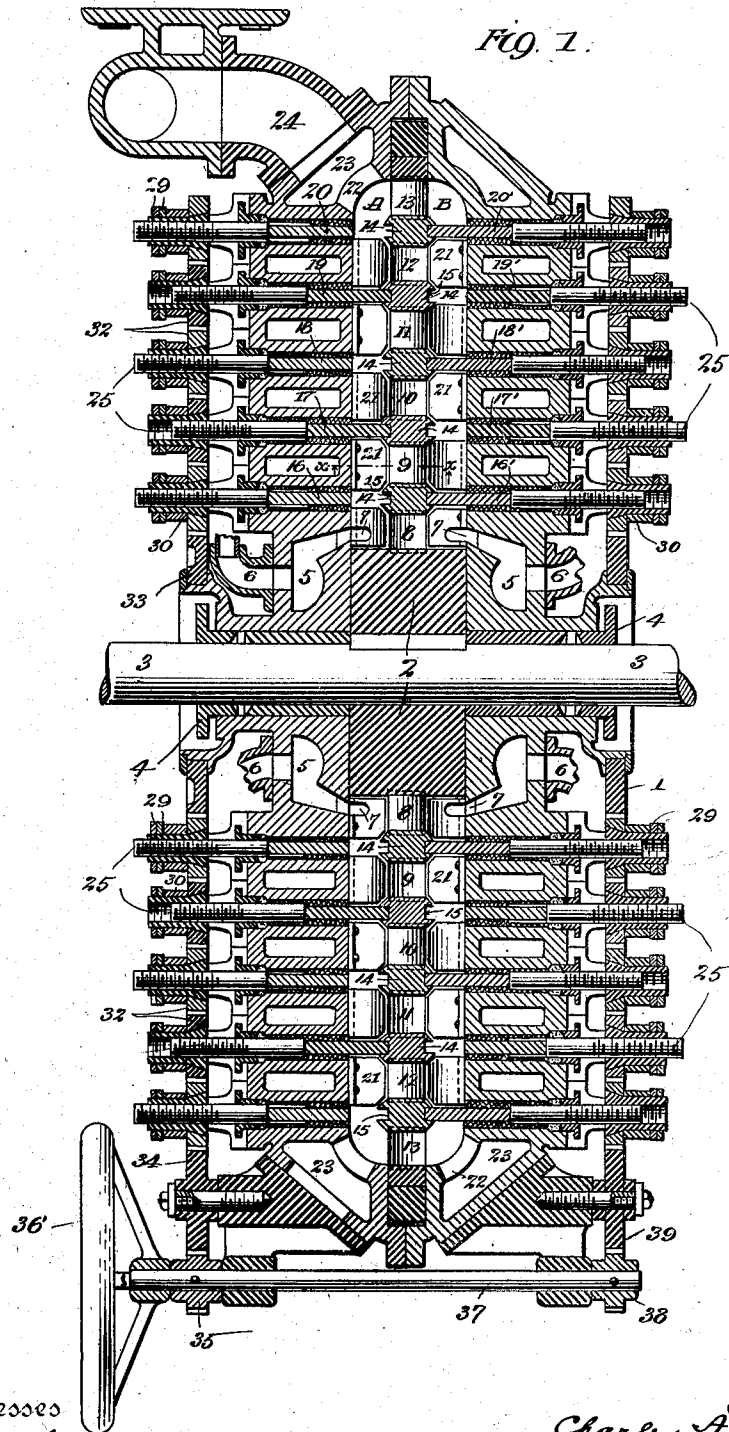


TURBINE.

Patented Nov. 9, 1909.

4 SHEETS—SHEET 1.

Fig. 1.



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TURBINE.

APPLICATION FILED JAN. 7, 1907. RENEWED APR. 20, 1909.

939,514.

Patented Nov. 9, 1909.

4 SHEETS—SHEET 2.

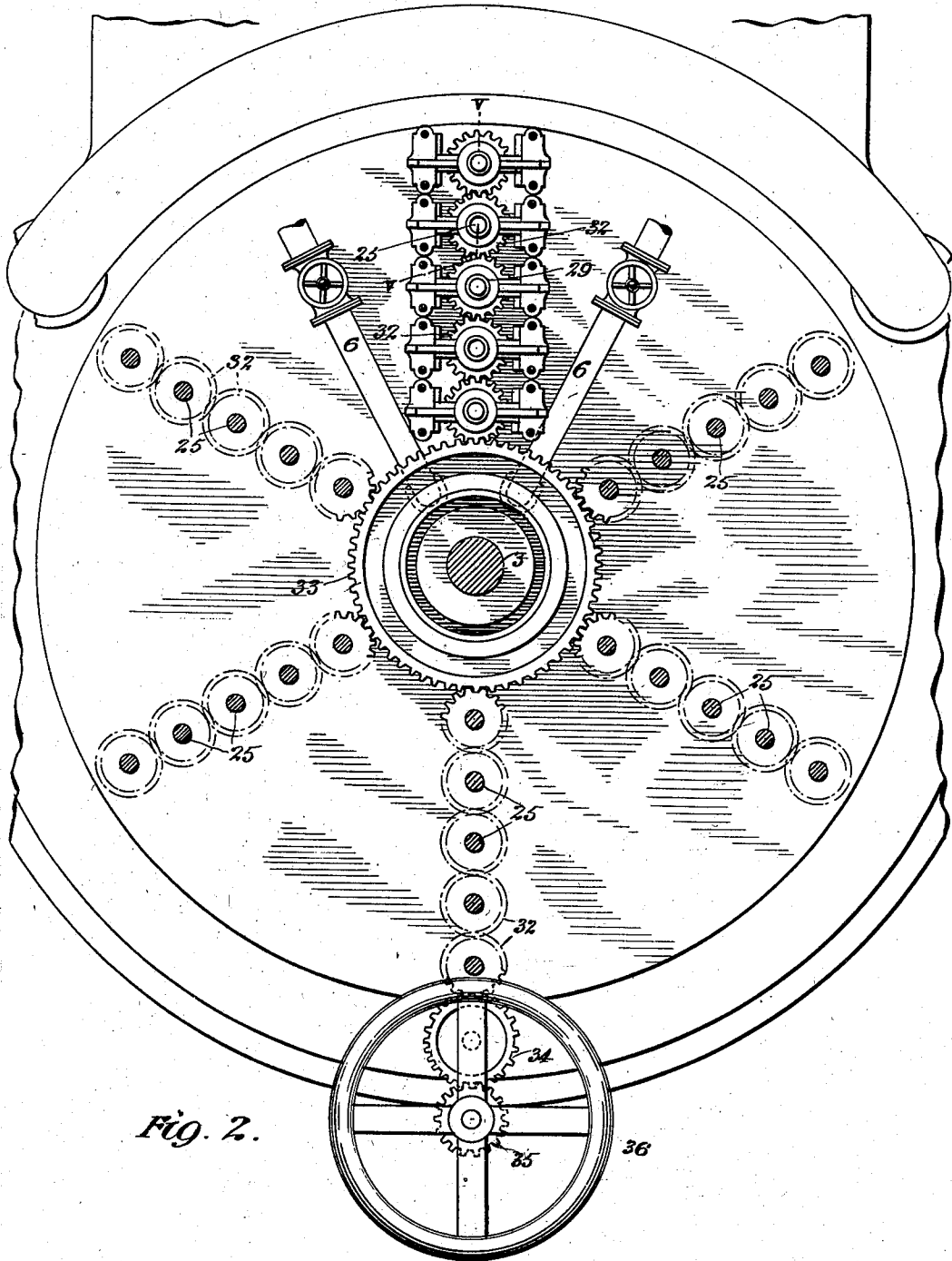


FIG. 2.

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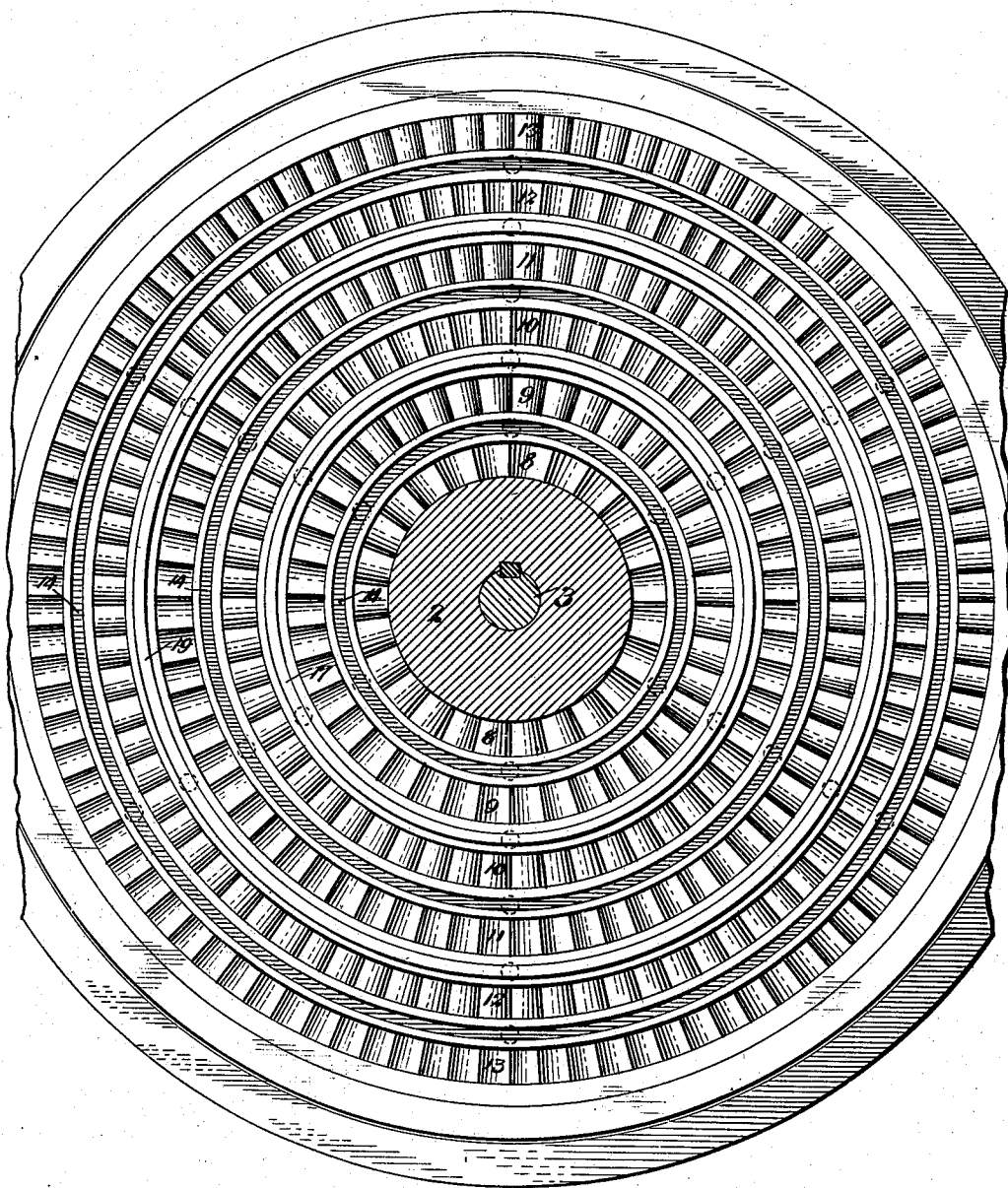
APPLICATION FILED JAN. 7, 1907. RENEWED APR. 20, 1909.

939,514.

Patented Nov. 9, 1909.

4 SHEETS—SHEET 3.

*Fig. 3.*



Witnesses

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939,514.

Patented Nov. 9, 1909.

4 SHEETS—SHEET 4.

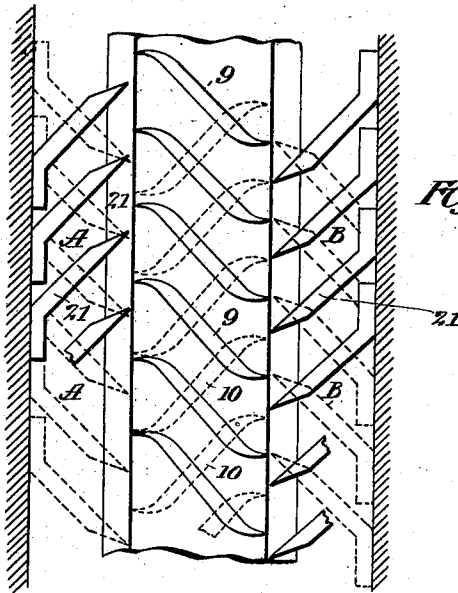


Fig. 4.

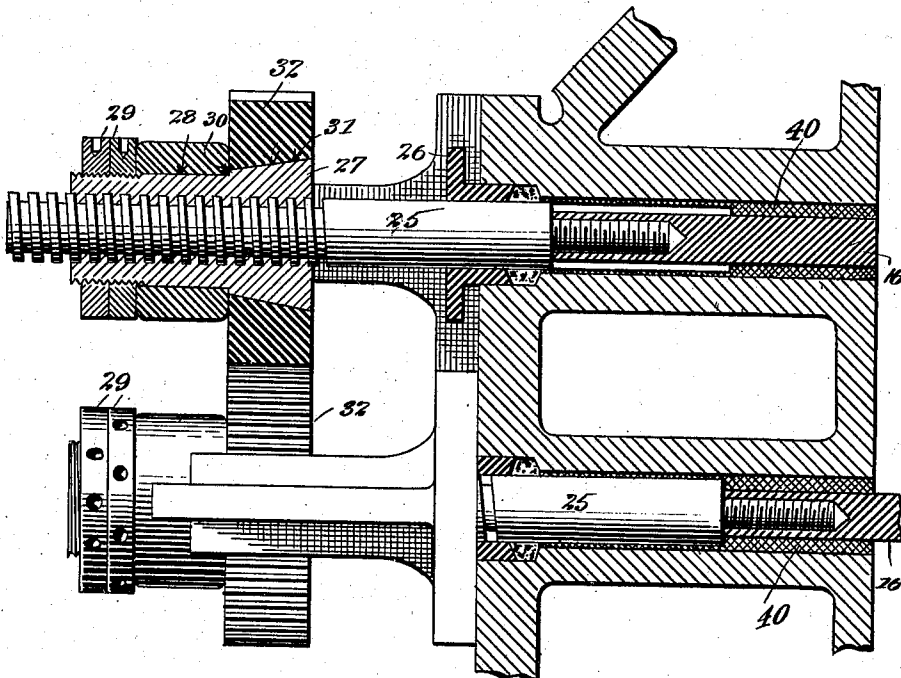


Fig. 5.

Witnesses  
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# UNITED STATES PATENT OFFICE.

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## TURBINE.

939,514.

Specification of Letters Patent.

Patented Nov. 9, 1909.

Application filed January 7, 1907, Serial No. 351,074. Renewed April 20, 1909. Serial No. 491,194.

*To all whom it may concern:*

Be it known that I, CHARLES A. KAISER, a citizen of the United States, residing at New York city, in the borough of Brooklyn and State of New York, have invented certain new and useful Improvements in Turbines, of which the following is a full, clear, and exact description.

My invention relates to steam turbines, and has for its particular object to provide a reversible steam turbine which can be manipulated to operate in either direction with perfect efficiency.

The invention is further designed to secure the reversal in a gradual or abrupt way as desired, so that the action can be very nicely controlled, as is very desirable in some cases, for example, in its use with boats and launches.

In one of its aspects the invention consists of a revoluble element having concentric annular series of blades or vanes against which the steam is impelled, first from one side and then from the other of the element, and which act together to impel the element rotarily. The direction in which the steam acts on each annular series of blades can be controlled, and is reversible throughout the entire system, so that the direction of rotation is controllable.

Another aspect of the invention consists in the arrangement of the partitions and walls for the respective passages at either side of the revoluble element, which are movable simultaneously and properly to secure a reversal in the path of the steam throughout the entire system, and by a simple manipulation of a single part or wheel on the outside of the casing of the turbine.

The invention further consists in the features of construction and combination hereinafter set forth and claimed.

In the drawings: Figure 1 is a sectional view of a steam turbine embodying the principles of my invention; Fig. 2 is a side elevation of the same; Fig. 3 is a face view of the removable element or wheel; Fig. 4 is a detail and somewhat diagrammatic view showing the relations of the fixed and movable vanes or blades; Fig. 5 is a detail sectional view showing certain features of the reversing mechanism; this section is taken on the line V—V of Fig. 2.

The ordinary steam turbine allows the

steam to expand continuously from the inlet to the outlet ports or connections, the expansion at each stage of the action corresponding to a reduction in the pressure and a tendency to increase the velocity. The arrangement of the fixed and the movable vanes or blades of the turbine is, however, such that the velocity is absorbed at successive stages, so that the steam does not acquire an excessive velocity in passing through the system, but remains at a substantially constant average velocity.

The essential principles to be observed in designing a steam turbine are to so arrange the passages for the steam that it may traverse the entire system at this general average velocity without being throttled or restricted at any point. The aggregate area of the passages must therefore gradually increase on account of the expansion of the steam. The second principle of design is that the arrangement of the fixed and the movable vanes must be such as to absorb the velocity of the steam, which tends to increase at every point, at successive stages, so that the velocity does not become excessive at any stage and give rise to undue losses by friction against the walls and passages. In other words, the steam turbine should have free unrestricted passages from one side to the other, so that in the absence of fixed and movable vanes the steam would acquire its full theoretical velocity from the particular pressure used, but this theoretical very high velocity should be prevented by the action of the movable vanes which successively absorb a part thereof at a plurality of different and successive stages. In carrying out the present invention I aim to secure these conditions of design in addition to making the turbine reversible.

Referring to the drawings in which like parts are designated by the same reference sign, 1 denotes a frame or casing, in which is journaled the revoluble element 2. This is conveniently keyed on the shaft 3, rotating in the journal bearings 4, of the casing, which are provided with glands or stuffing boxes, so as to make the bearings steam-tight.

5 indicate annular passages within the casing 1 into which the steam is initially admitted through one or more pipes or openings 6. The passages 5 therefore con-

stitute chambers in which the steam is initially collected under the full working pressure. These chambers terminate in annular ports 7, closely adjacent to the revoluble element or wheel 2. The revoluble element 2 is provided with an annular series of vanes 8, adjacent to the initial or steam supply ports 7. 9, 10, 11, 12 and 13 designate additional annular series of vanes all concentric with the vanes 8 and forming part of the wheel 2. The different series of vanes are separated by spacing rings 14, and the different rings have annular grooves 15, in their side faces, which cooperate with certain normally fixed partitions or walls, and which serve to direct the steam properly with respect to the vanes 8, 9, 10, 11, 12 and 13.

16 and 16' denote walls or partitions, which cooperate with grooves 15 of the ring 14, and it will be observed that the partition 16' is projected so that it enters the ring 15 on the right-hand side of the wheel. The partition 16 is, however, withdrawn to the left, so that it does not enter or approach the groove 15 on the left-hand side of the wall. It will be understood that these partitions or walls 16 and 16' are annular or ring-shaped, concentric with the axis of the wheel so as to enter the grooves 15 uniformly throughout the length thereof. There are provided additional annular partitions 17, 17', 18, 18', 19, 19' and 20, 20'. All these annular partitions are adapted to enter corresponding grooves 15 of the wheel 2, and the arrangement is such that the different partitions are always normally in alternate positions, that is to say, the partitions are withdrawn first on one side and then on the other of the wheel going from the center to the circumference thereof. The remaining partitions are, positioned in the grooves 15 alternately, first on one side of the wheel, and then on the other, proceeding from the center to the circumference. The result of this is that a sinuous path is provided which threads or winds through the wheel from side to side thereof, proceeding from the center to the circumference. This is the path which the steam traverses, and it is evident that since the steam moves from the center toward the circumference of the wheel, a gradually increasing cross sectional area is obtained therefor because there are a large number of vanes near the circumference than near the center of the wheel. This is one of the required conditions and compensates for the expansion of the steam in its passage.

Between the various partitions there are provided fixed vanes 21. These vanes have a certain action in controlling the direction of the steam, but they are not intended to restrict the flow thereof in any way. In other words, the steam is intended to have a free path of flow through the entire turbine, the

velocity being checked at a plurality of stages not by throttling, but by the action of the movable vanes.

The action of the steam in propelling the wheel is as follows: Supposing the partitions 16, 16', 17, 17', etc., are in the positions shown, steam enters through both the ports 7, 7'. From the port 7' the steam can only escape by passing to the left, through the vanes 8, and from the port 7, the steam is able to pass directly outward, past the ring 14, on account of the withdrawn position of the partition 16. The combined flow of the two ports 7, 7', therefore, passes into cavity of the fixed blades 21, adjacent to the movable vanes 9, and immediately traverses such vanes 9, passing through the wheel from one side to the other thereof. The steam then flows past the withdrawn partition 17', and successively through the wheel from side to side, acting on the vanes 10, 11, 12 and 13, finally issuing through the openings 22, into annular passages 23, which communicate with an exhaust pipe 24. It will be observed that the area available for the passage of the steam at every point is quite large, and the steam is not throttled at any point of its passage. The velocity, therefore, tends to increase at every point, and would increase to the theoretical maximum, or to a point where the surface friction absorbed the power, unless the velocity were checked at the successive stages. The velocity is checked by the relation of the fixed and the movable vanes, as will be clearly understood from a consideration of Fig. 4. In this figure a portion of the vanes 9 of the wheel are shown, this being generally a section on the line  $x-x$  of Fig. 1, looking in the direction of the arrows. Under these circumstances the steam is freely passing from the port 7 directly into the spaces between the blades 21 on the left-hand side of the figure. The steam is free to expand from between the blades 21 toward the right. This is because the spaces between the blades 21 on the right-hand side of the wheel are nearer to the exhaust than those on the left-hand side, and so consequently the steam thereat is at a pressure several pounds less than that which initially enters at the ports 7. For convenience the spaces between the blades 21 on the left will be denoted by reference character A, and the spaces between blades 21 on the right will be denoted by reference character B. Thus steam in the passages A is at about the boiler pressure, while steam in passages B is at a somewhat lower pressure. The difference of pressure between the steam in the passages A and B is therefore available to impel the steam into a state of velocity, moving from the left toward the right. This effect is, of course, at once attained, and it is evident that there is no throttling action on account of the ample width of the passages A and B at

every point. But in its passage from left to right the steam encounters the movable vanes 9 of the wheel, and these vanes are moving with sufficient rapidity, so that the steam which is reflected from their surface has less actual velocity than previously to such reflection. If the movable vanes are moving at about half the velocity of the steam, and the steam strikes these vanes so as to be reflected rearwardly therefrom, it is evident that nearly the whole of the velocity of the steam is absorbed by the movable vanes. This is the theoretical desired result, and is secured in practice with sufficient accuracy by having the vanes 9 of generally the form shown in Fig. 4 and inclined to the passages A. By reason of the blades 21, the steam is most free to expand in a forwardly inclined direction from the passages A, and the vanes 9 of the wheel are inclined backwardly enough to properly reflect the steam from the passages A, and absorb the velocity thereof. When the steam finally enters the passages B, it does so at the lower pressure corresponding to the work done in giving it velocity, but this velocity is not present when it enters the passages B, because it has been absorbed by the movable vanes 9. From the passages B the steam passes outward to the next set of fixed blades 21 and movable vanes 10 in exactly the same way as it initially entered the passages A from the port 7. The steam proceeds throughout the entire wheel and loses a part of its pressure at each stage, the general velocity remaining about the same since the theoretical constantly increasing velocity is absorbed at successive stages by the movable vanes. The steam finally passes into the exhaust pipe, spent in pressure and velocity, with all the available energy absorbed therefrom.

I will now describe the features by which the steam turbine is made reversible so as to work exactly as well in the opposite direction to that above set forth in connection with its forward movement. The various annular partitions 16, 16', 17, 17', etc., have been described as occupying certain positions, some entering the grooves 15, while others are withdrawn from such grooves. Means are provided for simultaneously shifting all of the partitions each to an exactly opposite position to that of Fig. 1. Under these circumstances the annular partition 16 would be moved inward so as to enter the left-hand groove 15 of the ring 14, and the partition 16' would be withdrawn so as to provide a free space past the ring 14 on this side. Under these circumstances the steam would find a sinuous passage through the turbine wheel from side to side, similar in all respects to that of the operation already described, except that the steam would act on the opposite faces of the movable vanes to those of its previous ac-

tion. For example, referring to Fig. 4, the steam would pass from the passages B, toward the passages A, and would act on the upper faces of the movable vanes 9. On account of the fact that the vanes 9 and the blades 21 are exactly the same when considered from one side as they are when considered from the other, it is obvious that the steam will act in exactly the same way whether it passes from B toward A, or from A, toward B. In one case, however, the turbine wheel will be impelled in one direction and in the other case in the other direction.

For the purpose of shifting the annular partitions 16, 16', 17, 17', etc., each is provided with a plurality of threaded studs 25, which pass through stuffing boxes 26, in the turbine casing.

27 indicates internally threaded sleeves or nuts which act upon the threaded portions of the studs 25. These sleeves or nuts rotate in bearings 28, being constrained against longitudinal movement by the nuts 29, and the shoulder 30. 31 indicates a coned portion of each of these sleeves or nuts, upon which is placed a gear wheel 32, which may be thereby fastened tightly in any desired angular relation. The various threaded studs 25 are situated in the same radial planes, as clearly shown in Fig. 2, and are separated by equal distances. The gears 32 are of the same size, and all intermesh with one another, and with an additional central gear 33. 34 is an additional gear which meshes with one of the gears 32, and 35 is a gear meshing with 34, and which has a hand wheel 36, by which it is turned. When the hand wheel 36 is turned, it is evident that the motion is transmitted to every gear of the entire system on one side of the turbine, because all of the gears mesh with one another, and with the central gear 33. Accordingly the various internally threaded sleeves 27 are turned in one direction or the other, depending on the rotation of the gears. Since any two adjacent gears rotate in opposite directions, it is evident that the various annular partitions will be moved alternately, first inward and then outward, as is required. The systems of gears on both sides of the turbine are made to operate simultaneously by having a shaft 37, which extends from the hand wheel 36 to gears 38 and 39, similar to the gears 34 and 35. Of course it is not absolutely necessary to have six of these studs 25 projecting from each of the annular partitions 16, 16', 17, 17', etc. In small turbines three studs from each partition will probably answer all requirements. It is best to have enough studs from each partition to insure an absolutely parallel movement thereof. It is merely necessary to properly position the various gears upon the cone surface 31, and afterward tighten them, whereupon

the apparatus is ready for use. The turbine may be reversed as often as desired by turning the hand wheel 36, and it is evident that the reversal is quick or gradual, soft or abrupt, according to the way in which the hand wheel is manipulated. This is particularly advantageous for use in boats and launches, which have to be delicately controlled in making a landing.

- 10 A feature of the invention lies in the manner in which the various annular partitions or walls 16, 16', 17, 17', etc., are supported from the casing. For this purpose I make use of a soft metal filling 40, between the partitions and the casing, in which said partitions may move toward and from the wheel.

What I claim, is:—

1. In a steam turbine, a wheel having concentric series of vanes, fixed vanes for directing steam to said series of vanes first from one side and then from the other for the successive series, and annular partitions laterally movable toward and from the wheel whereby the path of the steam may be alternated throughout the system.

2. In a steam turbine, a casing having fixed vanes rigidly attached thereto, a wheel revoluble between the fixed vanes and also having vanes thereon, and annular partitions between the fixed vanes movable to change the direction of the steam through the wheel.

3. In a steam turbine, a wheel having a series of vanes, fixed vanes or blades on either side of the vanes of said wheel, said fixed vanes on one side of the wheel having exactly the same relation to the vanes thereof, as the fixed vanes on the other side of the wheel have to said vanes and annular partitions movable axially between said fixed vanes to change the direction of the flow of steam.

4. In a steam turbine, a wheel having a series of vanes, said vanes having exactly the same characteristics when considered from one side of the wheel as they have when considered from the other side, both in the matter of form and direction, fixed vanes on either side of said wheel, said fixed vanes having the same characteristics and relations to the movable vanes on one side of the wheel as they have on the other, and annular partitions movable axially between said fixed vanes to change the direction of the flow of steam.

5. In a steam turbine, a wheel having a series of vanes inclined to the direction of movement of the wheel, said vanes having the same shape and direction when considered from one side of the wheel as they have when considered from the other, inclined fixed vanes or blades on either side of the wheel, the fixed vanes on each side being adapted to direct steam against the vanes

of the wheel to produce movement thereof, the fixed vanes on one side having the same form and characteristics with respect to the vanes of the wheel as those on the other side, and annular partitions movable axially between said fixed vanes to change the direction of the flow of steam.

6. In a steam turbine, a wheel revoluble in a fixed casing and having a series of vanes inclined to the direction of movement of the wheel, each vane being curved and bent at its edge and being the same in direction and form when considered from one side of the wheel as when considered from the other, and annular partitions movable toward and from the wheel for admitting steam against said vanes from one side or the other of the wheel, whereby the wheel is impelled in exactly the same way in each case except that the direction is reversed.

7. In a steam turbine, a wheel having a series of vanes inclined to the direction of movement of the wheel and having the same characteristics when considered from one side of the wheel as from the other both in form and direction, a series of partitions axially movable to admit steam to said vanes from either side of the wheel, and annular partitions movable axially between said fixed vanes to change the direction of the flow of steam.

8. In a steam turbine, a wheel having concentric series of vanes disposed in the same plane of rotation and also including rings having grooves on their lateral edges, annular partitions movable toward and from the wheel from opposite sides thereof and adapted to enter said grooves, and means for moving said partitions toward and from the wheel, adjacent partitions being moved in opposite directions whereby steam may be admitted through the vanes in either direction.

9. In a steam turbine, a wheel having concentric series of vanes, a plurality of annular partitions on both sides of the wheel each having a plurality of projecting studs, and means acting on said studs for moving all of the partitions simultaneously, alternate partitions being moved alternately toward and away from the wheel whereby the steam is admitted to the wheel in a different path at every point thereof.

10. In a steam turbine, a wheel having concentric series of vanes, annular partitions on both sides of the wheel having projecting threaded studs, sleeves on said studs, and means for rotating all of said sleeves whereby the partitions are moved toward and from the wheel to reverse its direction.

11. In a steam turbine, a wheel having concentric series of vanes, annular partitions on both sides of the wheel having projecting threaded studs, sleeves on said studs, and intermeshing gears for rotating all of

said sleeves whereby the partitions are moved toward and from the wheel to reverse its direction.

12. In a steam turbine, a wheel having concentric series of vanes, a plurality of annular partitions each having threaded studs, threaded sleeves on said studs each having coned portions, and intermeshing gears adapted to be secured on said coned portions in angularly adjustable relation.

13. In a steam turbine, a wheel having concentric series of vanes, a plurality of annular partitions each having threaded studs, threaded sleeves on said studs, and radially arranged intermeshing gears on said sleeves, said gears meshing with a single central gear.

14. In a steam turbine, a wheel having concentric series of vanes, a plurality of annular partitions each having threaded studs,

threaded sleeves on said studs in radially extending rows, intermeshing gears on said sleeves, and means whereby all of said gears are simultaneously rotated at the same angular velocity.

15. In a steam turbine, a revoluble element having concentric series of vanes, a series of annular partitions cooperating with said vanes, a casing in which said annular partitions are movable toward and from the wheel, and a soft metal filling surrounding said partitions and supporting them from the casing.

In witness whereof, I subscribe my signature, in the presence of two witnesses.

CHARLES A. KAISER.

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