No. 868,653

PATENTED OCT. 22, 1907.

R. H. GOLDSBOROUGH.

TURBINE.

APPLICATION FILED MAR. 28, 1906.

3 SHEETS—SHEET 1.

FIG 1

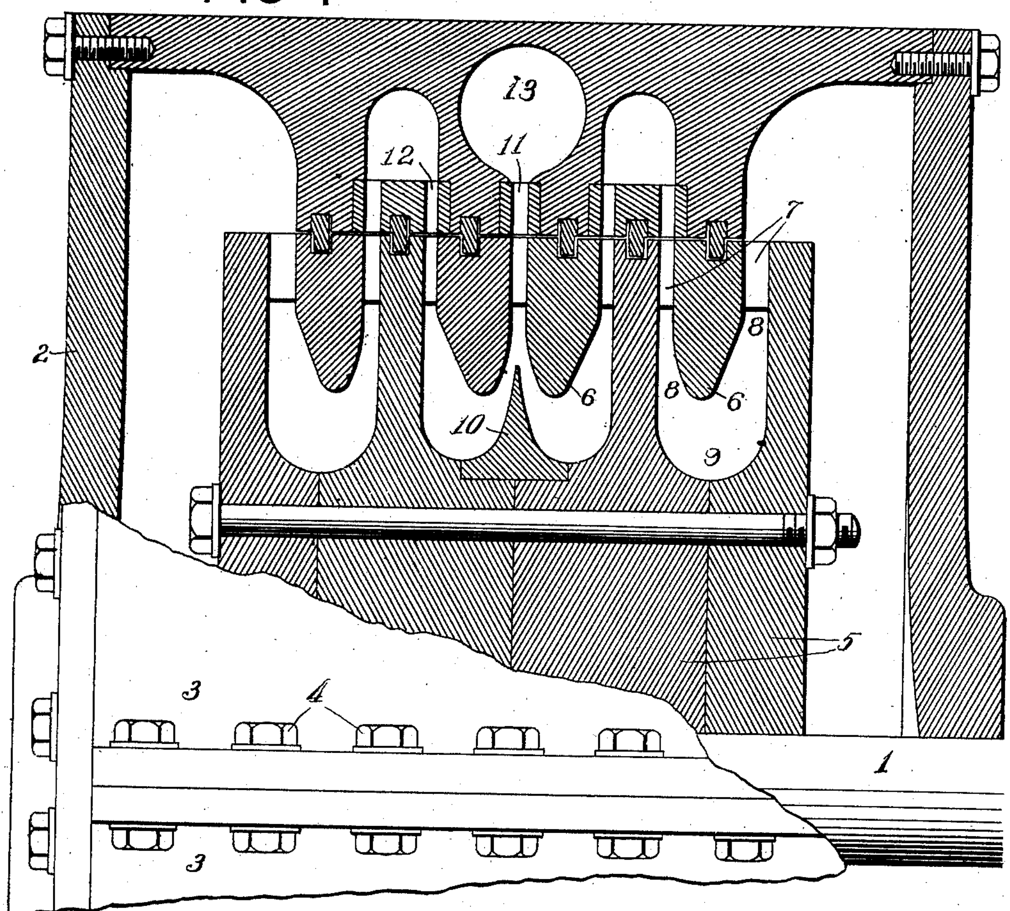
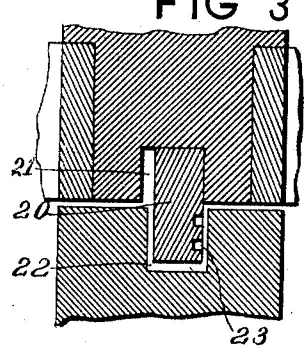


FIG 3



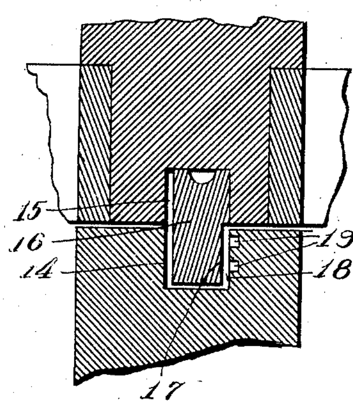


FIG 2

Witnesses

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3 SHEETS—SHEET 2.

FIG 4

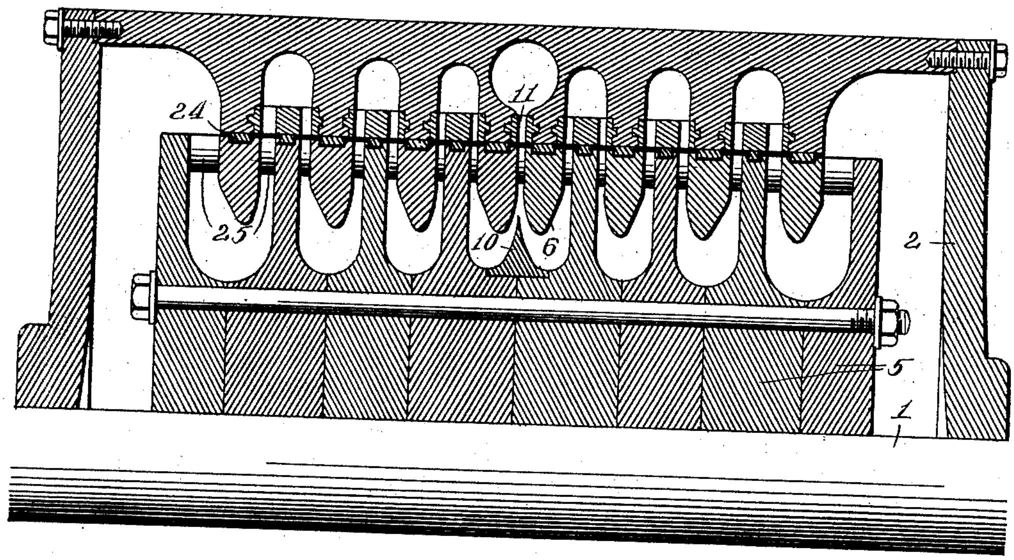


FIG 5

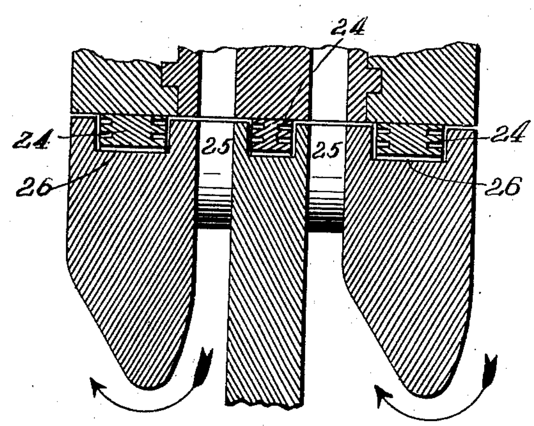
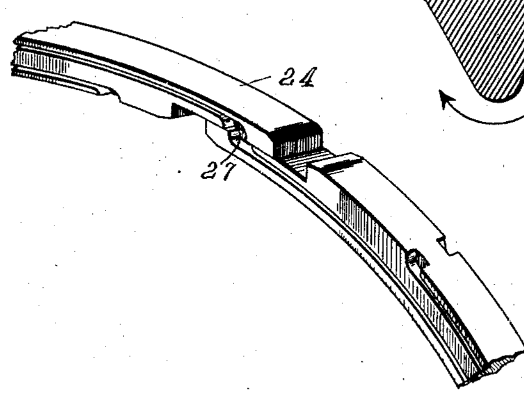


FIG 6



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3 SHEETS—SHEET 3.

FIG 7

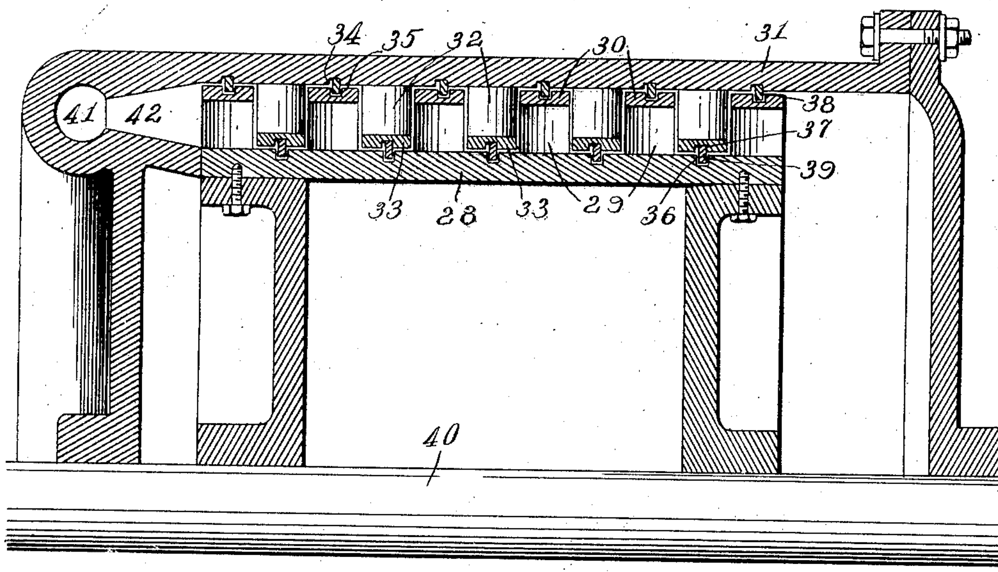
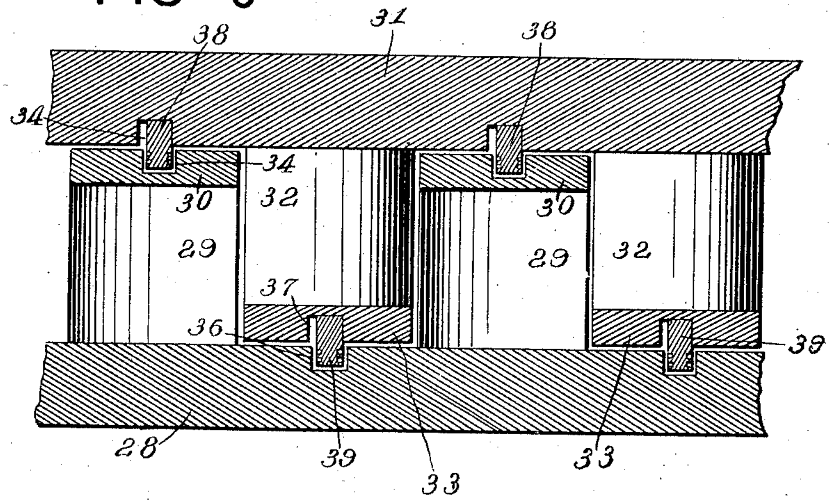


FIG 8



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UNITED STATES PATENT OFFICE.

RICHARD H. GOLDSBOROUGH, OF WASHINGTON, DISTRICT OF COLUMBIA.

TURBINE.

No. 868,653. Specification of Letters Patent. Patented Oct. 22, 1907.

Application filed March 28, 1906. Serial No. 308,594.

To all whom it may concern:

Be it known that I, Richard H. Goldsborough, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Turbines, of which the following is a specification.

My invention relates to turbines, and it consists in the constructions, combinations and arrangements herein described and claimed.

An object of my invention is to provide a simple and durable means for controlling the clearance between the rotor and stator of a turbine, whereby an efficiently small clearance can be maintained without danger of wear or binding of the parts during operation.

A further object of my invention is to provide a construction capable of being quickly and conveniently stripped and assembled.

In the accompanying drawings forming a part of this application, and in which similar reference symbols indicate corresponding parts in the several views, Figure 1 is a vertical, axial sectional view, illustrating one embodiment of my invention applied to a radial-flow turbine, part of the turbine casing being shown in elevation; Fig. 2 is a detail sectional view, on a larger scale, showing one of the clearance rings of Fig. 1, with the coöperating parts of the rotor and stator; Fig. 3 is a view similar to Fig. 2, illustrating a slight modification; Fig. 4 is a vertical, axial view, illustrating a modified embodiment of my invention applied to a radial-flow turbine; Fig. 5 is a detail sectional view, on a larger scale, clearly showing the construction of two of the annular series of vanes situated to the left of the central series in Fig. 1; Fig. 6 is a detail perspective view, illustrating a preferred arrangement of spiral grooves in the clearance ring; Fig. 7 is a vertical, axial sectional view, illustrating one application of my invention to an axial-flow turbine, and Fig. 8 is a detail sectional view, on a larger scale, clearly showing the construction of several of the annular series of vanes and the intermediate directing passages or nozzles.

Referring especially to Figs. 1, 2 and 3 of the drawings, 1 indicates a turbine shaft journaled in the heads 2 2 of a turbine casing 3; said casing being shown formed of semi-cylindrical portions secured together by bolts 4. A rotor, secured to the shaft 1, is shown comprising a series of disk members 5 and outer annular members 6. A plurality of annular series of vanes 7 are secured between the disks and annular members of the rotor and circumscribe annular passages 8 which are connected in pairs by annular chambers 9; a deflector 10 being arranged within the central, or initial, annular series of vanes for deflecting the discharge from said series laterally in both directions. The cylindrical portion of the turbine casing 3 is provided with annular series of ports 11 for directing the steam at an efficient angle against the alternate annular series of vanes, and with annular series of abutments 12 for receiving the outward discharge from the intermediate annular series of vanes. In the operation of this construction, steam is supplied to an annular steam chest 13, and is directed by the central series of ports through the initial, or central, annular series of vanes. The discharge from such series is deflected laterally in both directions by the deflector 10, and directed outwardly through the adjacent series of vanes. The steam is discharged outwardly through these vanes against the annular series of abutments 12; after which it is directed by the ports 11 against the next series of vanes, and finally led by the circumscribed passages 8 and connecting chambers 9 outwardly through the final series of vanes. The steam expands during its passage through the turbine, and the steam pressure at any series of vanes is less than the pressure at the next preceding series of vanes; thereby enabling the total expansion to be divided into steps proportionate to the number of annular series of vanes through which the steam successively passes.

The practical operation of turbines has demonstrated that the efficiency of operation depends primarily upon the maintenance of a small clearance between the rotor and stator. This has been found impracticable in existing turbines, since the expansion and deflection of the parts during operation necessitates a large clearance in order to prevent rubbing and binding. In my improved construction, a sufficiently large clearance is provided between the rotor and stator to obviate any danger of interference or rubbing between the parts; no attention being paid, in the first instance, to obtaining an efficient degree of clearance.

The rotor and stator are provided with coöperating annular channels, or recesses, 14 and 15 between the several annular series of vanes 7. A clearance ring 16 is loosely mounted in each pair of coöperating annular channels, the ring being of less axial thickness than said channels to permit of its automatic axial adjustment therein under the pressure of the operating steam and the action of the rotating parts.

In the construction illustrated in Figs. 1 and 2, the annular channels in the rotor and stator are arranged with their side walls in registry, and the clearance ring has an annular recess 17 formed in its side furthest removed from the steam inlet to the turbine; said recess preferably extending axially across the portion of the clearance ring projecting from the channels 15 in the stator. The radial face 18 of the channel 14 adjacent to the recess 17 is provided with suitable grooves 19, preferably of either spiral or annular form, which provide a passage for any steam leaking past the clearance ring. It will thus be seen that the grooves 19 act as packing grooves for retarding the leakage of steam, and also that the steam in said grooves will exert a cushioning action tending to prevent injurious contact of the clearance ring with the wall 18.

In assembling the turbine, the clearance rings 16 are sprung, or otherwise placed, in the annular channels 14 of the rotor, and the rotor then positioned in the lower semi-cylindrical portion 3 of the casing. The upper semi-cylindrical portion 3 is then placed in position, and the heads 2 and portions 3 finally bolted together.

In the normal operation of the turbine, the step-by-step expansion of the steam during its passage through the successive annular series of vanes causes an excess of steam pressure against the sides of the clearance rings toward the initial series of vanes through which the steam is first admitted to the turbine. Such excess of steam pressure tends to maintain the several clearance rings against the sides of the annular channels 15 in the stator furthest removed from the steam inlet to the turbine, as shown clearly in Figs. 1 and 2. In this position of the parts, any steam leakage between two adjacent stages, or series of vanes, would have to follow a path around that portion of the interposed clearance ring 16 which extends within the annular channel 14 in the rotor. Such passage of the steam would be first resisted by centrifugal action upon its entrance into the channel 14 of the rotor, and further resisted by the difficulty of flowing through the small clearance maintained between the grooved wall 18 of said channel and the adjacent face of the clearance ring.

From the above description, it will be clear that any contact between the wall 18 and the clearance ring will act to shift said ring axially in its channels 14 and 15, thereby preventing injurious pressure between the contacting surfaces while insuring the maintenance of an efficiently small clearance therebetween. Further, should excessive expansion or other operative condition cause the wall 18 of the channel 14 to recede from the clearance ring, such condition would simultaneously cause the opposite wall of the channel 14 to approach the clearance ring; the clearance at one side of the ring 16 being thus decreased as the other is increased. This provides a very satifsactory construction in which an efficiently small clearance is automatically maintained between the rotor and the sides of a clearance ring mounted for free axial adjustment; thus permitting the clearance rings and the casing to be spaced a sufficient radial distance from the rotor to obviate any danger of contact or rubbing against the rotor's periphery through expansion and deflection of the parts during operation.

Fig. 3 shows a slight modification, in which the clearance ring 20 is formed of substantially uniform axial width throughout, and the annular channels 21 and 22 in the stator and rotor are positioned slightly out of registry. In this modification, packing grooves 23 are formed in the clearance ring, instead of in the wall of the annular channel 22.

Figs. 4, 5 and 6 illustrate a modified construction, in which clearance rings 24 are loosely mounted in annular channels formed in the rotor between the several annular sets of vanes 25. As shown especially in Fig. 5, these rings are constructed to fit snugly against the inner periphery of the casing and to be spaced a sufficient distance 26 from the bottoms of their channels to prevent danger of contact against their inner peripheries.

A preferred construction is to employ split clearance rings of resilient material; whereby the rings will be maintained by their resiliency in contact with the inner periphery of the casing. Fig. 6 shows such a resilient ring provided with a spiral groove in each of its side faces; said grooves being widened circumferentially where they are intersected by the overlapping faces 27 of the ring ends, for maintaining a free passage through said grooves during contraction or expansion of the ring.

Figs. 7 and 8 illustrate a satisfactory application of my invention to a turbine of the axial-flow type. In this construction, a rotor drum 28, secured to the shaft 40, carries on its periphery a plurality of annular series of vanes 29, each of said annular series being provided with an outer annular shroud 30. The turbine casing 31 carries a plurality of stationary intermediates 32, which constitute passages, or nozzles, for receiving the discharge from each series of vanes and directing it at an efficient angle against the next succeeding vane series; said intermediates being provided with shrouds 33 at their inner ends. In this construction, the rotor and its series of vanes are sufficiently spaced from the stator and its intermediates to obviate any danger of wear or injurious contact of the rotating parts. Sets of coöperating annular channels 34 and 35 are formed in the casing and vane shrouds, and similar sets of coöperating channels 36 and 37 are provided in the rotor and nozzle shrouds. A clearance ring 38 is loosely mounted for free axial movement in each pair of the coöperating annular channels 34 and 35, said ring being supported in place by engagement of its outer periphery with the bottom of the channel 34 in the casing. A similar clearance ring 39 is positioned in each pair of coöperating channels 36 and 37, with its periphery engaging the bottom of the recess 37 in the stationary shroud 33 of the nozzles. I have found it very satisfactory to employ split clearance rings of resilient material, as shown in Fig. 6, said rings 38 and 39 being held in engagement, respectively, with the bottoms of the annular channels 34 and 37 by their own resiliency. In the operation of this construction, steam is supplied to an annular chest 41 and directed by a series of ports 42 at an efficient angle against the initial annular series of movable vanes 29, from which it is discharged successively through the following alternate series of stationary nozzles 32 and movable vanes 29. The steam expands gradually during its passage through the successive series of vanes and nozzles, thereby producing a gradual drop of steam pressure from the admission to the exhaust end of the turbine. Such fractional decrease in the steam pressure tends to maintain the clearance rings 38 and 39, respectively, against the sides of the stationary channels 34 and 37 toward the exhaust end of the turbine; and the function and operation of said rings is similar to that described in the constructions shown in Figs. 1, 2 and 3.

I have illustrated and described satisfactory and preferred constructions, but obviously changes could be made within the spirit and scope of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a turbine, the combination of a rotor, a stator, and clearance members mounted for free axial movement in

one of said parts and in frictional engagement with the other of said parts, substantially as described.

2. In a turbine, the combination of a rotor and stator provided with coöperating channels, and clearance members mounted for free axial movement in said coöperating channels, substantially as described.

3. In a turbine, the combination of a rotor and stator, and split rings of resilient material mounted for free axial movement on one of said parts in frictional engagement with the other of said parts, substantially as described.

4. In a turbine, the combination of a rotor and stator, and split rings of resilient material engaging said rotor and mounted for free axial movement, substantially as described.

5. In a turbine, the combination of a stator, a rotor provided with channels, and split rings of resilient material engaging the stator and extending within said channels in the rotor, said rings formed of less axial thickness than the channels and provided with grooves in their side faces, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

RICHARD H. GOLDSBOROUGH.

Witnesses:
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EDWIN S. CLARKSON.