July 16, 1968 R. N. PENNY ET AL 3,392,958

ADJUSTABLE NOZZLE GUIDE VANE ASSEMBLY FOR AN AXIAL FLOW TURBINE

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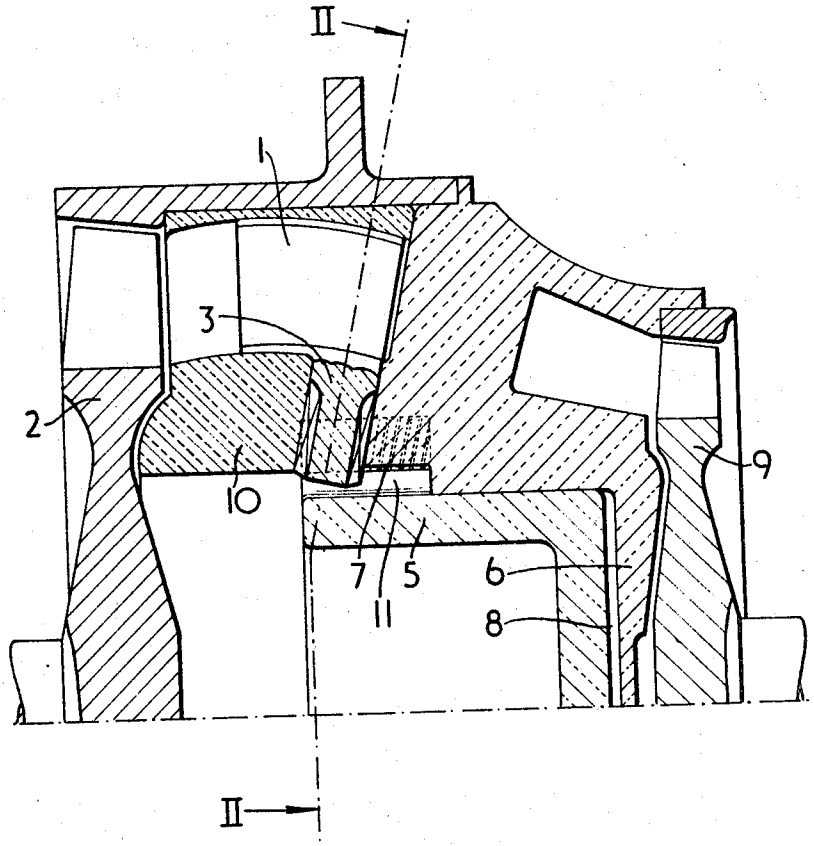


FIG. 1.

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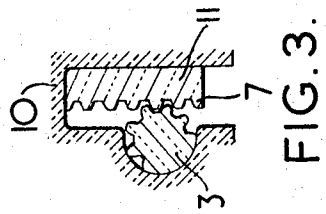


FIG. 3.

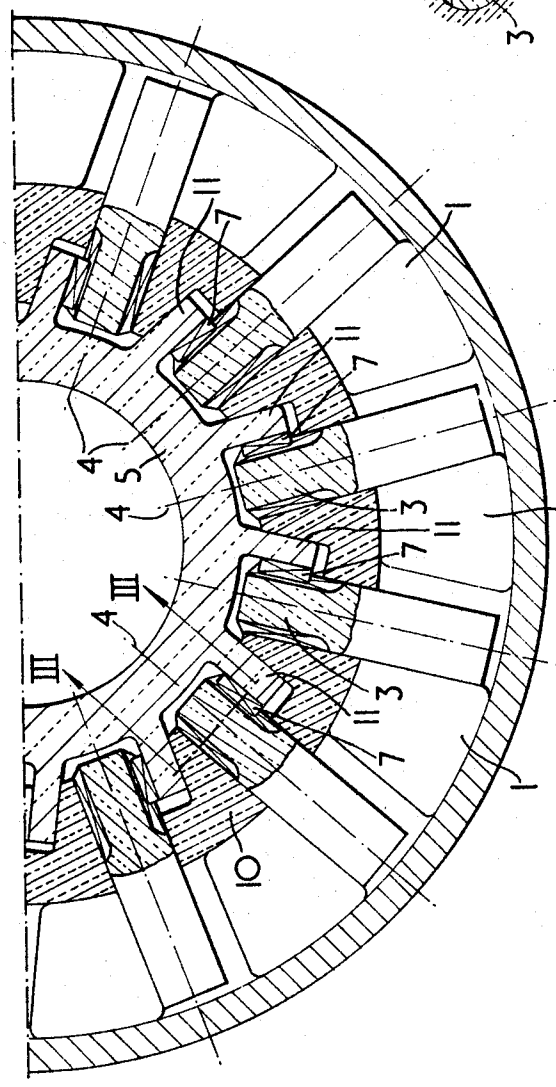


FIG. 2.

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ADJUSTABLE NOZZLE GUIDE VANE ASSEMBLY FOR AN AXIAL FLOW TURBINE

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5 Claims. (Cl. 253—78)

ABSTRACT OF THE DISCLOSURE

An adjustable nozzle guide vane assembly, for a turbine of the axial flow type, including nozzle guide vanes spaced apart circumferentially about the axis of the turbine in a circle and each mounted for turning about at an axis extending transversely to the axis of the turbine, a pinion carried by each vane and a piston co-axial with the circle of vanes and carrying circumferentially-spaced, axially-extending toothed rack portions, each engaging a respective pinion, whereby axial movement of the piston will turn the vanes about their respective axes.

The invention relates to an adjustable nozzle guide vane assembly for a turbine of the axial flow type.

In known nozzle guide vane assemblies, the vanes are turned by a common operating ring which is moved circumferentially about its axis. A circumferentially-movable operating ring is unsuitable for a turbine subject to a high operating temperature, e.g., of the order of 1100° C., as provision has to be made to allow for radial and circumferential expansion and contraction of the operating ring.

According to the invention, an adjustable nozzle guide vane assembly for a turbine of the axial flow type comprises a plurality of nozzle guide vanes spaced apart circumferentially about the axis of the turbine in a circle and each mounted for turning about at an axis extending transversely to the axis of the turbine, a pinion integral with or attached to each vane and an axially movable operating member co-axial with the circle of vanes and carrying a plurality of circumferentially-spaced, axially-extending toothed rack portions, each engaging a respective pinion, whereby axial movement of the operating member will turn the vanes about their respective axes.

Conveniently, the operating member is a piston mounted in a cylinder co-axial with and positioned radially within the circle of vanes, the piston having a skirt portion extending from the cylinder and formed on its outer peripheral surface with the said toothed rack portions, and the cylinder having inlet and outlet means through which operating fluid is arranged to be passed.

The operating fluid may be compressed air bled from a compressor of a gas turbine engine of which the turbine is a component. The supply of operating fluid to and from the cylinder and therefore the operation of the piston may be controlled by the operator of the gas turbine engine or it may be operated automatically, for example to maintain the turbine inlet temperature substantially constant.

The axis of turning of each vane may be coincident with the longitudinal axis through the center of pressure of the vane or it may be offset chordwise of the vane from said longitudinal axis. In the latter case, the loading of the working fluid on the vane can be used to assist or to oppose the torque applied to a vane by the pinion.

The piston and the cylinder are conveniently made of a ceramic or other non-metallic material capable of withstanding a high operating temperature, e.g., of the order of 1100° C., thereby to avoid seizure of the piston in the cylinder. The vanes and their pinions may also be made of a ceramic or non-metallic material capable of withstanding a high operating temperature.

The invention also includes a gas turbine engine having an adjustable nozzle guide vane assembly as set out hereinbefore.

An adjustable nozzle guide vane assembly for an axial flow turbine of a gas turbiine engine will now be described, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is an axial section through the assembly;

FIGURE 2 is a half section on the line II—II in FIGURE 1, and

FIGURE 3 is a scrap section on the line III—III in FIGURE 2.

Referring to the drawings, the assembly comprises a plurality of nozzle guide vanes **1** spaced apart circumferentially in a circle co-axial with a low pressure turbine **2** and positioned between the low pressure turbine **2** and a high pressure turbine **9**. Each vane **1** has an integral pinion **3** by which the vane can be turned about an axis **4** (see FIGURE 2), thereby to alter the nozzle angle. The pinions **3** are mounted in a block **10** and are arranged to be turned in unison by axial movement of a piston **5** arranged co-axially of the turbine **2** and the circle of vanes **1**. The piston **5** is movable axially in a cylinder **6** abutting the block **10**. The outer periphery of the piston **5** has a plurality of outwardly-extending ribs **11** formed with axially-extending toothed rack portions **7**, spaced apart circumferentially around the periphery of the piston and each drivingly engaged with a respective pinion **3**. Compressed air is bled from a compressor (not shown) of the gas turbine engine and is introduced through means (not shown) into the end part **8** of the cylinder **6** adjacent the head of the piston **5**, thereby to cause the piston **5** to move axially within the cylinder **6**. The axial movement of the piston **5** will cause the pinions **3** to be turned simultaneously about their axes **4**, thereby to turn the respective guide vanes **1**. The supply and exhaust of compressed air from the end **8** of the cylinder may be controlled by the operator of the engine or the operation may be automatic, for example to maintain the inlet temperature of the turbine **2** substantially constant. The axis of turning of each vane **1** is offset chordwise of the vane from the longitudinal center-line thereof through the center of pressure, whereby the fluid loading on the vane can be used to assist or to oppose the torque applied to the vane by the pinion **3**. The vanes **1**, the pinions **3**, the piston **5**, the ribs **11**, the toothed rack portions **7**, the block **10** and the cylinder **6** are all made from a ceramic or other non-metallic material capable of withstanding a high operating temperature, e.g., of the order of 1100° C. By using these materials, the adjustable nozzle guide vane assembly provided by this invention can be successfully used in the very hot region between the turbines **9** and **2**, where adequate cooling is not practicable.

What we claim as our invention and desire to secure by Letters Patent of the United States is:

1. An adjustable nozzle guide vane assembly for a turbine of the axial flow type, the assembly including a plurality of nozzle guide vanes spaced apart circumferentially about the axis of the turbine in a circle and each mounted for turning about at an axis extending transversely to the axis of the turbine, wherein the improvement comprises a pinion carried by each vane, an axially movable operating member co-axial with the circle of vanes and a plurality of circumferentially-spaced, axially-extending toothed rack portions, carried on said operating member and each engaging a respective pinion, whereby axial movement of the operating member will turn the vanes

about their respective axes, said operating member, said rack portions, said pinions and said vanes being made of a ceramic material.

2. An assembly as claimed in claim 1 in which the operating member is a piston mounted in a cylinder coaxial with and positioned radially within the circle of vanes and the piston has a skirt portion extending axially of the cylinder and formed on its outer peripheral surface with the said toothed rack portions.

3. An assembly as claimed in claim 2 in which the cylinder includes fluid inlet means arranged to receive compressed air bled from a compresosr of a gas turbine engine of which the turbine is a component.

4. An assembly as claimed in claim 1 in which the axis of turning of each vane is coincident with the longitudinal axis through the center of pressure of the vane.

5. An assembly as claimed in claim 1 in which the axis of turning of each vane is offset chordwise of the vane from the longitudinal axis through its center of pressure.

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