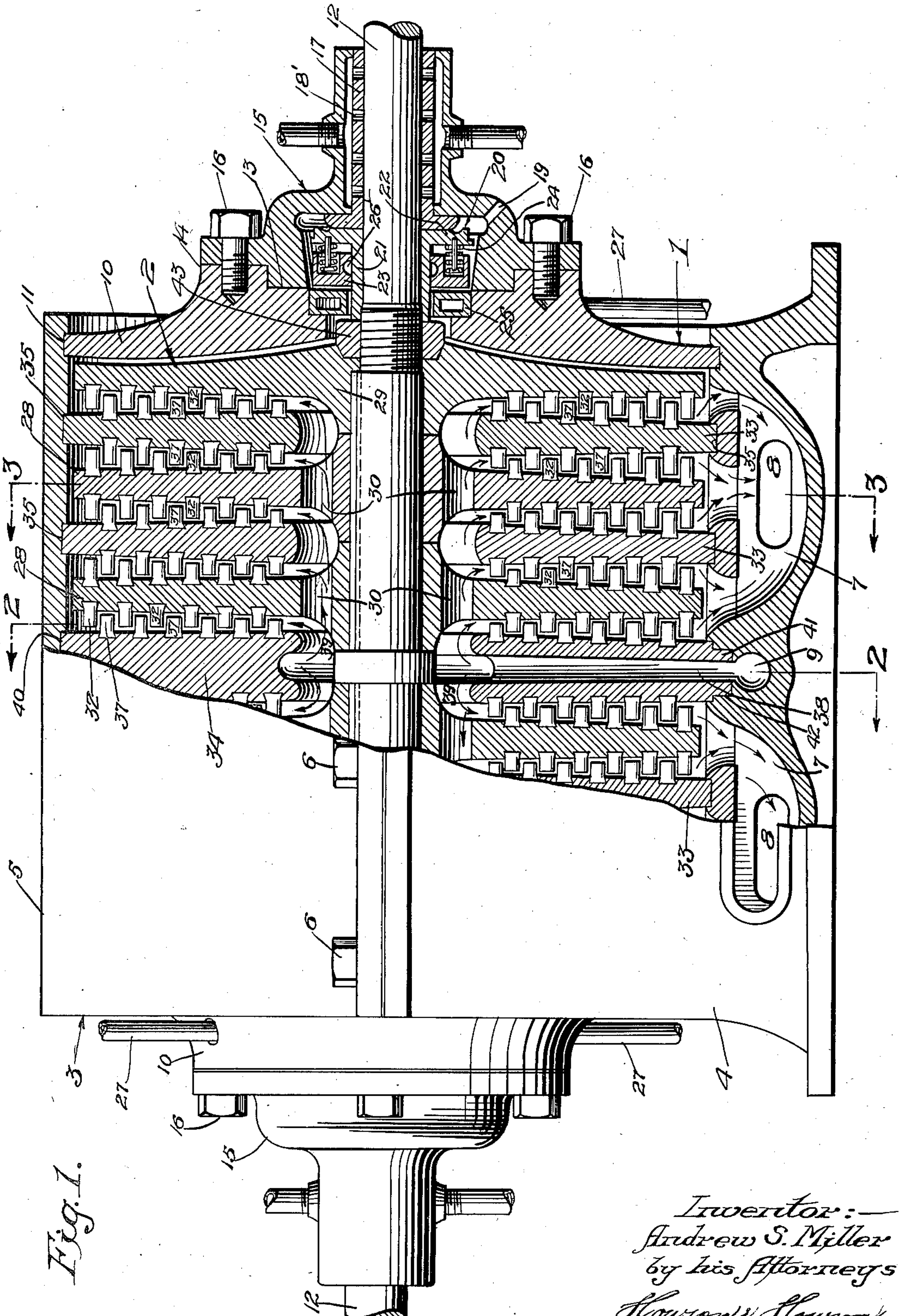
Nov. 12, 1935. A. S. MILLER 2,021,078

TURBINE

Filed Nov. 8, 1933 3 Sheets-Sheet 1



Inventor:—
Andrew S. Miller
by his Attorneys
Howson & Howson

Nov. 12, 1935. A. S. MILLER 2,021,078

TURBINE

Filed Nov. 8, 1933 3 Sheets-Sheet 2

Fig. 2.

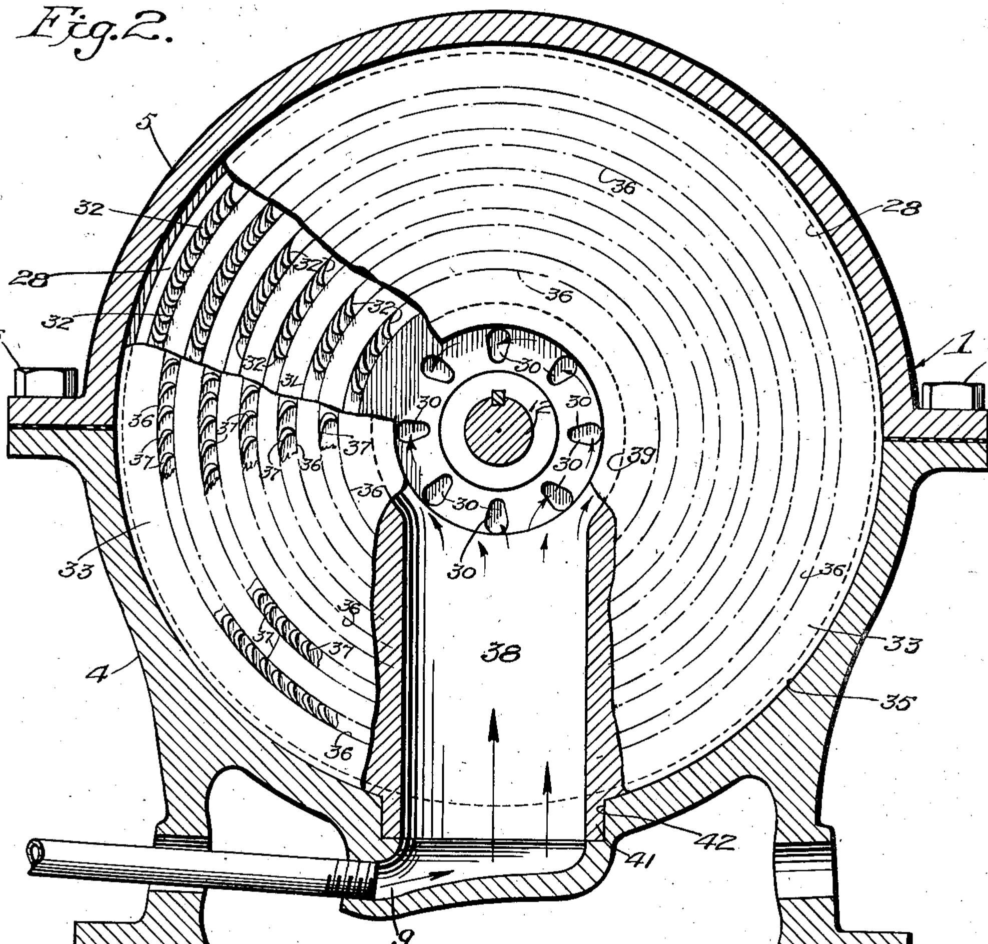
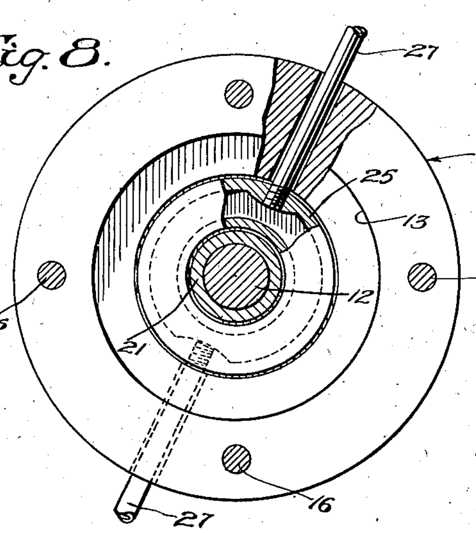


Fig. 8.



Inventor:—
Andrew S. Miller
by his Attorneys
Howson & Howson

TURBINE

Filed Nov. 8, 1933 3 Sheets-Sheet 3

Fig. 3.

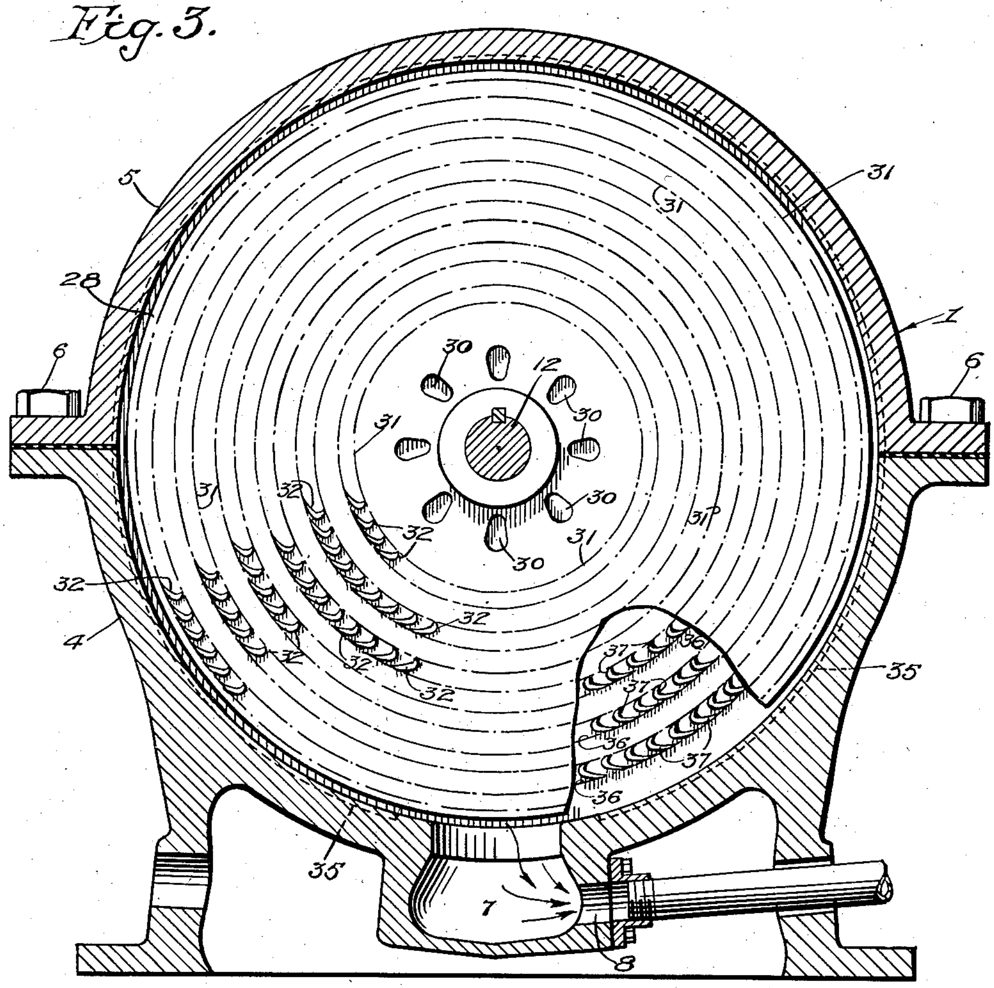


Fig. 4.

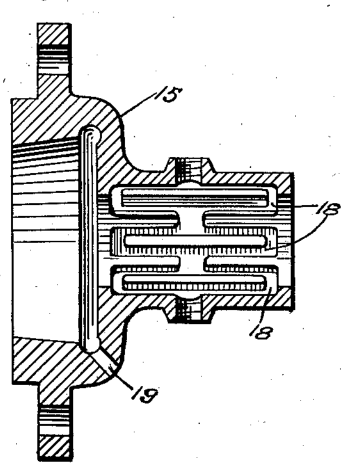


Fig. 5.

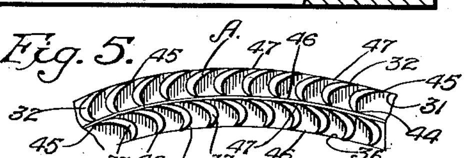


Fig. 6.

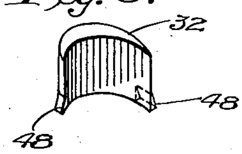
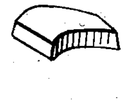


Fig. 7.



Inventor:—
Andrew S. Miller
by his Attorneys
Howson & Howson

Patented Nov. 12, 1935 2,021,078

UNITED STATES PATENT OFFICE

2,021,078

TURBINE

Andrew S. Miller, Spokane, Wash.

Application November 8, 1933, Serial No. 697,182

9 Claims. (Cl. 253—85)

This invention relates to turbines and, more particularly, to turbines for general use. Heretofore, existing turbines have been too heavy and expensive for general use and their range of usefulness has, accordingly, been limited. The general object of the present invention is to provide an improved turbine or like engine which, by virtue of certain novel features of construction, obviates the objectionable characteristics of prior devices of this class and lends itself to efficient and economic general use.

A more specific object of the invention is to provide a radial flow multi-stage turbine of the impulse and reaction type having a self-balanced rotor and in which vibration and axial thrust is substantially eliminated. The construction of the device is such that the maximum pressure of the steam or other impelling medium is confined within the rotor unit, the interior wall of the housing of the device not being subjected to such maximum pressure.

Other objects and features of the invention will appear hereinafter. The invention may be clearly understood from the following detailed description of the exemplary form illustrated on the drawings.

In the drawings:

Fig. 1 is an elevational view of the device showing a substantial portion of the same in section;

Fig. 2 is a sectional view taken along line 2—2 of Fig. 1;

Fig. 3 is a sectional view taken along line 3—3 of Fig. 1;

Fig. 4 is a detail sectional view of one of the end bonnets of the device;

Fig. 5 is a detail view illustrating clearly the construction and arrangement of the rotor and stator vanes or blades;

Fig. 6 is a perspective view of one of the vanes;

Fig. 7 is a perspective view of the spacing block or fitting piece which is used to secure the vanes in place; and

Fig. 8 is a face view of one of the housing heads with the bonnet removed, a portion being shown in section.

Referring to the drawings and particularly to Fig. 1, the device comprises generally a stator assembly 1 and a rotor assembly 2. The stator comprises essentially a housing 3 which is preferably formed of half cylindrical section 4 and 5 bolted together as at 6. Section 4 constitutes the base of the housing and it is formed to provide a pair of axially spaced exhaust chambers 7 located symmetrically with respect to the center of the device. The exhaust chambers communicate with exhaust ports 8. The steam or other impelling medium enters the exhaust chambers directly from the rotor stages so that the exhaust steam is evacuated freely without obstructing the passage of exhaust steam leaving the rotor chamber which would lower the efficiency of the turbine. The location of the exhaust ports in the lowest part of the housing also prevents moisture from collecting in the rotor chamber. The exhaust pipes may be connected as illustrated in Fig. 3 or in any other suitable manner.

Section 4 of the housing is also formed to provide an admission channel 9 which is centrally located between the exhaust chambers and which may be arranged for a pipe connection as illustrated in Fig. 2. By having the admission or inlet channel, as well as the exhaust chambers, in the lower part of the turbine so that connections are made to the lower part, the construction of the device is simplified and disassembly for repair or replacement of the parts is greatly facilitated. This feature, in conjunction with the two-part construction of the housing, enables the ready removal of the upper section 5 which gives access to substantially the entire interior of the device and particularly to the rotor assembly thereof. In addition, the feature in question enhances the balancing of the device due to the manner of admission of the steam, or other impelling medium, and its equal and uniform distribution to the axially divided halves thereof and to the rotor stages of each half.

A pair of circular removable heads 10 form part of the stator assembly and serve to close the ends of the housing. These heads have their circumferential portions rigidly secured in annular channels 11 formed on the inside wall at each end of the housing. An opening is provided through the center of each head to admit the rotor shaft 12. On the outer side of each head and centrally located with respect thereto is a circular recess 13 formed by the annular projection 14, into which recess a bonnet 15 is fitted, the bonnet being bolted to the head as at 16. Inside each bonnet is a bearing 17 for the rotor shaft which is thus rigidly supported and accurately aligned with respect to the housing.

As shown in Fig. 4, the bearing supporting sleeve portion of each bonnet has its interior surface formed to provide grooves or recesses 18 which provide a tortuous path for the flow of lubricant. It will be seen that intercommunicating longitudinal and arcuate grooves are provided. Each bearing is perforated throughout its entire circumferential surface, as at 18', the openings being tapered inward, as illustrated. A continuous flow of lubricant, which cools the bearing as well as lubricates the rotor shaft journals, may be had by providing pipe connections to bonnets, as illustrated. The lubricant flows throught the tortuous path of the bonnet and is distributed through the bearing openings to the bearing and shaft surfaces. Each bonnet may be provided with a drain opening 19.

Arranged on the rotor shaft is a collar 20 which is mounted upon the shaft so as to revolve therewith and abuts against the bearing, preventing axial or longitudinal movement of the rotor shaft and the rotor assembly carried thereby. Collar 20 has a sleeve portion 21 and a flange 22. A slidable collar 23 is mounted on the sleeve portion of collar 20 so as to revolve therewith. There are provided a plurality of coiled springs 24 which are arranged to urge collar 22 away from flange 21 and into light engagement with a hollow ring 25 which surrounds sleeve portion 21 and is secured to head 10. An annular recess or channel 26 is provided in collar 23 and is adapted to receive packing to prevent leakage of oil or other lubricant into the rotor chamber from the bearing. The hollow ring 25 has circulating therethrough a cooling fluid which serves to reduce the temperature inside bonnet 15 and insures a cool bearing. The inner side of ring 25 is preferably insulated to prevent the transfer of heat between the bearing and the rotor assembly. As shown more clearly in Fig. 8, pipes 27 extend through openings in head 10 to ring 25 in order that a continuous flow of cooling fluid may be had through ring 25. The specific arrangement of the collars effectively prevents leakage of the lubricant between the bearing compartment and the rotor chamber, while ring 25 effectively cools the bearing and prevents heat transfer.

Coming now to the rotor assembly, there is keyed on the rotor shaft on each side of the center of the device a plurality of rotor disks or wheels 28 and 29. These disks have their hubs in abutment as shown. The disks 28 are substantially similar to each other and constitute the inner disks, while disks 29 are differently constructed and constitute the outer or end disks. Each of the disks 28 is provided with a plurality of circularly arranged openings 30 immediately adjacent its hub, the purpose of these openings being to transmit steam, or other impelling medium, centrally and axially of the device from the center towards the ends thereof. Each of the rotor disks is tapered outwardly so as to have a diminishing area of cross-section from the hub to the periphery. On their faces, the rotor disks are provided with concentric beveled or dovetailed grooves 31 at regular intervals from a point near the shaft to a point adjacent the periphery of the disks. Firmly secured in the grooves are the rotor blades or vanes 32 (see Fig. 6) which project at right angles to the faces of the disks and have their curved sides inclined in a direction parallel to the line of rotation of the disks, as illustrated more clearly in Figs. 2, 3 and 5.

Arranged alternately between the rotor disks are the stator disks or wheels 33 and 34. Disks 33 are shaped generally similar to the rotor disks each having a radially diminishing area of cross-section. These disks have their circumferential portions secured in annular recesses or channels 35 formed on the inner wall of the housing. A large circular passage is provided in the center of these stationary disks to admit the rotor shaft and the hubs of the rotor wheels and to serve as a steam passage to adjacent rotor stages. On their faces, these disks are provided with grooves 36 and vanes 37, which are similar to the corresponding elements of the rotor disks, but vanes 37 are inclined in a direction opposite that of the rotor vanes 32, as illustrated clearly in Figs. 2, 3 and 5. Each row of stator vanes is positioned directly between adjacent rows of the rotor vanes so that the rotor and stator vanes intermesh, as clearly illustrated in Fig. 1.

The centrally located stator disk 34 is of different construction than the other stator disks and is formed to provide an admission port 38 leading from the admission channel 9 radially to the centrally located annular chamber 39. Aside from its peculiar construction to provide for admission of the steam, or other impelling medium, this disk is generally similar to the other stator disks and is similarly secured in an annular recess or channel 40 formed in the inner wall of the housing. The details of construction of this disk, particularly as regards the admission port, are shown clearly in Figs. 1 and 2. The disk is provided on its periphery with a projection 41 through which the admission port extends and the projection is seated in a recess 42 in the lower part of the housing where the admission port communicates with admission channel 9.

A lock nut 43 secures each of the outer rotor disks in position on the rotor shaft. The outer side or surface of each of these rotor disks is curved radially, as illustrated in Fig. 1, to correspond with the inner face of the housing to which it is in close proximity. These rotor disks have no steam passages through their central parts and steam, or other impelling medium, cannot pass axially beyond them. It must, therefore, take its course through the vanes on the inner side of these disks. In consequence, live steam under pressure does not contact with the inner wall of the housing and the housing wall is, therefore, not subjected to maximum steam pressure. This arrangement makes a heavy housing unnecessary even though superheated, high pressure steam may be employed. Furthermore, the heat absorbed by the heads of the housing is much reduced due to the avoidance of contact with live steam and this aids in the cooling of the bearing compartment.

Referring particularly to Fig. 5 of the drawings, there is shown in cross-section a row or series of rotor vanes A and an adjacent row or series of stator vanes B in cooperative relation with the rotor vanes. The opposite inclination of the two sets of vanes is clearly shown. The vanes are identical in shape and area of cross-section and their sides converge into points at 44 and 45. A portion of the outer or convex side of the vanes at 45 is arranged substantially parallel to the circular line or plane within which they are located. Both sets of vanes are arranged in each of their respective circles so as to provide a wide inlet at 46 and a relatively narrow outlet at 47. It will be noted from Fig. 1 that the length of the vanes increases in proportion to their distance from the rotor shaft and the area of the passages between them increases in a corresponding manner due to the gradual reductions radially in cross-sectional area of the stator and rotor wheels. This permits the gradual increase in volume of the steam to expand to a desired range of pressure with a minimum of friction in its passage through the turbine.

Also, in consequence of the uniform setting of all the vanes in the rotor unit, there is an increasing number of vanes in each series from the shaft outward. The resultant increase in the number of passages permits the gradual increase in the volume of the steam to expand to a desired range of pressure in each series of vanes. The increasing volume of the steam is by the described arrangement automatically taken care of. As the volume of the steam increases in each series of vanes, the pressure decreases and the velocity of the steam increases in a corresponding manner.

The vanes may be fastened in the grooves of the rotor and stator disks in any suitable manner. For example, the vanes may be formed as illustrated in Fig. 6 and may be secured in the grooves by spacing blocks made of soft tough metal, such as that shown in Fig. 7. It will be seen that the vanes are provided with beveled portions 48 corresponding to the sides of the beveled or dovetailed grooves, which beveled portions are adapted to seat snugly in the said grooves. The vanes, when thus formed, may be individually positioned in the grooves by inserting each vane lengthwise in the groove and then turning the vane until it is inclined at the proper angle with the beveled portions 48 seated in the sides of the groove. One side of the spacing block is curved to conform with the convex side of the vane, while the other side of the block is curved to conform with the concave side of the vane. The block is of a thickness slightly greater than the depth of the groove. After each vane is inserted in the groove in the manner above described, a spacing block may be placed in the groove in the same manner, that is, the block may be inserted lengthwise in the groove and then turned to cause its beveled sides to seat in the sides of the groove. The vanes and spacing blocks are thus inserted and secured alternately in a groove until the groove is completely filled.

It will be observed that the last spacing block to be inserted in the groove between the first and last vanes cannot be placed in the groove in the manner described. This block may be bent so that it may be positioned in the groove without turning and the block may then be straightened out so that its beveled ends will seat themselves against the beveled sides of the groove. The vanes and blocks are so designed that they completely fill the groove and the vanes are equally spaced. Although the vanes will be rigidly secured in the groove, when assembled with the spacing blocks as above described, the blocks may be upset after all the vanes in a circle are placed in position to further insure the security of the vanes. Tests have shown that the vanes are so completely anchored in the groove when assembled as described that it is impossible to dislodge them without mutilating them. This solid setting of the vanes is not affected by expansion or contraction due to varying temperatures. The space between the vanes is smooth and flush with the face of the wheel or disk, offering no obstruction to the steam in its passage.

In operation of the device, steam or other impelling medium, at maximum pressure enters the admission chamber 9 and passes radially through port 38 to the annular chamber 39 from which it passes axially in both directions through the openings of the rotor disks and the annular spaces therebetween. The steam is thus distributed equally and uniformly to both sides of the turbine and it is then distributed uniformly to the respective rotor stages of each section. As it passes simultaneously through the various rotor stages, the steam is guided by the stator vanes so as to strike the rotor vanes on the inner side of their curved portion at 44 with great force. The jets of steam are not distorted by the impact but follow the curved path 44—45 of their passages. As the steam expands in the passages formed by the vanes, the resultant back pressure would be taken on the point 45 of the stator vanes but the pressure and velocity of the jets of steam continuously entering the passages of the rotor vanes act as a barrier across the inlet 46 of the rotor vanes which tends to force the expanding steam into the passages. This action of the steam results in an even pressure being maintained in the passages and the velocity of the steam as it leaves the passages continues to increase in correspondence with the increase in volume. This action of the steam is repeated in each series of vanes until the point of exhaust is reached.

A minute fraction of clearance is provided between each series of stationary and moving vanes and between outer ends of the vanes and adjacent faces of rotor members. As a result, leakage and entrainment of steam between each series of vanes is reduced to a minimum.

The stabilizing effect produced on the rotor wheels by the tension effective radially against points 44 and 45 of the running vanes from the expanding steam entering and leaving the passages in each series of vanes tends to reduce the centrifugal force induced by the speed on the rotor wheels. The constant tension in opposite directions both radially and axially, exerted by the steam on each rotor wheel, results in a perfect balancing of the rotor and a complete absense of rotor vibrations.

Since these conditions are obtainable in a high speed turbine, greater economy in steam consumption can also be accomplished. In a turbine as described and shown on the drawings, the uniform arrangements of the vanes, their curvature, pitch of inclination and area of port opening, preclude any waste or dissipation of the steam which, when entering the turbine, applies its expansive force most effectively against the running vanes. The energy expended in the process of turning the rotor wheels develops a power which is proportionate to the speed of the rotor. That speed, and the volume of steam passing through the rotor under a given pressure is largely determined by the described arrangements of the vanes. A high speed steam turbine of the type disclosed herein is very desirable, as satisfactory speed-reducing appliances are now employed in connection with high speed engines and motors which make a high speed steam turbine practicable.

Although there is illustrated and described herein a single preferred embodiment of the invention, it will be understood that this is for purposes of illustration only and does not limit the scope of the invention. Any changes or modifications which fall within the scope of the appended claims are deemed to be within the spirit and scope of the invention.

I claim:

1. In a turbine, a housing formed to provide a pair of axially and symmetrically spaced exhaust chambers and ports and a centrally disposed admission channel in its base, a central stationary

disk within said housing having an admission port leading from said channel to an inner annular chamber, and a rotor comprising a rotatable axial shaft, and a plurality of vane-carrying disks mounted on said shaft and disposed symmetrically with respect to said central stationary disk, each said rotor disks having a plurality of circularly arranged openings therethrough adjacent said shaft and in communication with said annular chamber, whereby steam or other impelling medium is admitted centrally of the device and is passed axially of the device and supplied to all of the rotor stages simultaneously through which it flows radially outward to said exhaust chambers.

2. In a turbine, a housing formed to provide a pair of axially and symmetrically spaced exhaust chambers and a centrally disposed admission channel in its base, a central stationary vane-carrying disk within said housing having an admission port leading from said channel to an inner annular chamber, a plurality of spaced stationary vane-carrying disks disposed symmetrically with respect to said central stationary disk and each having a central opening, and a rotor comprising a rotatable axial shaft, and a plurality of vane-carrying disks mounted on said shaft and disposed alternately with respect to said stationary disks and symmetrically with respect to said central stationary disk, each said rotor disks having a plurality of circularly arranged openings therethrough adjacent said shaft and in substantially axial alignment with the stator disk openings and said annular chamber, whereby steam or other impelling medium is admitted centrally of the device and is passed axially of the device and supplied to all of the rotor stages simultaneously through which it flows radially outward to said exhaust chambers.

3. In a turbine, a housing formed to provide a pair of axially and symmetrically spaced exhaust chambers and a centrally disposed admission channel in its base, a central stationary vane-carrying disk within said housing having an admission port leading from said channel to an inner annular chamber, a plurality of spaced stationary vane-carrying disks disposed symmetrically with respect to said central stationary disk and each having a central opening, and a rotor comprising a rotatable axial shaft, and a plurality of vane-carrying disks mounted on said shaft and disposed alternately with respect to said stationary disks and symmetrically with respect to said central stationary disk, each said rotor disks having a plurality of circularly arranged openings therethrough adjacent said shaft and in substantially axial alignment with stator disk openings and said annular chamber, whereby steam or other impelling medium is admitted centrally of the device and is passed axially of the device and supplied to all of the rotor stages simultaneously through which it flows radially outward to said exhaust chambers, the rotor and stator vanes intermeshing with each other and being inclined in opposite directions.

4. In a turbine, a housing formed to provide a pair of axially and symmetrically spaced exhaust chambers and ports and a centrally disposed admission channel in its base, a central stationary vane-carrying disk within said housing having an admission port leading from said channel to an inner annular chamber, a plurality of spaced stationary vane-carrying disks disposed symmetrically with respect to said central stationary disk and each having a central opening, and a rotor comprising a rotatable axial shaft, and a plurality of vane-carrying disks mounted on said shaft and disposed alternately with respect to said stationary disks and symmetrically with respect to said central stationary disk, each said rotor disks having a plurality of circularly arranged openings therethrough adjacent said shaft and in substantially axial alignment with the stator disk openings and said annular chamber, whereby steam or other impelling medium is admitted centrally of the device and is passed axially of the device and supplied to all of the rotor stages simultaneously through which it flows radially outward to said exhaust chambers, the rotor and stator vanes intermeshing with each other and increasing in length proportionately to their distance from the axis of the device and being inclined in opposite directions.

5. In a multi-stage turbine, means for admitting an impelling medium centrally of the turbine, a rotor comprising a rotatable axial shaft and a plurality of vane-carrying disks mounted on said shaft, said rotor disks having openings therethrough adjacent said shaft, whereby the impelling medium is passed axially of the turbine in opposite directions and is supplied to all of the rotor stages simultaneously through which it flows radially outward, and means for exhausting the impelling medium after it has passed through said stages.

6. In a multi-stage turbine, means for admitting an impelling medium centrally of the turbine, a rotor comprising a rotatable axial shaft and a plurality of vane-carrying disks mounted on said shaft, said rotor disks having openings therethrough adjacent said shaft, a plurality of stationary vane-carrying disks disposed alternately with respect to said rotor disks and each having a central opening in substantially axial alignment with the rotor openings, whereby the impelling medium is passed axially of the turbine in opposite directions and is supplied to all of the rotor stages simultaneously through which it flows radially outward, and means for exhausting the impelling medium after it has passed through said stages.

7. In a multi-stage turbine, means for admitting an impelling medium centrally of the turbine, a rotor comprising a rotatable axial shaft and a plurality of outwardly tapered vane-carrying disks mounted on said shaft, said rotor disks having openings therethrough adjacent said shaft, a plurality of stationary outwardly tapered vane-carrying disks disposed alternately with respect to said rotor disks and each having a central opening in substantially axial alignment with the rotor openings, whereby the impelling medium is passed axially of the turbine in opposite directions and is supplied to all of the rotor stages simultaneously through which it flows radially outward, and means for exhausting the impelling medium after it has passed through said stages.

8. In a multi-stage turbine, means for admitting an impelling medium centrally of the turbine, a rotor comprising a rotatable axial shaft and a plurality of outwardly tapered vane-carrying disks mounted on said shaft, said rotor disks having axially-extending abutting hubs and openings adjacent said hubs, a plurality of stationary outwardly tapered vane-carrying disks disposed alternately with respect to said rotor disks and each having a central opening in substantially axial alignment with the rotor openings, whereby the impelling medium is passed

axially of the turbine in opposite directions and is supplied to all of the rotor stages simultaneously through which it flows radially outward, and means for exhausting the impelling medium after it has passed through said stages.

9. In a multi-stage turbine, means for admitting an impelling medium axially of the turbine, a rotor comprising a rotatable axial shaft and a plurality of vane-carrying disks mounted on said shaft, said rotor disks having openings therethrough adjacent said shaft, a plurality of stationary vane-carrying disks disposed alternately with respect to said rotor disks and each having a central opening in substantially axial alignment with the rotor openings, whereby the impelling medium is passed axially of the turbine and is supplied to all of the rotor stages simultaneously through which it flows radially outward, and means for exhausting the impelling medium after it has passed through said stages.

ANDREW S. MILLER.