas in the nozzles of the successive stages to accommodate the steam in its successive stages of expansion are provided for by making the nozzles in each disk of greater radial extent than those in the next preceding disk. The same result could be secured by providing greater numbers of nozzles in the successive disks, or by making the nozzles wider, but I consider the system of making them successively deeper as the best for the purpose.

It will be seen that the principles of the invention are the same when applied to the axial flow turbine as in the radial flow, since the steam in passing through the inclined nozzles 10^a exerts a rotating impulse by reaction, and that in passing through each set of nozzles, it is carried to a greater

degree of expansion. All parts of the rotor in this form of turbine rotate in unison and the receiving chambers between the several chambers of expansion are formed in the rotor itself instead of in stationary inclosing casings.

I claim—

1. A reaction turbine consisting of a rotating member having end walls and concentric outer and inner cylindrical walls connected and rotating in unison, each said cylindrical wall inclosing a chamber for working fluid and each having approximately tangential nozzle passages, and means for admitting the working fluid to the chamber nearest the axis, said walls having their outer surfaces flush with the discharge orifices of the nozzles, and being continuously curved concentrically with the axis of rotation between adjacent nozzles.

2. A rotor having disk-like end walls and intermediate concentric inner and outer cylindrical walls all rotating in unison, said cylindrical walls having approximately tangential nozzle passages, and each of said walls having all points on its outer and inner surfaces at equal radial distance respectively from the axis, whereby projections productive of retarding fan action are eliminated.

3. An elastic-fluid-impelled turbine, comprising a single rotor having internally inclosed chambers, and inclined nozzles arranged to conduct the working fluid from one chamber to the next, and finally entirely out of the rotor, the partitions between the chambers being of uniform thickness and containing the nozzles entirely between their bounding surfaces.

4. In an elastic fluid turbine, a rotor having a plurality of inclosed chambers, a hollow trunnion for admitting the working fluid to one of said chambers and nozzles arranged between the successive chambers and entirely inclosed within the walls thereof, in directions approaching the path of rotation to drive the rotor by reaction of the working fluid.

5. A multi-stage reaction turbine, comprising a rotor having a series of closed chambers in its interior, means for admitting steam to one of said chambers, a nozzle through which the steam is discharged into the next chamber in such a direction as to drive the rotor by its reaction, and a discharge nozzle arranged to permit escape of the steam from such chamber tangentially, to impart a further driving force to the rotor, the discharge orifice of such nozzle being in the outer surface of the chamber wall.

6. A turbine comprising a rotating member provided with a plurality of sets of passages arranged concentrically of the axis of rotation, said passages having their outlet ends arranged to discharge in a direction approaching the path of rotation, whereby to drive the rotating member by reaction of the working fluid, the spaces between the sets of passages being chambers entirely closed except for such passages, and each being of uniform cross-sectional area at all points, and means for admitting working fluid to the rotating member and causing such fluid to pass successively through the passages and chambers.

7. A multi-stage reaction turbine having an inlet and a plurality of sets of outlet passages at different distances from the inlet, and receiving chambers between the sets, each receiving chamber being of uniform cross-sectional area at all points.

8. A steam turbine comprising a rotary member having a series of inclosed chambers in its interior, each of which is of uniform diameter at all points, and partitions between the successive chambers, said partitions having inclined passages for the flow of steam from one chamber to the next, which passages are contained wholly between the inner and outer surfaces of the partitions, and means for admitting steam to the central chamber.

9. A turbine, comprising a rotary disk having in its interior a central chamber and co-axial annular chambers, said chambers being entirely inclosed by the ends or faces of the disk and being separated one from another by circular partitions, said partitions having inclined passages to permit working fluid to pass from one chamber to the next and to impart rotating pressure in thus passing, and the partitions being smooth on their outer surfaces.

10. A multi-stage reaction steam turbine comprising a rotor having axially alined trunnions, one of which is tubular for admitting steam at its axis and having means for expelling the steam tangentially at a distance from the axis, said rotor having also a receiving chamber into which the steam discharged from the discharge means is contained, said chamber being at a greater distance from the axis than the discharging means, said tangentially arranged discharging means having its outlet flush with the wall of the inner chamber, for permitting steam to pass from said chamber and to impel the rotor in so passing.

11. A reaction turbine consisting of a rotating element having alined trunnions, and having inner and outer cylindrical walls concentric with the axis of said trunnions separated from one another by intermediate annular spaces, the innermost wall surrounding a space in the center of the rotating element, one of said trunnions having a passage communicating with said central space and the several cylindrical walls having substantially tangential outlet passages.

12. A reaction turbine comprising a series

of spaced parallel revoluble diaphragms having substantially smooth surfaces, nozzle perforations extending through and located entirely within the boundaries of said diaphragms and a casing revoluble with and marginally closing the spaces between said diaphragms.

In testimony whereof I have affixed my signature, in presence of two witnesses.

GEORGE O. GRIDLEY.

Witnesses:
W. J. SAXIE,
RUTH P. KEYES.