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[54] **VARIABLE VANES**
9 Claims, 6 Drawing Figs.

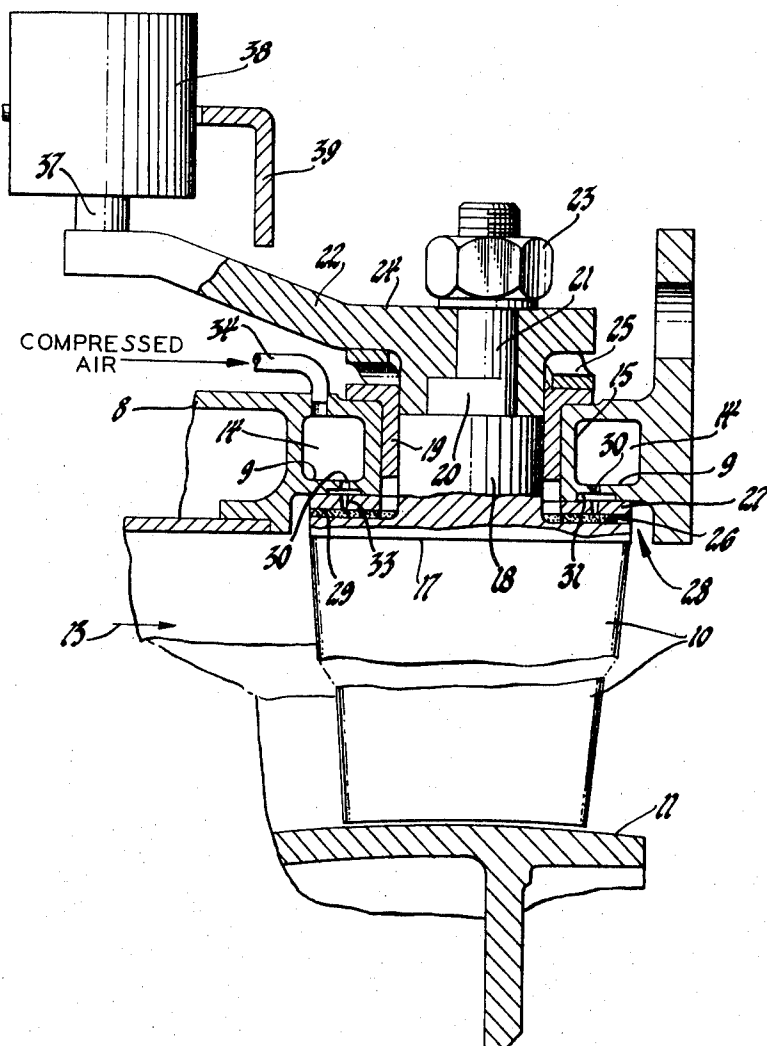
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308/(Consulted); 230/114(H); 415/160

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ABSTRACT: A variable vane ring for a turbine includes cantilevered vanes each of which has a stem mounted in a bushing in the outer shroud of the turbine nozzle. A gas-lubricated porous metal thrust bearing disposed between the vane and the shroud is of sufficient size that the resultant force from the loadings on the vane passes through the thrust bearing so that tilting moments need not be carried by the stem. Conventional linkage is provided to rotate the vanes in unison to change the blade angle of the vane cascade.



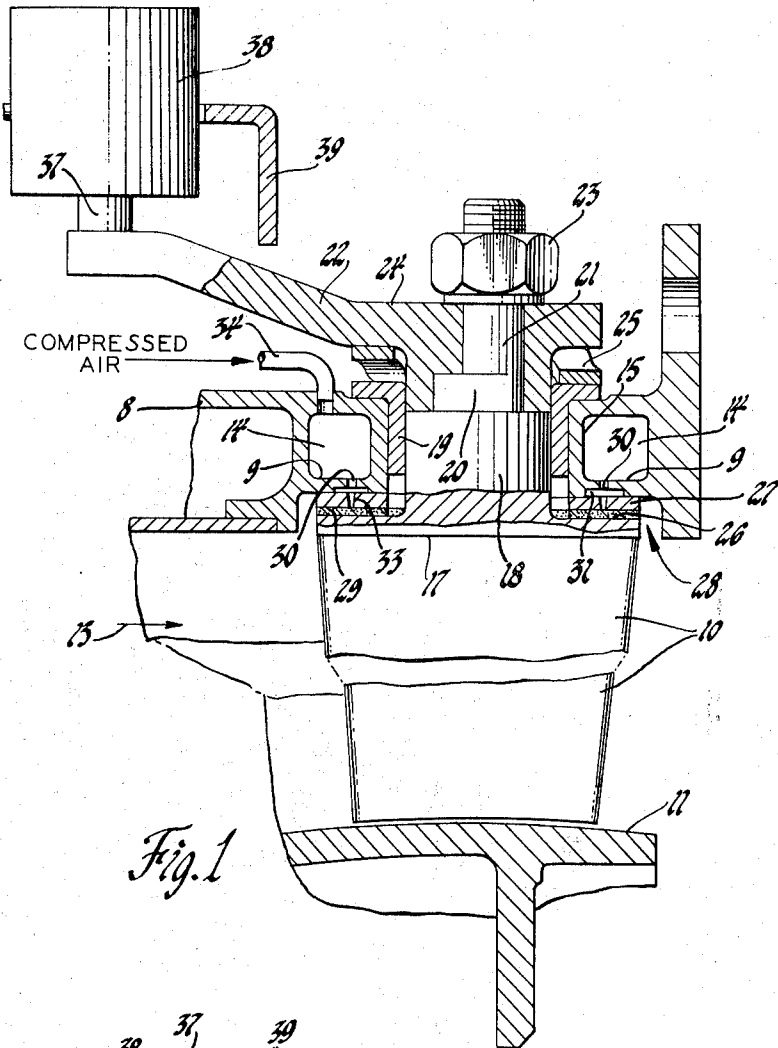


Fig. 1

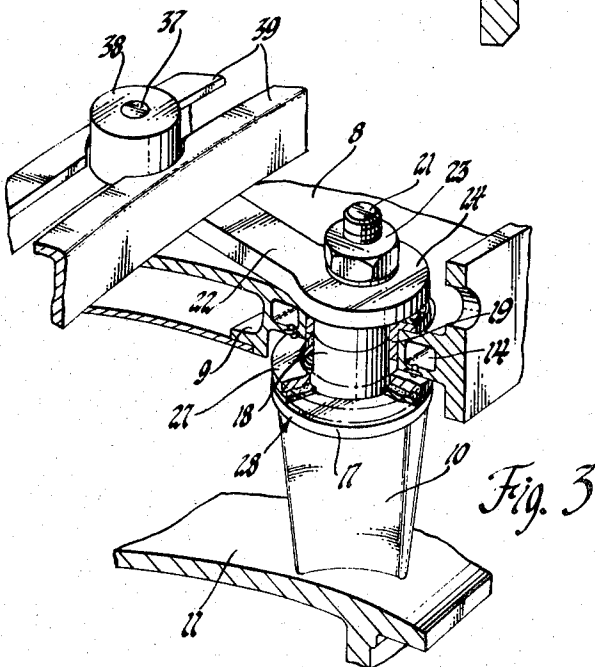


Fig. 3

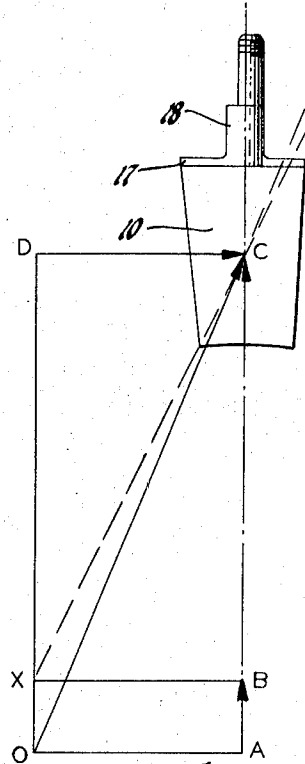
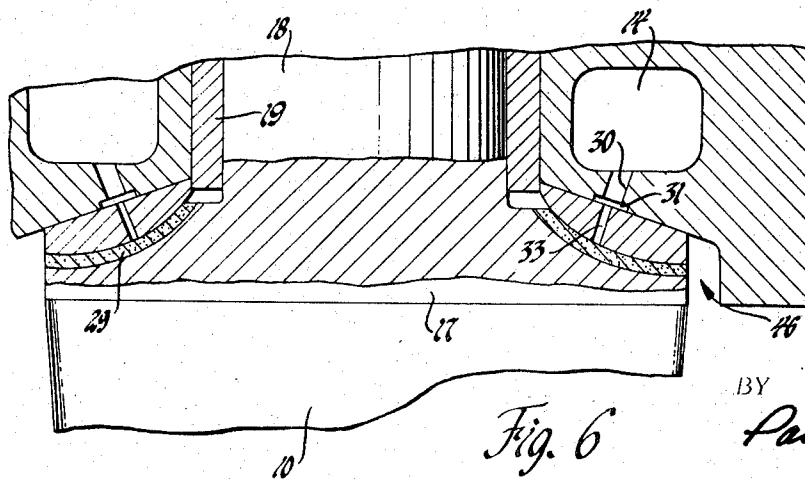
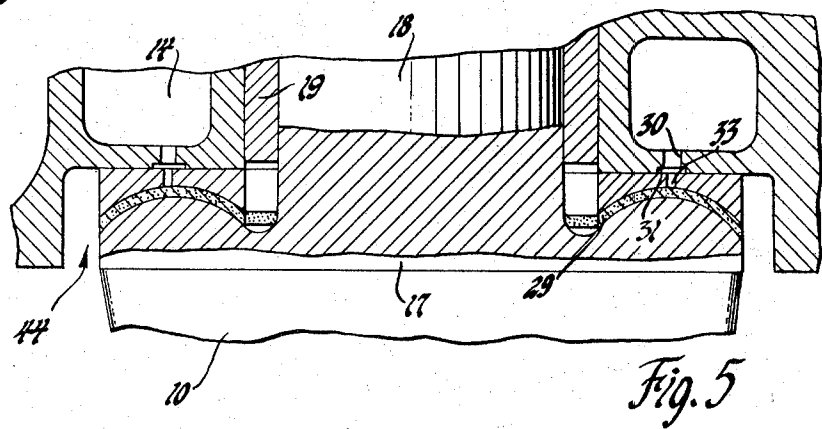
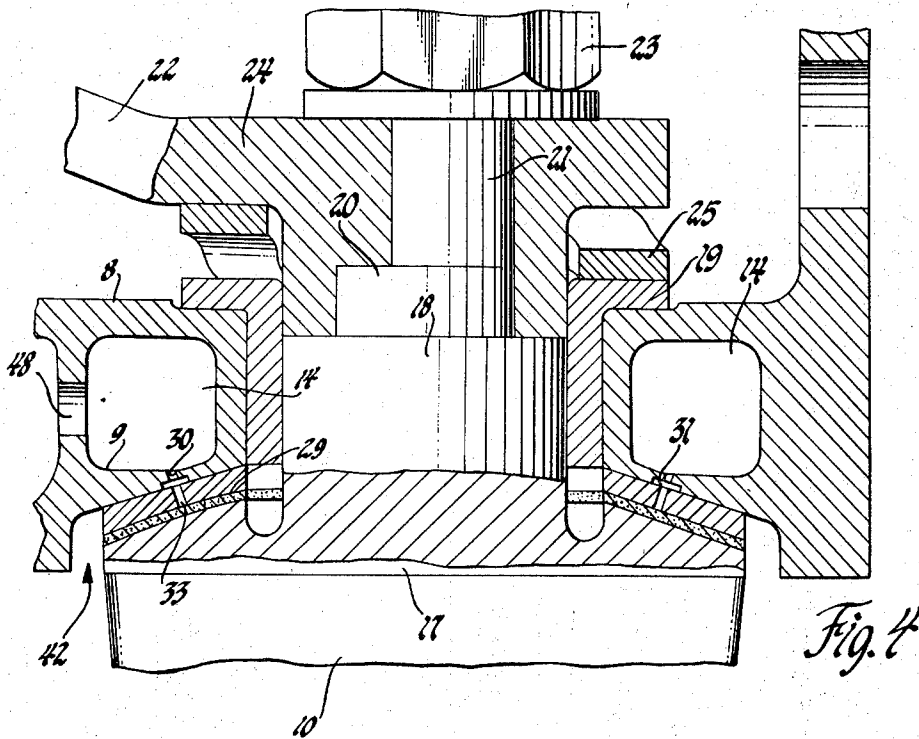


Fig. 2

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VARIABLE VANES

My invention is directed to vane rings in which the setting or blade angle of the vanes may be varied, and particularly to such a vane ring especially suited for use in high temperature turbines.

There have been various proposals to put variable angle vane rings in turbines to control or vary the operation of the turbine in one way or another. These may, for example, adapt the turbine to varying loads, balance output between successive turbines in a series, or reverse rotation of turbines. Similar variable vane rings are used in compressors to cause them to operate efficiently at varying air flows or rotational speeds.

The principal object of my invention is to provide a variable vane ring well suited to the requirements of high temperature turbines, particularly through the use of improved bearing means for supporting the vanes, absorbing the force exerted by the vane on the support while providing for free rotation of the vane in its support; all this with a structure well adapted to withstand the high temperatures associated with gas turbines and other such machinery. It is a further object of my invention to provide a variable vane installation in which the vane is supported principally by a thrust bearing which encompasses the force vector generated by the gas and other loads on the vane. More generally, it is an object of my invention to provide a freely rotatable turbomachine vane support suited for high temperature operation.

The nature of my invention and the advantages thereof will be clear to those skilled in the art from the succeeding detailed description of preferred embodiments of the invention and the accompanying drawings thereof.

FIG. 1 is a sectional view of a turbine nozzle taken on a plane containing the axis thereof.

FIG. 2 is a force diagram.

FIG. 3 is an axonometric view illustrating an actuating mechanism for the vanes.

FIG. 4 is a view similar to FIG. 1 illustrating a spherical thrust bearing.

FIG. 5 is a view similar to FIG. 1 illustrating a concave thrust bearing.

FIG. 6 is a view similar to FIG. 1 showing a convex thrust bearing.

Referring first to FIG. 1, the engine includes a turbine case 8 which is of double-walled construction, the inner wall defining an outer shroud 9 of a turbine nozzle. An annular row or cascade of turbine nozzle vanes 10 extend from the outer shroud 9 substantially into contact with an inner shroud 11. This inner shroud is connected to and supported from the turbine case 8 by any suitable structure (not illustrated). A flow path 13 for hot gas is defined between the shrouds 9 and 11 and through the cascade defined by vanes 10. An annular air space 14 extends around the engine between the inner and outer walls of the case. Hollow bosses 15 which define a mounting for the vanes extend across the air space 14 radially of the engine. Each vane includes a circular base or platform 17 and a cylindrical stem 18, the stem being journaled in a flanged bushing 19 pressed into the hollow boss 15. Stem 18 includes a reduced portion 20. An offset shaft 21 integral with stem 18 mounts, with portion 20, an actuating arm 22 which is nonrotatable on the shaft 21 and is retained by a nut 23 threaded onto the end of the shaft. The vane is biased radially outwardly of the engine by a wave spring 25 slightly compressed between the flange of bushing 19 and the hub 24 of arm 22.

The base 17 of the vane has a radial face 26 which forms one portion of a thrust bearing 28, the other portion being defined by a bearing ring 27 fixed to the shroud 9. Bearing ring 27 has an annular facing 29 of porous metal which may be sintered porous metal or laminated porous metal, or any high temperature resistant porous material through which air under pressure will flow at a suitably controlled rate. Air is supplied to the facing 29 from the air space 14 through a metering hole or holes 30 to an annular recess 31 in the shroud 9 surrounding the boss 15. A number of closely spaced small air distribu-

tion holes 33 conduct the air through the bearing ring 27 into the porous facing 29. The air seeps through the facing and into the interface between the facing and the face 26 of the vane. The air flowing through the slight gap between the facing and the base of the vane minimizes friction which would resist adjustment of the vane. This air, as well as any flowing from the edges of the facing, provides a cooling flow past the base of the vane which is cooled thereby and thus serves to some extent as means for cooling the rest of the vane.

The air by which the air bearing is lubricated and cooled may come from any suitable source such as the compressor of the engine, either directly or through the combustion chamber air jacket. In FIG. 1, an air inlet from any suitable source is indicated at 34.

Referring now to FIG. 2, the nature of the forces exerted on the vane is illustrated. Vector BC represents the force due to the static pressure of gas in the nozzle exerted on the area of the base of the blade. This force is directed axially of the stem 18. Vector d.c. represents the gas load; that is, the force exerted on the blade by the air stream passing by, which is essentially the resultant of the lift and drag of the blade airfoil. The vector AB which is also directed axially of the blade represents the relatively small force exerted by the spring 25 which acts to keep the blade seated against its bearing when the engine shuts down. Thus, the resultant of the forces exerted on the blade, exclusive of that of the spring, is the vector XC making an angle with the axis of rotation of the blade, and the total force exerted on the blade is the vector OC. There will, of course, be both radial and axial forces exerted on the base and stem of the blade to counteract these loads. In the form shown in FIGS. 1 and 2, the axial forces are borne entirely by the thrust bearing surface 26 and the transverse loading by the stem 18.

By making the base 17 of sufficient size to surround or contain the vector OC, there is no overturning moment exerted on the stem 18. Or, in other words, the bearing 19 does not have to exert a torque on stem 18 to resist a torque exerted by the gas loads. This, of course, assures that the loads on the stem 18 are relatively slight and that the resistance to rotation of the vane will be moderate. The considerably heavier axial force is exerted against the air bearing which has a low coefficient of friction.

Obviously, the area of the gas bearing is less than that of the blade face so that the effective pressure on the gas bearing must be greater than the static pressure within the turbine nozzle. The desirable value of pressure can be determined by calculation or by experiment. The rate of supply of the air can be controlled by holes 30 or 33 to achieve the desired results without waste of the air. The static pressure within the nozzle ordinarily is substantially less than the total pressure, depending upon the nature of the turbine, since the velocity of flow through the nozzle may be quite high. In some cases the static pressure within the nozzle is very low. Therefore, in some cases it may be feasible to use combustion chamber jacket air or compressor seal leakage air, or some such source, for the supply of bearing air to line 34. In other cases some special provision might be made to develop a higher pressure than those present in the motive fluid path of the engine.

FIG. 3 illustrates generally a type of linkage for concurrent rotation of the vanes. In this structure the actuating arm 22 bears a spindle 37 on which is mounted a roller 38. The rollers 38 are engaged in notches in two actuating rings 39 which are suitably coupled together and to a suitable power device or actuator to move the rings circumferentially of the turbine case and thus change the blade angle of all the vanes simultaneously.

FIGS. 4, 5, and 6 show installations similar to that of FIG. 1 except that the air bearings are not flat and are capable of handling some radial loads. In FIG. 4, the bearing is a zone of a sphere; in FIG. 5 it is a concave surface of revolution; and in FIG. 6 a convex surface of revolution.

In these FIGS. parts corresponding to those of FIGS. 1 and 2 have the same numerals notwithstanding different shapes. The

spherical bearing of FIG. 4 is given number 42, the concave bearing of FIG. 5 has number 44, and the convex bearing of FIG. 6 has 46. These configurations may be adopted so that a measure of side thrust can be taken by the air bearing to increase the ease of operation of the bearing by taking some of the load or all of the gas load off the actuating stem 18.

FIG. 4 illustrates the provision of one or more holes 48 to lead air to the chamber 14 from which it is supplied to the air bearing. Hole 48 in the turbine case may communicate, for example, with the combustion chamber jacket.

It will be apparent to those skilled in the art that my variable vane arrangement provides a structure which is relatively easy to rotate and which is resistant to high temperatures. The material of the air bearing may be a high temperature alloy or ceramic material which is resistant to heat. The circulation of air helps to cool the blade, and the air bearing may be configured to serve both as a thrust bearing and as a partial axial bearing to absorb transverse loads.

The detailed description of preferred embodiments of the invention for the purpose of explaining the principles thereof is not to be considered as limiting the invention, since many modifications may be made by the exercise of skill in the art.

I claim:

1. A variable nozzle for a high-temperature turbine comprising, in combination, a first shroud and a second shroud defining between them an annular gas flow path, an annular cascade of vanes cantilever mounted on the first shroud and

extending adjacent to but unsupported by the second shroud, each vane having a pivotal mounting on the first shroud defining an axis of rotation extending spanwise of the vane, the pivotal mounting including a pressurized gas lubricated porous thrust bearing between the vane and the first shroud, the thrust bearing surrounding the location of the resultant force vector of the various forces exerted on the vane other than those exerted by the pivotal mounting.

2. A nozzle as recited in claim 1 in which the pivotal mounting includes also a stem on the vane and a radial bearing on the first shroud coacting with the stem.

3. A nozzle as recited in claim 2 in which the thrust bearing is substantially flat and radial.

4. A nozzle as recited in claim 1 in which the thrust bearing is flat.

5. A nozzle as recited in claim 1 in which the thrust bearing is a spherical zone.

6. A nozzle as recited in claim 1 in which the thrust bearing is a surface of revolution concave toward the vane.

7. A nozzle as recited in claim 1 in which the thrust bearing is a surface of revolution convex toward the vane.

8. A nozzle as recited in claim 1 in which the thrust bearing has an extension axially of the said axis so as to accept loads transverse to the axis.

9. A nozzle as recited in claim 1 in which each vane includes a circular base forming one element of the said thrust bearing.

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