United States Patent [19]

Deich et al.

[11] **3,756,740**

[45] **Sept. 4, 1973**

[54] **TURBINE STAGE**

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[22] Filed: **Aug. 13, 1971**

[21] Appl. No.: **171,589**

[52] **U.S. Cl.** ..... **415/170 R,** 277/53

[51] **Int. Cl.** **F04d 29/08**

[58] **Field of Search** ..... 415/191, 170 R; 417/170, 171, 172; 277/53, 54, 55, 56, 57

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[57] **ABSTRACT**

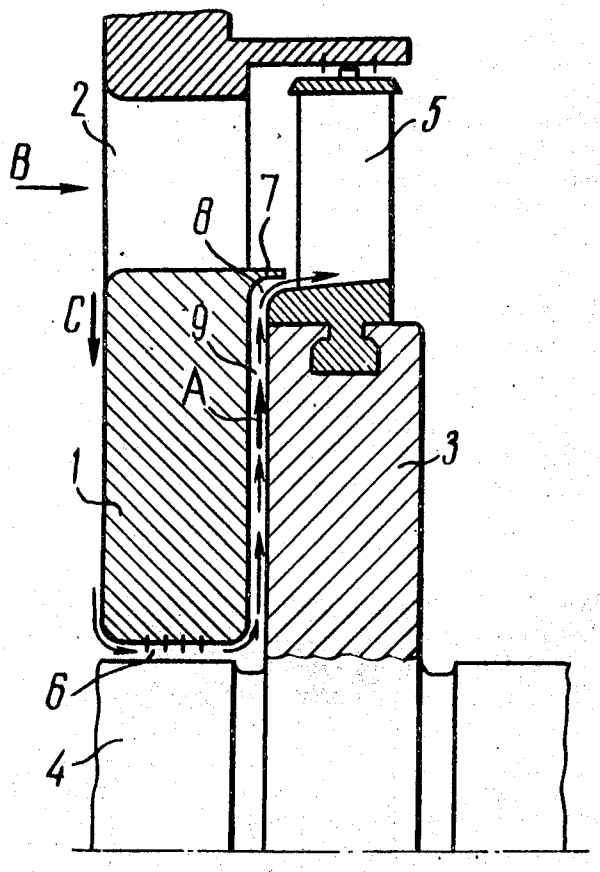
The present invention relates to turbine-building industry and, more particularly, the invention relates to improvements in turbine stages.

The proposed stage comprises a diaphragm with a nozzle ring and a rotor disk with moving blades. The disk is mounted behind the diaphragm with a gap so that the main flow of working medium forced from the nozzle ring acts on the moving blades of the rotor.

The gap between the disk and the diaphragm is an inter-rim gap.

Made on the end face of the diaphragm along the whole length of its root surface on the side facing the inter-rim gap is a projection which partially closes the root surface of the moving blade and forms with this surface an annular gap for passing the working medium.

1 Claim, 5 Drawing Figures



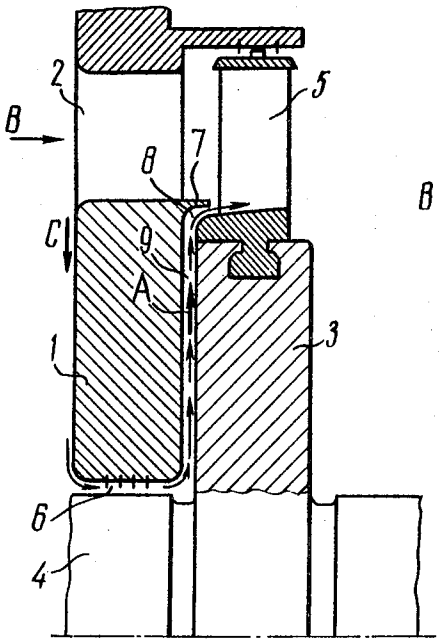


FIG. 1

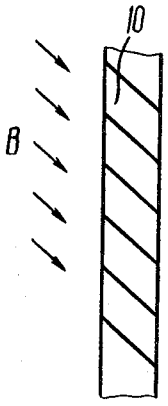


FIG. 2

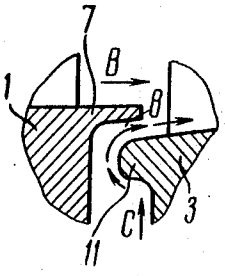


FIG. 3a

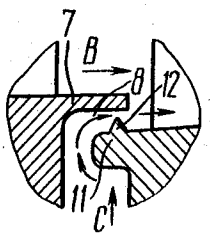


FIG. 3b

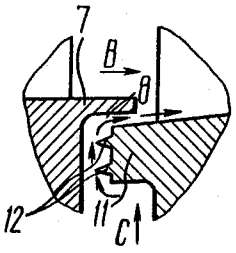


FIG. 3c

TURBINE STAGE

The present invention relates to turbine-building industry and, more particularly, has reference to an improved turbine stage which can be used both in single-stage and multistage turbines, for example, designed for driving an electric generator, a turbocompressor or used an aircraft engine.

It is known a turbine stage comprises a diaphragm with a nozzle ring and a disk of a rotor with moving blades. The turbine disk is mounted on a shaft extended through the diaphragm with a gap. The rotor disk is disposed behind the diaphragm so that the main flow of working medium from the nozzle ring acts on the moving blades of the rotor mounted on the shaft and rotates it.

Provided between the diaphragm and the shaft is a diaphragm gap, while between the faces of the diaphragm and the rotor disk there is provided so called an inter-rim gap. Through the diaphragm gap a portion of the working medium flows into the inter-rim gap due to the action of the pressure difference appearing in the nozzle ring of the diaphragm under the effect of expansion of the main flow of working medium.

As a result, a portion of the main flow of working medium bypasses the nozzle ring and enters the inter-rim gap, from which it swells into the main flow in front of the moving blades. For the sake of brevity the portion of the main flow of working medium entering the inter-rim gap will be further referred to as a leakage. Such a leakage is unavoidable in an actual turbine stage due to the presence of gaps between separate elements of the rotor and stator of the turbine. Hence, the leakage through the inter-rim gap does not take part in the development of power of the stage and results in an increase in consumption of working medium so that the effiency of the stage, as well as of the entire turbine, is considerably reduced.

Furthermore, the leakage through the inter-rim gap features a radual direction of the outlet and enters the main flow in front of the moving blades of the turbine rotor perpendicular to the main flow of working medium moving in an axial direction. This also reduces the efficiency of the turbine stage, because the velocity field of the main flow in front of the moving blades is distorted.

In order to reduce the leakage of working medium through the inter-rim gap, the latter is provided with a labyrinth packing consisting of a number of series-connected narrow pass sections for the working medium and made on the face of the rotor disk or of the diaphragm in the form of combs whose points are close to the face of the diaphragm or the rotor disk.

The labyrinth packing makes it possible only to reduce the leakage of working medium without turning it in an axial direction, i.e. in the direction of the main flow of working medium. The application of a single labyrinth packing permits the efficiency of a turbine stage to be increased to a small degree, because the clearances of the labyrinth packing increase in the process of operation of the turbine due to thermal expansions.

An object of the present invention is to increase the efficiency of a turbine stage.

This and other objects are accomplished due to the fact that the turbine stage formed by a diaphragm with a nozzle ring and with a rotor disk carrying moving

blades mounted behind the disk in the direction of movement of the main flow of working medium, according to the invention, has a projection located on the face of the diaphragm along the whole length of its root circle on the side facing the gap between the diaphragm and the disk of the rotor which partially closes the root surface of the moving blade and forming therewith an annular gap for passing the working medium.

Such a making of the turbine stage not only reduces the leakage of working medium through the inter-rim gap but also directs the leakage in the axial direction essentially coinciding with the direction of the main flow of working medium. This results in partial utilization of the energy of the leakage on the moving blades of the rotor of the stage, therefore, to a considerable increase in the efficiency of the stage and the turbine as a whole.

The internal surface of the projection is preferably provided with grooves inclined at an angle approximately equal to the angle α of the nozzle ring.

The bevel grooves on the internal surface of the projections turn the leakage to the side of rotation of the turbine rotor.

Such a twisting of the leakage makes it possible to utilize the energy of the leakage on the moving blades of the rotor, thus increasing the efficiency of the turbine stage. The turbine stage accomplished according to the present invention at a 3 percent leakage (as compared with the main consumption of working medium) has an efficiency 4 to 5 percent higher than the turbine stage provided with a conventional packing of the inter-rim gap having one or several combs.

Further objects and advantages of the present invention will be apparent from the following detailed description of some embodiments thereof taken in connection with the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional view of the turbine stage according to the invention;

FIG. 2 is a view along the arrow A in FIG. 1;

FIG. 3 a, b, c are modifications of the turbine stage at a section of the inter-rim gap.

The turbine stage (FIG. 1) comprises a diaphragm 1 with a nozzle ring 2 and a disk 3 of the rotor. Passed with a clearance through the diaphragm 1 is a shaft 4 mounting the disk 3 of the rotor with moving blades 5. Provided between the diaphragm 1 and the shaft 4 is so called diaphragm gap 6. On the face of the diaphragm 1 along the entire length of its root circle is a projection 7. The projection 7 is made in the form of a lip which partially closes the root surface of the moving blade 5 and forms with the root surface an annular gap 8 for passing a portion of working medium further referred to as leakage and denoted as C in FIG. 1.

Provided between the diaphragm 1 and the disk 3 of the rotor is so called an inter-rim gap 9. Made on the internal surface of the projection 7 are grooves 10 (FIG. 2) inclined at an angle α of the nozzle ring 2 and the diaphragm 1. The angle α is an angle formed by the direction of the flow and the inlet edge (not shown).

The proposed turbine stage operates as follows.

The working medium such as gas or steam forced from the nozzle ring 2 of the diaphragm 1 and having an axial direction (indicated by the arrow B in FIG. 1) acts on the moving blades of the rotor and rotates it. Under the action of the pressure difference appearing on the diaphragm 1 a portion of the main flow of working medium or "leakage" bypasses the nozzle ring 2

and enters the diaphragm gap 6 as shown in FIG. 1 by the arrow C. Such a leakage is unavoidable in an actual turbine stage.

Through the diaphragm gap 6 the leakage (as shown by the arrow) flows into the inter-rim gap 9 under the action of a pressure drop appearing in the nozzle ring 2 of the diaphragm 1 due to the expansion of the main flow of working medium in this gap. The leakage flowing through the inter-rim gap 9 enters the annular gap 8 formed by the projection 7 partially closing the root surface of the moving blade 5. Within the annular gap 8 the leakage is turned (as shown by the arrow) and takes the direction of the main flow. The bevel grooves 10, which may be made on the internal surface of the projection, twist the leakage in the direction of rotation of the rotor (shown in FIG. 1 by the arrow D). Such twisting of the leakage makes it possible to utilize its energy on the moving blades of the rotor, therefore, to increase the efficiency of the stage.

The packing of the inter-rim gap in the proposed turbine stage may be made in various modifications (FIG. 3*a*, *b*, *c*). In FIG. 3 a the annular gap 8 for passing the leakage is formed due to partial closure of the shoulder 11 made on the end face of the root surface of the moving blade 5 by the projection 7. In this case the leakage passing through the inter-rim gap 9, before entering the annular gap 8 makes an additional turn (as shown by the arrow in FIG. 3*a*) so that such a leakage is reduced.

The packing of the inter-rim gap shown in FIG. 3*b* differs from the above-described construction only in that the shoulder is provided with a comb 12 facing the projection 7. The comb 12 ensures an additional sealing of the inter-rim gap 9 which reduces the leakage due to lowering the gap between the projection 7 of the diaphragm 1 and the shoulder 11.

The combs may be made on the end face of the shoulder 11, (FIG. 3*c*) facing the inter-rim gap 9. This considerably decreases the leakage of working medium. However, in this case the operational rebiality of the inter-rim packing 9 is somewhat deteriorated if the magnitude of the gap under the combs is substantially reduced.

We claim:

1. A turbine stage comprising, in combination: a diaphragm having a ring of inclined nozzles, a shaft passing through said diaphragm so as to form an annular gap therewith; a rotor disk with rotatable blades mounted on said shaft downstream of said diaphragm and forming a gap in the direction of movement of the main flow of a working medium; an annular projection made on the end face of said diaphragm extending about the entire circumference of its root circle at the side facing the gap between said diaphragm and said disk, said projection having a plurality of annularly spaced grooves on its internal surface, said grooves being inclined in an axial direction at an angle approximately equal to that α of said inclined nozzles; and an annular gap for passing the working medium being formed between said projection and said disk partially closing the space between the root surface of said moving blade and said root circle whereby leaked fluid passes over the root surface of the rotor disk in the same direction as the main flow fluid passing through said rotor blades.

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