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1,546,049

H. H. WAIT

REENTRANT TURBINE

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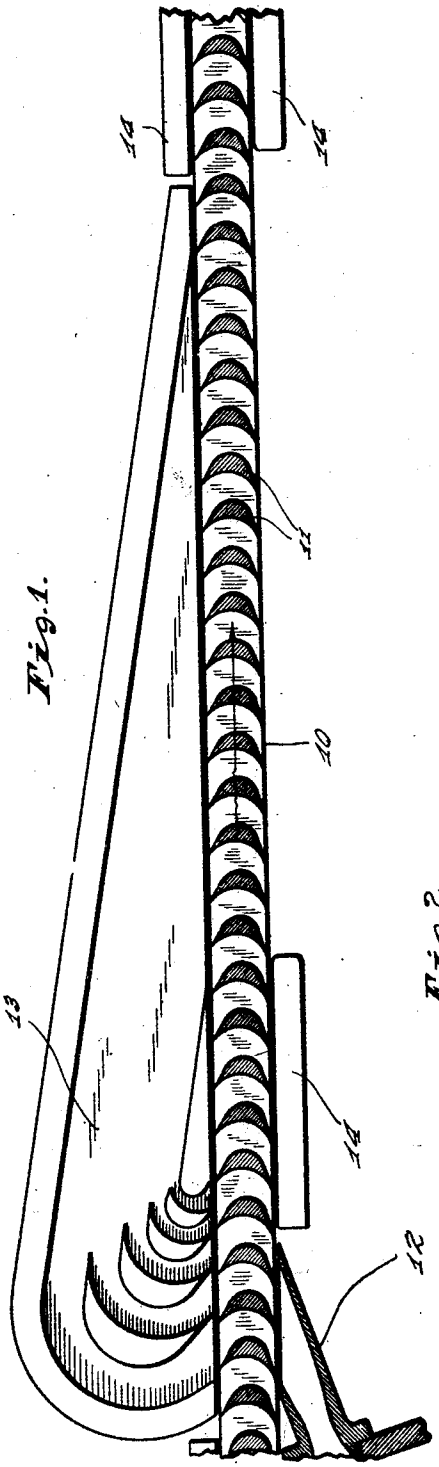


Fig. 1.

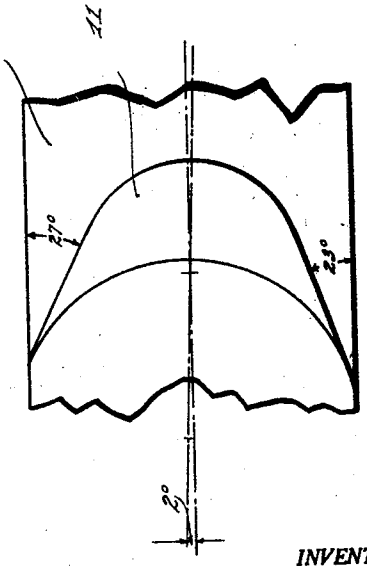


Fig. 2.

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UNITED STATES PATENT OFFICE.

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REENTRANT TURBINE.

Application filed May 11, 1923. Serial No. 638,153.

To all whom it may concern:

Be it known that I, HENRY H. WAIT, a citizen of the United States, residing at Anderson, in the county of Madison and State of Indiana, have invented a new and useful Reentrant Turbine, of which the following is a specification.

It is the object of my invention to increase the output of a re-entrant type turbine-wheel, so that the total power obtained from the steam in its passages through a re-entrant turbine-wheel of a given size may be increased.

Ordinarily, in turbine-wheels, when the edges of the movable blades are not symmetrically located, that edge of the movable blade which is toward the receiving or high-pressure side is farther advanced in the direction of rotation, and makes a less acute angle with the adjacent face of the turbine-wheel, than is and does the opposite edge of the blade. This dissymmetry is especially desirable in the reaction-type turbine; but is also sometimes used in the impulse-type turbine, though more frequently in the impulse-type turbine the blade-edges are symmetrically located.

Obviously, when the steam passes twice or more through a single turbine-wheel, as in the re-entrant type of turbine, the same steam enters such turbine-wheel first from one side, and then from the other. In other words, each side is at times a receiving side. It is impossible, however, that each edge of a blade be advanced farther and be less acute than the other edge. Therefore, it has been the usual practice in re-entrant turbines to locate the two edges of a blade symmetrically, so that such edges are substantially opposite each other, with neither edge advanced.

I have discovered, both from theoretical considerations and from actual demonstration, that in the re-entrant turbine there is an advantage in having that edge of the moving blade which last receives the steam more advanced in the direction of rotation, and at less acute angle to the adjacent wheel-face, than is the other blade-edge; and that thereby I can abstract more power from the steam in its passage through a re-entrant turbine-wheel of a given size than is otherwise possible.

By thus tilting the blades, the angle of the discharge end of the return-guide passage does not need to be so acute. Consequently a return-guide passage for a given amount of steam does not need to occupy so great a portion of the circumference of the wheel, or conversely a return-guide passage of larger cross-sectional area may be used on a given portion of the circumference of the wheel, when the wheel blades are tilted in accordance with my invention.

It is usual on turbines of the re-entrant type to place several nozzles and their corresponding return-guide passages around the circumference of the wheel, and the output is limited by the number and size of these nozzles and return-guides which will go in the circumference or that part thereof which is allotted thereto.

The output of a turbine may be increased by increasing the radial length of the wheel blades; but on slow-speed turbines this method of increasing the output cannot be carried very far without making the primary nozzle of undesirable proportions, and on high-speed turbines the length of the blades cannot be increased beyond certain limits without reducing their factor of safety to dangerous limits.

The present invention offers a desirable and safe means of increasing the total output either on slow-speed or high-speed turbines, but is especially desirable for the higher speeds because it reduces the length of the wheel-blades for a given output or conversely permits a greater output for a given space on the wheel circumference.

It is desirable that the jet of steam directed against the wheel blades from the nozzle or return guide should not strike the back or convex side of the revolving blades, as that would detract from the efficiency. Therefore the angle of the nozzle or passage which directs steam on to the wheel should be of such a value that the jet will clear the back of the blade. On account of the movement of the wheel-blades themselves the angle of the nozzle or return guide has to be more acute than the angle of the back of the blade, and the higher the speed of the blades relatively to that of the steam jet the greater must be the difference in the acuteness of the angle of the back of the blade and of the directing passage.

In re-entrant turbines part of the velocity of the steam jet is abstracted in each passage through the wheel. Therefore the steam as

last discharged from a return-guide passage is going much slower relatively to the blades than an earlier discharge, as at the primary nozzle, and so the discharge angle of the last-discharging return-guide must be much more acute. Tilting the wheel-blades in accordance with this invention thus makes it possible to have the discharge angle of the last-discharging return-guide less acute, thus reducing the necessary angular extent of such return-guide; and thereby making it possible to use a greater number of return guides in the circumference or a given part thereof. Such blade-tilting affects the proper angle of the return-guide passage by a very much greater angle than the angle of tilt of the wheel-blades. Therefore the gain in capacity by a slight tilting of the blades is very great.

While tilting the blades in this way decreases the discharge angle of the primary nozzle in two-passage turbine wheels, or of an intermediate return-guide in turbine wheels through which the steam passes more than twice, steam emerges from this nozzle or earlier return-guide at so much higher velocity than it does from the last-discharging return-guide that its angle is always less acute than that of such last-discharging return-guide; so that the primary nozzle or intermediate return-guide occupies relatively so little of the circumference in relation to the last-discharging return-guides that there is more than ample room for the increase in angular extent thereof that accompanies such decrease in discharge angle even for the greatest amount of blade-tilting.

The accompanying drawing illustrates my invention in its simplest form, in connection with a two-passage re-entrant turbine wheel: Fig. 1 is a fragmentary diagrammatic developmental view through such a re-entrant turbine wheel having blades mounted in accordance with my invention, with a nozzle and a return-guide associated therewith; and Fig. 2 is an enlargement of a fragment of Fig. 1, showing one of the blades and its back-tilted mounting.

The re-entrant turbine wheel 10, as usual, has a series of blades 11, properly shaped and spaced to provide between them steam passages which divert the path of the steam passing through the turbine wheel. Steam from any number of primary nozzles 12 is discharged obliquely into the spaces between the turbine blades, from the high-pressure or first-receiving side of the wheel 10; and on the other side of such wheel the steam which has passed once through the wheel is received by a corresponding number of return-guides 13 as it leaves the turbine-wheel the first time and is directed back by such return-guide against the other side of the turbine wheel, so that it will pass therethrough a second time. For simplicity, I have illustrated my invention with a two-passage turbine wheel, with return-guides on only that side of the turbine-wheel which is opposite the primary nozzles; and while that is probably the most advantageous form of my invention, it is merely illustrative and does not exclude from the scope of my invention reentrant turbine-wheels through which the steam passes more than twice. The turbine wheel may have associated with it a suitable shroud 14, as set forth in my co-pending application, Serial No. 626,401, filed March 20, 1923; but this shroud is not essential to my present invention. After passing a plurality of times through the turbine wheel 10, (twice as illustrated), the steam discharged from the turbine wheel, if desired, may be carried to other turbine wheels, as is also set forth in my aforesaid co-pending application; but the present invention is not concerned with what is done with the steam after it finally leaves the wheel 10.

The blades 11 are in general somewhat crescent-shaped, thick in the middle and thin at the edges, as is usual. Each blade per se is preferably substantially symmetrical, though this is not essential. According to my invention, each blade is mounted so that the angle of the blade-edge toward that side of the turbine wheel on which the last-discharging return-guides 13 are located is less acute than is the corresponding angle of the other blade-edge. To get this with the symmetrical blade which I prefer, that means that the middle line of the blade is slightly tilted with respect to the middle line of the wheel 10, so that the blade-edge toward the last-discharging return-guide side is advanced somewhat farther than is the other blade-edge. This tilting of the blade 11 is usually comparatively slight, being shown as 2° in Fig. 2; but this makes the difference in the angles between the blade faces at the two edges equal to twice the angle of such tilting, or 4° in the case shown. I have indicated this by angles of 23° and 27° on the primary-nozzle side and on the return-guide side respectively; but these angles of 23° and 27° are given merely to show the existence of this difference in angle and the fact that it is double the angle of tilting of the blade, and not to limit to any paricular values the angles of the blade-faces to the wheel-faces.

By reason of this arrangement of angles, in the two-passage turbine-wheel shown, the steam from the primary nozzle 12 is discharged against the blades 11 and into the spaces between them, preferably entering the turbine-wheels substantially parallel to the proper blade-faces at the blade-edge toward the nozzle-face of the wheel; and this steam is deflected by the concave face of each blade and discharged from the turbine

wheel into the return-guide. The steam in thus passing through the turbine wheel gives up part of its energy to produce movement of the turbine wheel, and loses part of its velocity. The steam received by the return-guide 13 is deflected thereby and discharged again against the blades 11 of the same turbine wheel, but from the other side. The steam thus discharged from the return-guide 13 into the re-entrant turbine-wheel for a second passage therethrough is at a lower velocity than when it was first discharged from the primary nozzle 12. This steam from the return-guide also enters between the blades substantially parallel to the proper blade-faces at the receiving blade-edge, which in this case is the blade-edge toward the return-guide blade-face, but does so at a less acute angle than would be necessary if the blades were not tilted. This steam is also deflected in its second passage through the wheel, by the concave faces of the blades, so that when the steam finally leaves the turbine-wheel, which in this two-passage turbine-wheel is the second time and is on the primary-nozzle face, it will do so at low speed, so that it will be relatively quiescent.

I claim as my invention:

1. In a re-entrant type turbine, the combination with a primary nozzle and a return-guide, of a turbine-wheel between the primary nozzle and the return-guide, which turbine wheel carries a series of blades the edges of which are farther advanced in the direction of rotation on the return-guide side of the turbine-wheel than on the primary-nozzle side thereof.

2. In a re-entrant type turbine, the combination with a primary nozzle and a return-guide, of a turbine-wheel between the primary nozzle and the return-guide, which turbine-wheel carries a series of blades which make a more acute angle with the face of the wheel at the primary-nozzle side than they do at the return-guide side thereof.

3. In a re-entrant type turbine, the combination with a primary nozzle and a return-guide, of a turbine-wheel between the primary nozzle and the return-guide, which turbine-wheel carries a series of blades which are symmetrical per se but are unsymmetrically mounted on the turbine-wheel so that the blade-edges at the return-guide side of the turbine-wheel are farther advanced in the direction of rotation than are those at the primary-nozzle side thereof.

4. In a re-entrant type turbine, the combination of a turbine-wheel which carries a series of blades, a plurality of directing discharge-passages arranged to discharge steam against the turbine-wheel so that the steam passes a plurality of times through the turbine-wheel, the edges of the blades on the turbine-wheel being farther advanced in the direction of rotation on that side of the turbine-wheel against which the steam is last discharged than on the other side thereof.

5. In a re-entrant type turbine, the combination of a turbine-wheel which carries a series of blades, a plurality of directing discharge-passages arranged to discharge steam against the turbine-wheel so that the steam passes a plurality of times through the turbine-wheel, the blades on the turbine-wheel being mounted so that they make a less acute angle at the face of the wheel against which the steam is last discharged than they do at the other face of the wheel.

6. In a re-entrant type turbine, the combination of a turbine-wheel which carries a series of blades, a plurality of directing discharge-passages arranged to discharge steam against the turbine-wheel so that the steam passes a plurality of times through the turbine-wheel, the blades on the turbine-wheel being symmetrical per se but being unsymmetrically mounted on the turbine-wheel so that the blade edges at that side of the turbine-wheel against which the steam is last discharged are farther advanced in the direction of rotation than are those at the other side of the turbine-wheel.

In witness whereof, I have hereunto set my hand at Indianapolis, Indiana, this 9th day of May, A. D. one thousand nine hundred and twenty-three.

HENRY H. WAIT.