No. 794,613. PATENTED JULY 11, 1905.

R. H. GOLDSBOROUGH.

TURBINE.

APPLICATION FILED SEPT. 6, 1904.

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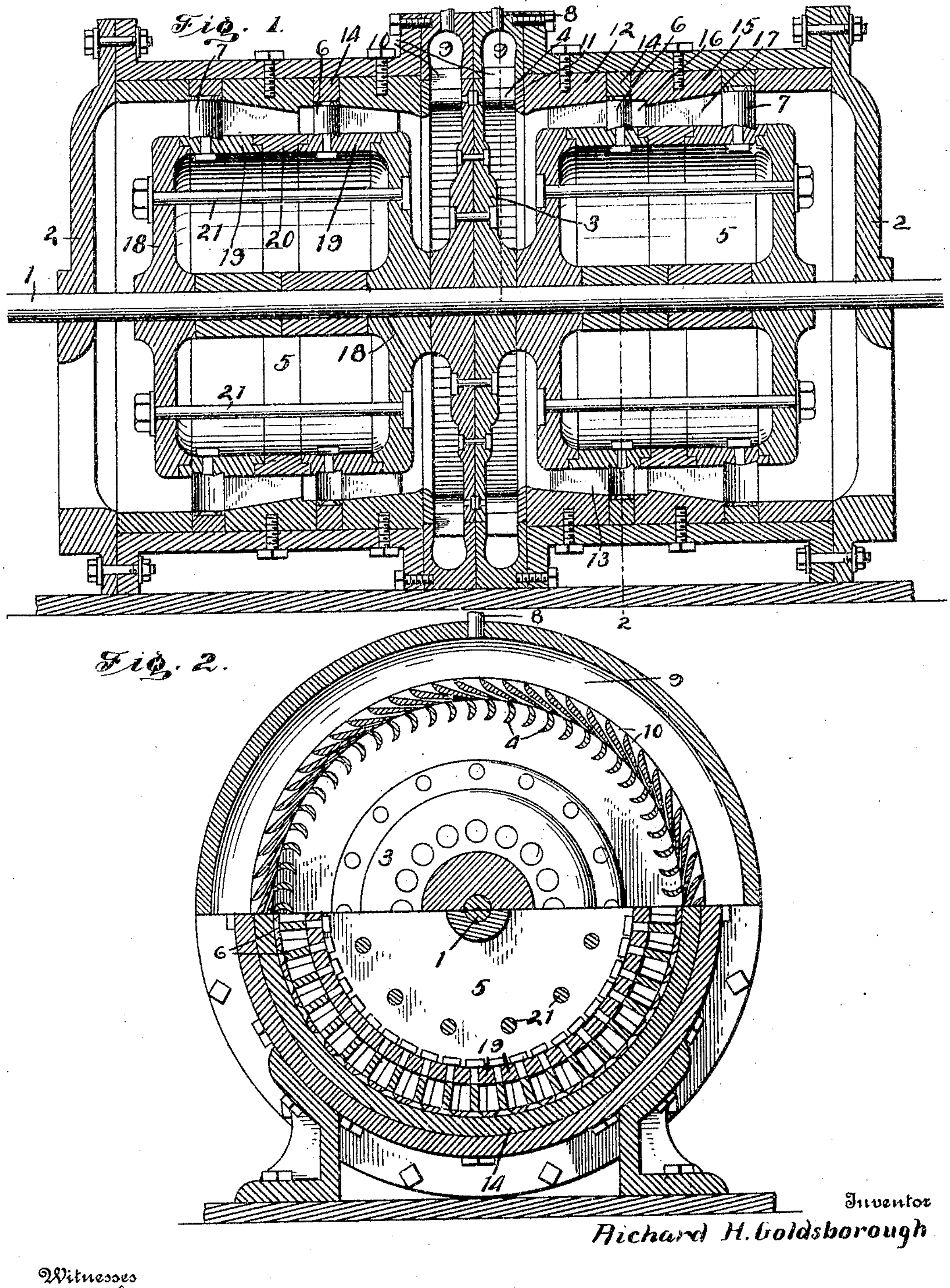

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5 SHEETS—SHEET 2.

Fig. 4.

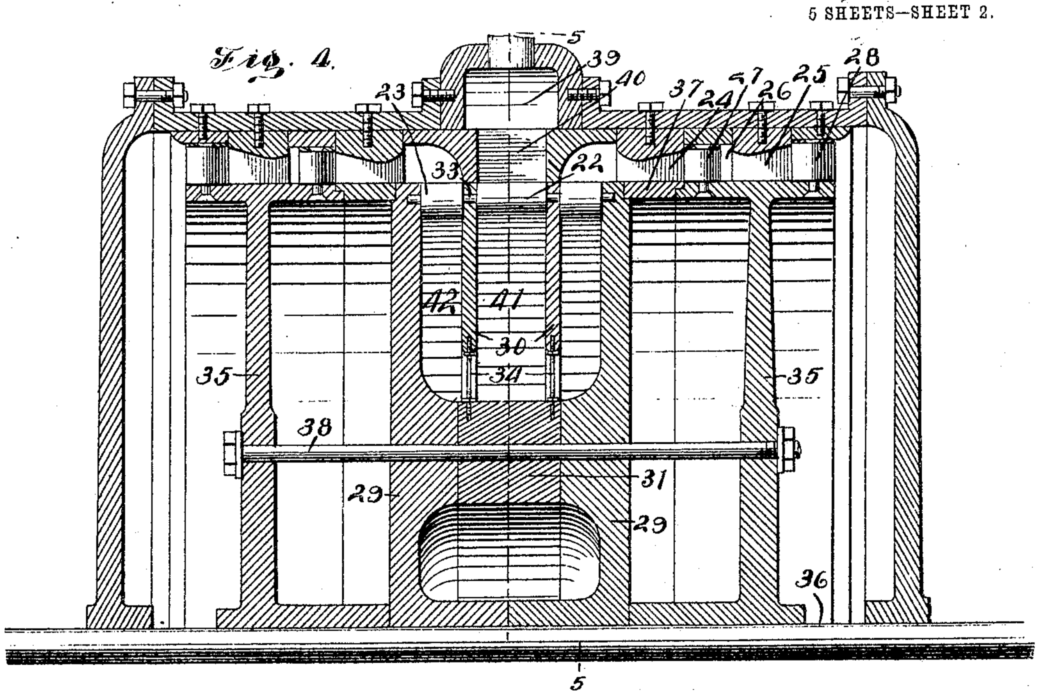
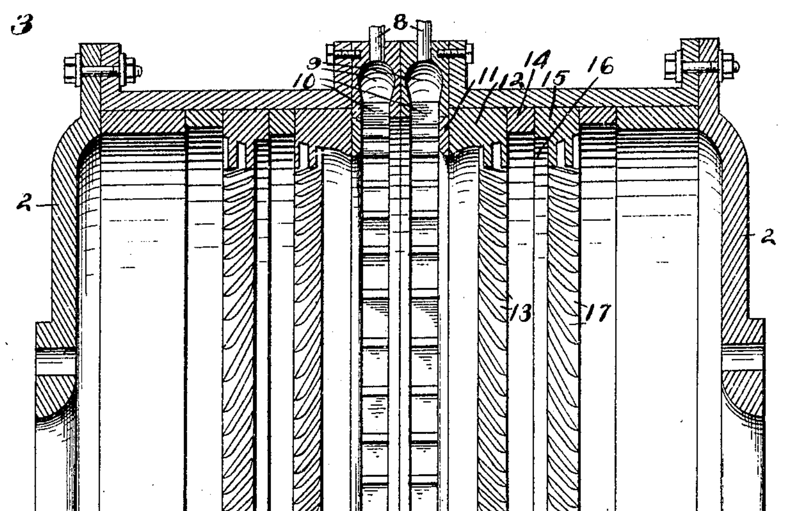


Fig. 3



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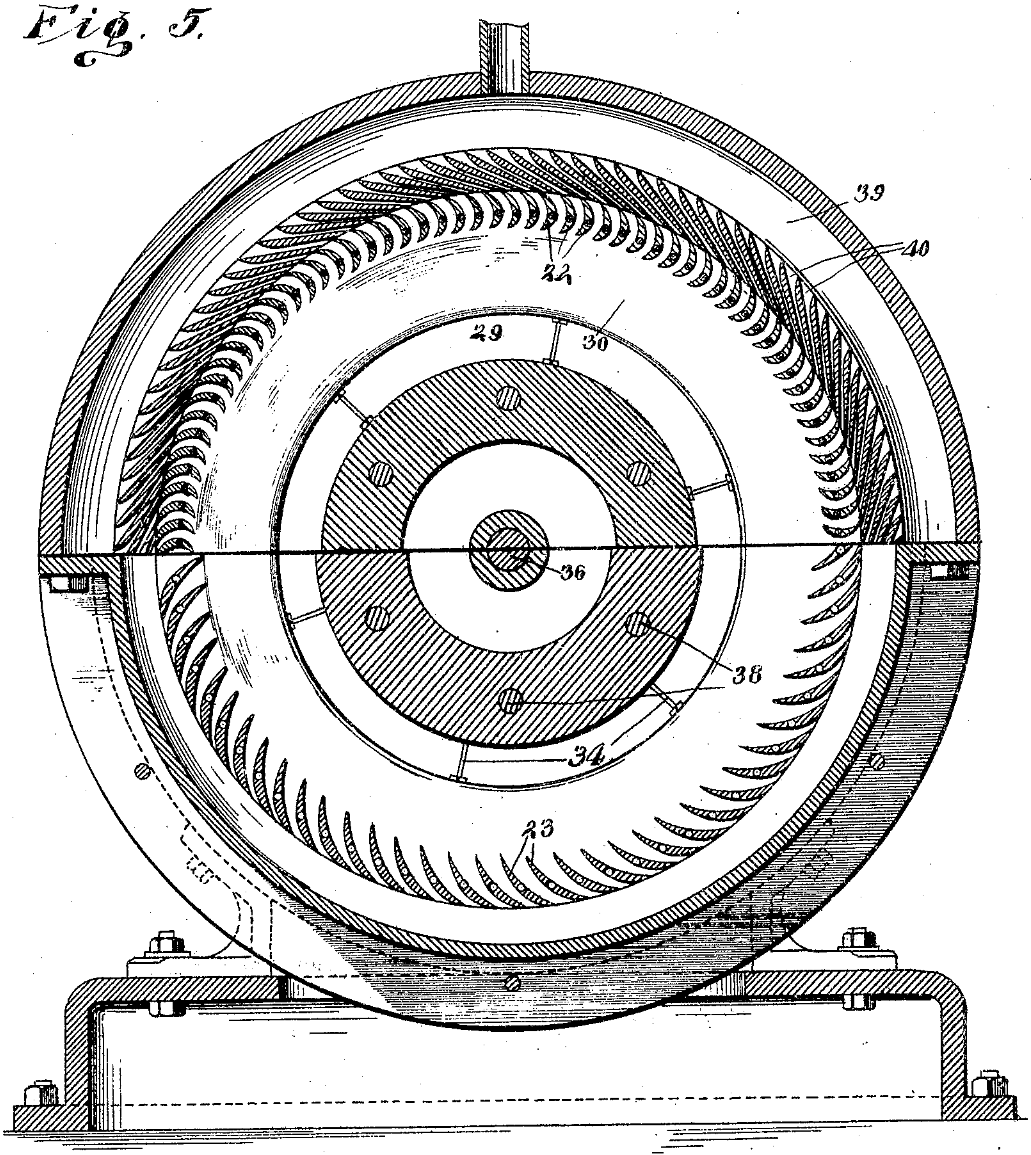
5 SHEETS—SHEET 3.

Fig. 5.



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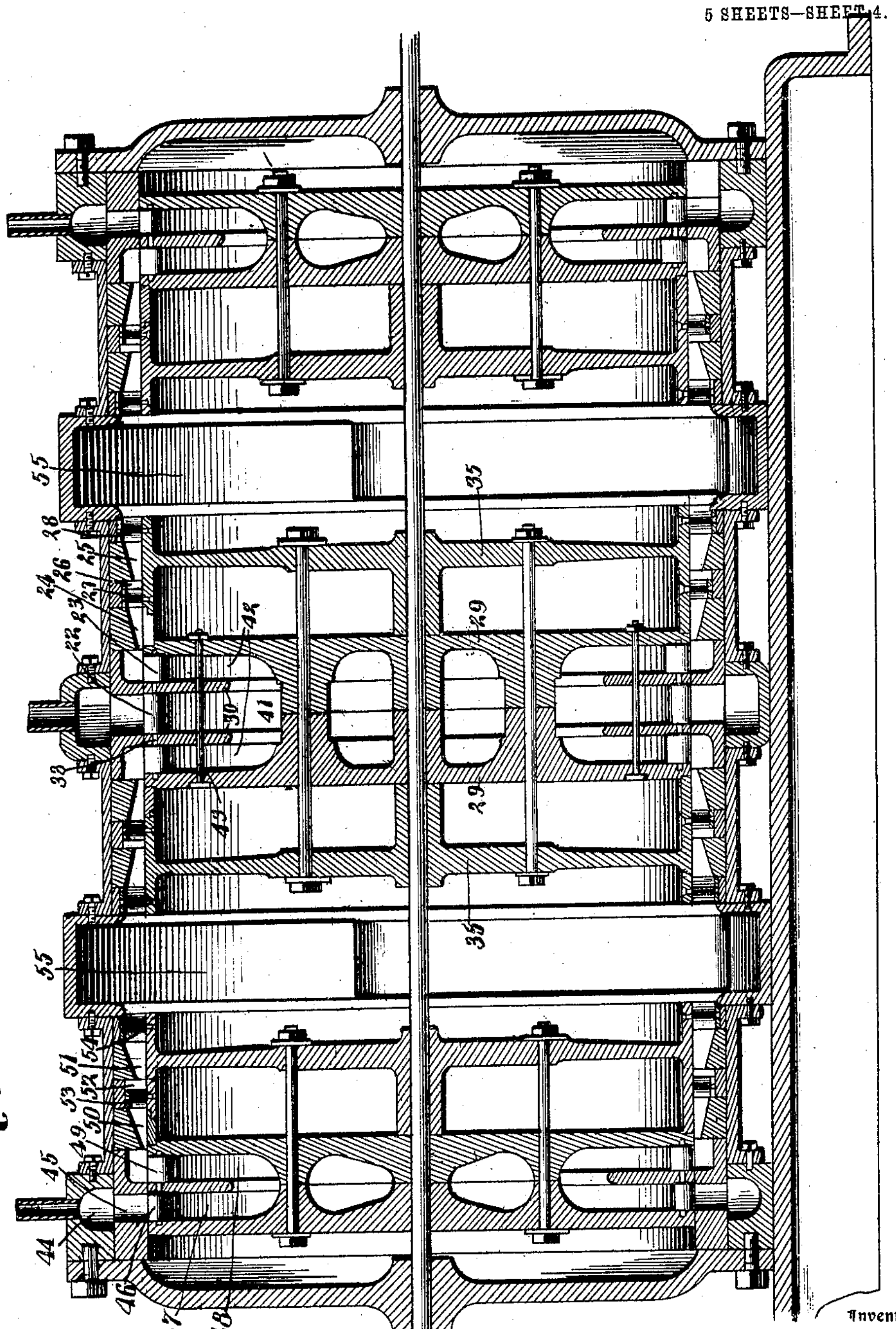

Fig. 6.

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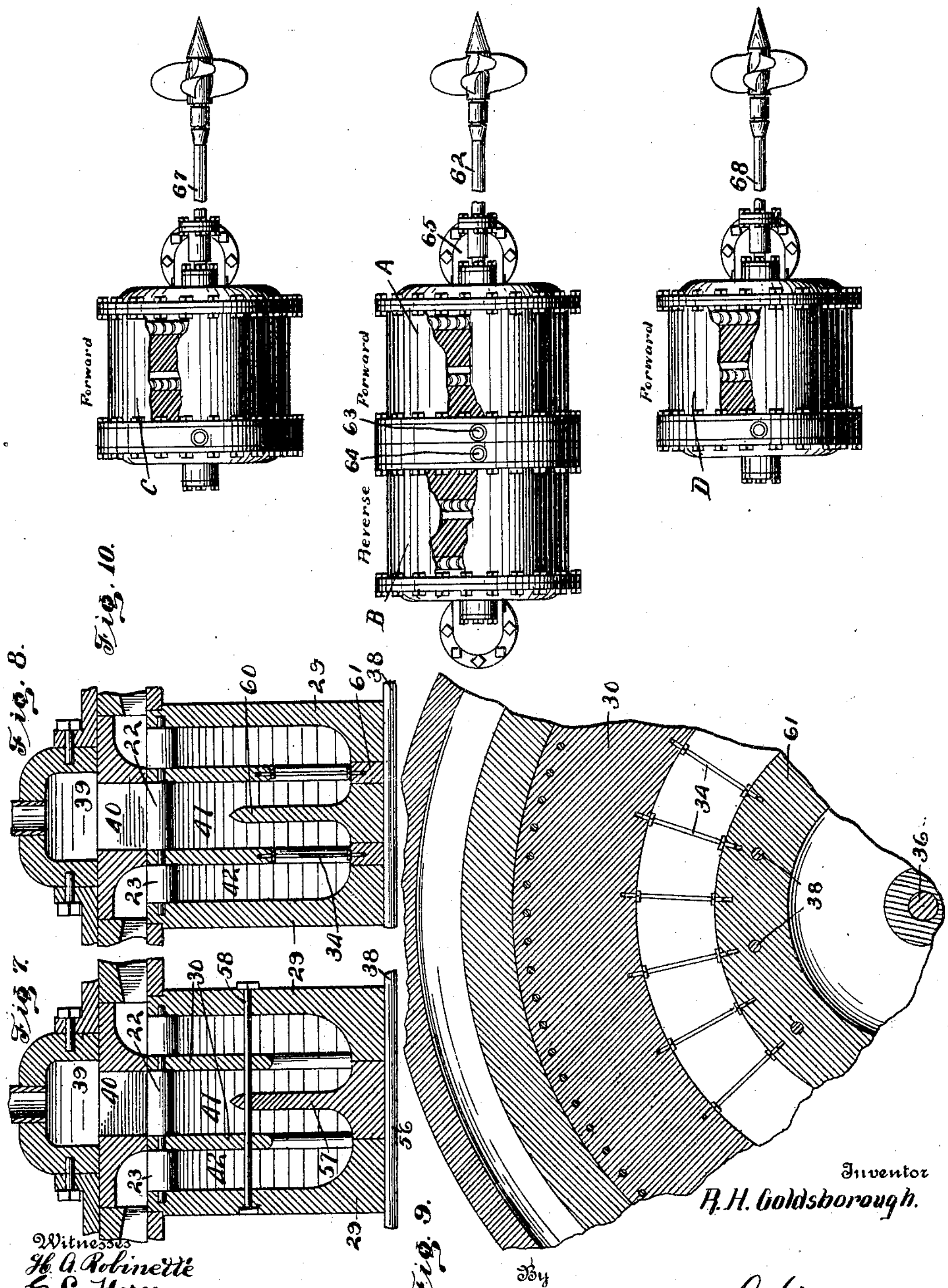
5 SHEETS—SHEET 5.



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No. 794,613. Patented July 11, 1905.

UNITED STATES PATENT OFFICE.

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

TURBINE.

SPECIFICATION forming part of Letters Patent No. 794,613, dated July 11, 1905.

Application filed September 6, 1904. Serial No. 223,429.

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 compound types of turbines; and it consists in the parts, constructions, and combinations herein described and claimed.

My invention relates particularly to a compound turbine in which the energy of the steam is utilized in fractional parts, partially kinetically and partially in the form of pressure, to produce high efficiency at low rotation speeds.

The objects of my invention are to provide a construction in which the well-known losses occurring during the expansion and regeneration of steam will be minimized and in which harmful friction of the actuating-steam passing through the turbine will be largely eliminated, thus insuring a construction capable of a highly efficient and economical operation.

A further object of my invention is to provide a perfectly-balanced construction free from axial thrust along the shaft during normal operation and in which the action of the steam will tend to prevent deflection of the shaft intermediate of its bearings.

A further object of my invention is to provide a construction in which portions of the actuating-steam can be cut off without in any way throttling or affecting the operation of the remaining steam-supply, thereby permitting operation at maximum efficiency under great variations of load.

Referring to 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. Fig. 2 is a sectional view on the line 2 2 of Fig. 1. Fig. 3 is a view similar to Fig. 1 with the rotating parts removed from the casing. Fig. 4 is a vertical axial sectional view illustrating a modified construction. Fig. 5 is a sectional view, on a smaller scale, taken on the line 5 5 of Fig. 4. Fig. 6 is a vertical axial sectional view illustrating a further modification of my invention. Figs. 7 and 8 are detail sectional views, on an enlarged scale, illustrating preferred constructions of the central turbine-wheel shown in Fig. 4. Fig. 9 is a sectional view on the line 9 9 of Fig. 8; and Fig. 10 is a plan view, partly in section, illustrating more or less diagrammatically a preferred arrangement of turbines for driving the three propeller-shafts of a ship.

Referring especially to Figs. 1, 2, and 3 of the drawings, 1 indicates a turbine-shaft suitably journaled in the end members 2 of a turbine-casing. The shaft carries a central turbine-wheel 3, provided with an annular series of vanes 4, extending axially from its opposite faces, and two side wheels or drums 5, each of which carries a plurality of annular series of vanes 6 and 7, extending radially from its periphery. A suitable number of supply-pipes 8 are provided for supplying steam to two annular steam-chambers 9 in the turbine-casing, from which the steam is directed by the admission ports or nozzles 10 at an efficient angle against the outer periphery of the annular series of vanes 4. The outer ends of each of the annular series of vanes 4 carry a flat ring or shroud 11, which is positioned with its outer face in close relation to an annular member 12. The member 12 is provided with a plurality of passages 13, extending through its inner periphery and constructed to direct the steam at an efficient angle against the annular series of vanes 6. As shown in Figs. 1 and 3, the inner sides of the passages 13 are closed by the adjacent periphery of the corresponding drum 5; but obviously the member 12 could be provided with means for closing the inner sides of such passages. A spacing-ring 14 is positioned in the turbine-casing between the annular member 12 and the analogous annular member 15, which latter member is provided with an annular chamber 16 for receiving the steam discharged through the vanes 6 and with a plurality of passages 17, arranged to direct the steam from the chamber 16 at an efficient angle against the annular series of vanes 7. The steam discharged through the vanes 7 may be conducted through a further annular series of vanes by means of a discharge-chamber and plurality of passages similar to those just described, or it may exhaust directly into the turbine-casing, as shown in the drawings. The drums 5 are shown comprising two end members 18, vane-carrying rings 19, and a spacing-ring 20, securely clamped together by a series of bolts 21.

In the operation of my invention steam is maintained at any desired pressure within the annular chamber 9, from which it is directed by the admission-ports 10 at an efficient angle against the outer periphery of the annular series of vanes 4. The ports 10 are preferably constructed to provide for a comparatively small expansion of the steam flowing therethrough, whereby the steam impinges on the vanes 4 at a relatively low velocity, and thus permits its kinetic energy to be efficiently utilized at a low peripheral speed of the turbine. The steam is discharged from the vanes 4 into the annular chamber or passage between the central wheel 3 and the contiguous end member 18 of the adjacent drum 5, from which it is discharged through the lateral passages 13 against the annular series of vanes 6. It will be clear that the cross-section of said annular chamber measured across cylindrical surface concentric with the annular series of vanes 4 decreases in approaching the center of the wheel and that the steam discharged from the vanes into the annular chamber will pass successively through portions thereof of decreasing cross-section. This gradual decrease in the section of the steam-passage tends to transform a portion of the kinetic energy remaining in the steam after its deflection from the vanes 4 into pressure and to produce a material regeneration of the steam-pressure at the largest cross-sectional portion of the annular chamber, which exists adjacent to the inner edges of the annular series of vanes 4. The zone or ring of high steam-pressure thus maintained adjacent to the inner edges of the vanes acts in a very efficient manner to produce a strong reaction of the steam in its passage from the vanes and greatly augments the rotative effect of the steam passing through the vanes. The steam discharging from the annular chamber through the lateral passages 13 passes through a portion of said annular chamber having a relatively large cross-section adjacent the entrance-orifices of said passages 13, causing a regeneration of the steam-pressure adjacent the entrance-orifices and maintaining a relatively high pressure and low velocity of the steam at said orifices. The steam maintained at a relatively high pressure at the entrance-orifices of the lateral passages 13 is expanded through any desired degree in said passages and directed thereby at an efficient angle against the annular series of vanes 6. The vanes 6 discharge into the annular chamber 16, which supplies the entrance-orifices of a plurality of lateral ports 17, the cross-section of said chamber 16 measured across the path of the steam being preferably formed greater than the aggregate cross-section of the orifices of the passages 17. This proportioning of the parts provides a construction in which a portion of the kinetic energy of the steam discharged from the vanes 6 will be transformed into pressure, thus producing a material regeneration of the steam-pressure in said chamber, where it will act to effect an efficient reaction on the vanes 6 of the steam discharging therefrom. The steam which has had its pressure regenerated in the annular chamber 16 is then finally expanded through the plurality of lateral ports 17, which are constructed to direct it at an efficient angle against the annular series of vanes 7, from which it is discharged into the end of the turbine-casing, which constitutes an exhaust-chamber in communication with the atmosphere or with a condenser. As shown especially in Fig. 1, the cross-section of the exhaust-chamber increases immediately at the end of the drum 5, thus constituting, in effect, a divergent exhaust-passage which will act to produce a free flow of steam through the vanes 7 and to maintain the steam at a low density adjacent the discharge edges of said vanes.

I have described a construction in which each drum 5 carries two annular series of vanes; but obviously a greater or less number of series could be employed, if desired.

Figs. 4 and 5 illustrate a modified construction in which the steam is discharged radially inward through a central annular series of vanes 22 and then passes radially outward through two annular series of vanes 23, arranged at the respective sides of said vanes 22. The vanes 22 are preferably constructed to utilize the energy of the steam mainly in the form of kinetic energy, and the vanes 23 are suitably formed to be actuated chiefly by the pressure or reaction of the steam passing therethrough, as clearly shown in Fig. 5. The vanes 22 and 23 are shown carried between two disks 29 and interposed annular partitions 30, which latter are arranged to extend within an annular chamber, the side walls and inner wall of which are formed by said disks and by an annular spacing member 31 clamped therebetween. As shown especially in Fig. 4, the partitions 30 divide the annular chamber into three subsidiary annular chambers 41 and 42. Fig. 4 illustrates a satisfactory construction in which the vanes 22 are provided with extensions or bolts 33, arranged to extend through apertures in the partitions 30 and vanes 23, with their ends seated in recesses in the disks 29. The partitions 30 are shown with their inner ends secured to the spacing member 31 by tie-rods 34. Disks 35, carried by the turbine-shaft 36 adjacent the disks 29, are provided with a plurality of annular series of vanes 27 and 28. Spacing-rings 37 are positioned between the disks 35 and 29, and clamping-bolts 38 are shown for clamping said several disks and spacing-rings together. In the operation of this construction steam flows from the annular steam-chamber 39 through the admission-ports 40, which are constructed to provide for any desired degree of expansion therein and to direct the steam at an efficient angle about the outer periphery of the annular series of vanes 22. The ports 40 are preferably constructed to provide for a comparatively limited expansion of the steam flowing therethrough, whereby the steam acquires a relatively low velocity permitting its kinetic energy to be efficiently utilized at a low peripheral speed of the vanes 22. The steam is discharged from the vanes 22 into the annular chamber 41, from which it passes laterally in both directions to the annular chambers 42, which conduct it to the inner peripheries of the two annular series of vanes 23. It will be clear that the cross-sections of the annular chambers 41 and 42, measured across cylindrical surfaces concentric with the annular series of vanes 22 and 23, are greatest adjacent the inner edges of said vanes and decrease uniformly in approaching the turbine-shaft and that the steam discharged inwardly through the annular chamber 41 will pass successively through portions thereof of decreasing cross-section, while the steam conducted outwardly through the annular chambers 42 will pass successively through portions thereof having increasing cross-sections. The steam in passing through the successively-decreasing cross-sections of the annular chamber 41 will have a portion of its kinetic energy transformed into pressure, with a resultant zone of relatively high pressure at the point of maximum cross-section adjacent the inner edges of the vanes 22. The zone of high pressure thus maintained adjacent the inner edges of the vanes 22 will produce an efficient reaction on said vanes of the steam discharging therefrom. The steam conducted radially outward through the annular chambers 42 to the vanes 23 will pass successively through sections of increasing cross-section, whereby a portion of its kinetic energy will be transformed into pressure and the maximum regeneration of pressure will occur adjacent the inner edges of the vanes 23, where the steam will be maintained in a condition of relatively high pressure and low velocity. The steam entering the vanes 23 at a relatively high pressure will pass therethrough with a rapidly-increasing velocity, whereby an effective rotative force will be exerted on said vanes by the pressure or reaction of the steam. The steam discharged outwardly from the vanes 23 is conducted through passages 24 and 25 and annular chambers 26 to the radially-extending annular series of vanes 27 and 28 in a manner similar to that described in reference to the sets of vanes 6 and 7 of Fig. 1. This construction provides an efficient type of compound turbine in which the excessive and well-recognized loss caused by successive expansions and regenerations of the steam are minimized, and I have above described my theory of its principle of operation.

Fig. 6 illustrates a modification in which the turbine-casing of the construction shown in Figs. 4 and 5 is extended to receive at each end an additional compound turbine-wheel carried by a common shaft 36 and to provide two exhaust-chambers intermediate said three turbine-wheels. The central wheel in this construction corresponds to the construction shown in Figs. 4 and 5 and has its parts designated by similar reference-numerals. It is modified to some extent, however, in that the inner portions of the partitions 30 are supported by bolts 43, which are secured to the disks 29 and take the parts of the tie-rods 34. (Shown in Fig. 4.) The compound turbine-wheels shown in the respective ends of the casing are duplicates and embody one-half of the construction shown in Fig. 4. In the operation the steam is conducted from an annular steam-chest 44 through admission-ports 45, which are constructed to direct it at an efficient angle against an annular series of vanes 46, carried by each end wheel. The steam is discharged from the vanes 46 into an annular chamber 47, from which it is conducted by an annular chamber 48 to reaction-vanes 49 in a manner identical with that described in reference to similar vanes 22 23 and annular chambers 41 and 42 of Figs. 4 and 5. The steam discharged from the vanes 49 is directed by lateral passages 50 51 and annular chambers 52 through successive annular series of vanes 53 and 54 in a manner similar to that fully described in reference to the sets of vanes 27 and 28 of Figs. 4 and 5. In this construction the steam-supply can be cut off from any one or more of the three compound turbine-wheels to provide for efficient operation under great ranges of load, and the intermedially-arranged exhaust-chambers 55 will act to maintain a low density about said idle wheels, thereby minimizing the harmful resistance of their rotating parts.

Fig. 7 illustrates an alternative construction of the central portion of the turbine-wheel shown in Fig. 4, in which a spacing member 56 between the disks 29 is provided with an annular partition 57, which extends medially within the annular chamber 41 to a point beyond the inner edges of the partitions 30. The partition 57 insures an equal flow of the steam from the chamber 41 to the two side chambers 42 and also provides a rigid support for the middle of a bolt 58, which is secured to the disk 29 and supports the inner edges of the partitions 30.

Figs. 8 and 9 illustrate a further modification in which the two disks 29 are separated by a spacing member 59, carrying a central annular partition 60, extending within the chamber 41, and by two retaining-rings 61, to which are secured the tie-rods 34 for supporting the inner edges of the partitions 30.

Fig. 10 illustrates more or less diagrammatically a preferred arrangement of turbines for driving the three propeller-shafts of a ship. In this construction the central propeller-shaft 62 carries two independent turbines A and B, which may be of a construction similar to one of the end compound wheels shown in Fig. 6 or may comprise one-half of the construction shown in Fig. 1. The ports and vanes of the turbine A are constructed to rotate the propeller-shaft in the direction required for propelling the ship forward, and the turbine B is constructed to produce a reverse rotation of the propeller-shaft. The turbines A and B are provided, respectively, with independent steam-supply pipes 63 and 64 and exhaust-conduits 65 and 66 to permit the independent operation of either one while the other one is running idle. The side propeller-shafts 67 68 carry, respectively, turbines C and D, which are similar to the turbine A and constructed to rotate their shafts in the direction required for producing a forward movement of the ship. It will be seen that this provides a very satisfactory construction and arrangement in which the steam actuating the turbines A, C, and D will produce an axial thrust along the several propeller-shafts in a direction opposed to the axial thrust exerted by the propellers thereon, thus obviating the excessive frictional losses and other disadvantages entailed by use of extensive thrust-bearings. When it is desired to reverse the direction of the ship, the steam is cut off from the "forward" turbines A, C, and D and the reverse-turbine B is set in operation. The steam operating the turbine B passes therethrough toward the left and produces an axial thrust along the propeller-shaft 62 in a direction opposed to the axial thrust exerted thereon by the propeller when revolving in its reverse direction, thereby providing a construction in which opposed axial thrusts are exerted on the propeller-shafts upon both the forward and reverse motion of the ship.

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 turbine-shaft, an initial wheel carried by said shaft and provided with annular series of axially-extending vanes circumscribing a common inner annular chamber, turbine-wheels carried by said shaft laterally to said initial wheel and provided with annular series of radially-extending vanes, means constructed to discharge a fluid medium radially inward through the annular series of vanes carried by the initial wheel into the common annular chamber circumscribed thereby, and means constructed to conduct the fluid medium radially outward from said annular chamber and to discharge the same through said radially-extending vanes, substantially as described.

2. In a turbine, the combination of a turbine-shaft, an initial wheel carried by said shaft, an annular series of axially-extending vanes carried on each side of said wheel and circumscribing an inner annular chamber, turbine-wheels carried by said shaft at each side of said initial wheel and provided with annular series of radially-extending vanes, independent means constructed to discharge a fluid medium radially inward through each annular series of vanes carried by the initial wheel into the inner annular chamber circumscribed thereby, and means constructed to conduct the fluid medium radially outward from said annular chambers and to discharge the same through the annular series of radially-extending vanes carried by the adjacent lateral wheels, substantially as described.

3. In a turbine-wheel, the combination of a turbine-shaft, an initial wheel carried by said shaft, and provided with annular series of radially-extending vanes circumscribing a common inner annular chamber, turbine-wheels carried by said shaft laterally to said initial wheel and provided with annular series of radially-extending vanes, means constructed to discharge a fluid medium radially inward through the annular series of vanes carried by the initial wheel into the common annular chamber circumscribed thereby, and means constructed to conduct the fluid medium radially outward from said annular chamber and to direct the same across the peripheries of said laterally-carried wheels at an efficient angle against said annular series of radially-extending vanes, substantially as described.

4. In a turbine, the combination of a turbine-wheel provided with an annular recess about its periphery, two annular partitions secured within said recess and constructed to divide the same into three annular passages communicating at their inner portions, three annular series of vanes carried by said wheel in position to circumscribe, respectively, said three annular passages of the annular recess, and means constructed to direct a fluid medium radially inward through the central of said annular series of vanes into the circumscribed annular passage, substantially as described.

5. In a turbine, the combination of a turbine-wheel provided with an annular recess about its periphery containing a radially-extending partition, two annular partitions arranged in said recess and constructed to divide it into three annular passages with communicating inner portions, and a common clamping means engaging said several partitions, substantially as described.

6. In a turbine, the combination of a turbine-wheel provided with an annular recess

about its periphery containing a radially-extending partition, two annular partitions arranged in said recess and constructed to divide it into three annular passages with communicating inner portions, and a plurality of clamping-bolts extending through said several partitions, substantially as described.

7. In a turbine, the combination of a turbine-wheel comprising two disk members, and an intermediate spacing member, constituting the side and bottom of an annular chamber, two annular partitions arranged in said chamber and constructed to divide it into three annular passages with communicating inner portions, an annular partition carried by said spacing member and constructed to extend within the central annular passage, and a plurality of clamping-bolts extending through said several partitions, substantially as described.

8. In a turbine, the combination of a turbine-wheel comprising two disk members, and an intermediate spacing member, constituting the sides and bottom of an annular chamber, two annular partitions arranged in said chamber and constructed to divide it into three annular passages with communicating inner portions, an annular partition carried by said spacing member and constructed to extend within the central annular passage, and a plurality of clamping-bolts extending through said several disk members and partitions, substantially as described.

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

RICHARD H. GOLDSBOROUGH.

Witnesses:
G. AYRES,
CHARLES LOWELL HOWARD.