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(54) Stator vane with inner and outer shroud

(57) Vibration induced compressor vane failure from tip leakage vortex bursting is eliminated or minimized. By securing the vane at opposite ends to inner and outer stationary casings (44, 42), tip leakage is entirely avoided hence avoiding the mechanism for inducing vibration. By contouring the inner surface of the flow path to converge the flow in a downstream direction with a cantilevered compressor vane having a vane tip spaced from the inner casing surface, airflow lift off is precluded or minimized maintaining the flow attached to the flowpath surfaces with consequent avoidance of tip vortex induced vibration.

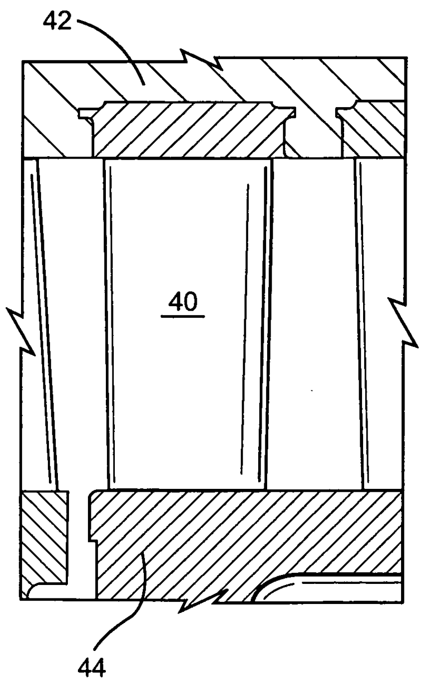

Fig. 3

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Description

[0001] The present invention relates to stator vanes in a compressor between inner and outer stationary components and particularly relates to apparatus for minimizing or eliminating tip leakage vortex bursting.

[0002] In compressors for turbines, stator vanes are typically mounted on a fixed or stationary casing surrounding a compressor rotor mounting buckets. Thus, air flowing into the compressor is compressed and heated for flow to various components of the turbine. At the aft end of the compressor, the stator vanes fixed to the outer stationary component are cantilevered in a radial inward direction and have tips spaced from an inner stationary component. These stator vanes at the aft end of the compressor are typically used to straighten the flow from the compressor. As the compressed air flows through the flow path defined between the inner and outer stationary components, a portion of the compressed air flows about the tip of the cantilevered stator vanes from the high pressure side to the low pressure side of each of vane, i.e. from the concave side to the convex side. As the flow passes between the tip and the inner stationary component, however, it forms a vortex. Under certain aerodynamic conditions, it has been discovered that the vortex as it bursts from the vane tips can cause a frequency of vibration in the stator vanes which reinforces the blade natural frequency. This can lead to failure of the compressor stator vanes. Accordingly, there is a need for apparatus which will minimize or eliminate tip leakage vortex bursting with consequent induced vibration such that stator vane failure resulting from such induced vibration is reduced or eliminated.

[0003] In an embodiment of the invention there is provided a compressor comprising: inner and outer stationary casings; and a plurality of stator vanes extending between and secured at radially opposite ends to said inner and outer casings thereby eliminating tip leakage between opposite sides of each stator vane and stator vane vibration induced by tip leakage vortex bursting.

[0004] In an embodiment of the invention, there is provided a compressor comprising: a stator vane segment including a plurality of stator blades and inner and outer stationary shrouds about the blades eliminating tip leakage along the inner shroud and between opposite sides of the inner ends of the stator blades.

[0005] In a further embodiment of the invention, there is provided a compressor comprising: a stator vane segment including a plurality of stator blades and a radial outer shroud, a stationary inner casing spaced from a tip of the stator blades and having a contoured surface exposed to the flow path for converging the flow in a downstream direction.

[0006] Various embodiments of the invention will now be described in connection with the accompanying drawings, in which:

FIGURE 1 is a fragmentary schematic cross-sectional illustration of a compressor and turbine;

FIGURE 2 is a fragmentary cross-sectional view of a configuration of a compressor at the aft end of the compressor according to the prior art;

FIGURE 3 is a fragmentary cross-sectional view illustrating a stator vane between stationary components according to an aspect of the present invention;

FIGURE 4 is a view similar to Figure 3 illustrating a further aspect of the present invention;

FIGURE 5 is a perspective view of a compressor vane segment according to an aspect of the present invention; and

FIGURE 6 is a view similar to Figure 4 illustrating a further aspect of the present invention.

[0007] Referring now to Figure 1 there is illustrated a compressor section generally designated 10 and a turbine section generally designated 12. It will be appreciated that the compressor 10 compresses and heats air for use by various portions of the turbine 12. Also illustrated is one of a plurality of combustor cans 14 wherein a portion of the compressed air from compressor section 10 is mixed with fuel and combusted for flow into the various stages of the turbine 12. The turbine converts the pressurized heated combusted gases into mechanical rotational energy whereby the rotation of the turbine rotor can perform useful work, e.g., when coupled to a generator to generate electricity. A portion of that generated work is used to rotate the rotor 16 of the compressor 10 to initially compress the air supplied to the turbine.

[0008] As illustrated in Figure 1, the rotor 16 of the compressor mounts a plurality of buckets 18 for rotation therewith and a plurality of stator vanes 20 fixed to the outer casing 22 of the compressor. At the aft end of the compressor, there are one or more arrays of stator blades 24 cantilevered from and fixed to the outer casing 22. In the illustration, there are three axially spaced circumferential arrays of circumferentially spaced stator vanes 24. As noted previously, the stator vanes 24 cantilevered between the stationary outer casing 22 and the stationary inner casing 26 have tips which are closely spaced from the inner casing 26 as illustrated in Figure 2. The gap between the tips and the inner casing 26 permit flow from the high pressure concave sides of the stator vanes 24 to the low pressure convex sides of the stator vanes 24 causing the formation of vortices. These vortices have been found to have a back and forth frequency component which under certain aerodynamic conditions may reinforce the natural frequency of the stator vanes 24. Should this occur, there is an enhanced possibility that the stator vanes can fail.

[0009] To minimize or eliminate this possibility, and referring to Figure 3, there is illustrated a stator vane 40 comprising one of a plurality of stator blades or vanes in an annular array of such vanes about the axis of the compressor. The vanes 40 are disposed between the outer fixed stationary casing 42 and an inner fixed cylindrical casing 44. The opposite ends of the stator vanes are fixed to the casings 42 and 44, respectively. Consequently, the gap between the tip of the stator vane and the stationary inner casing illustrated in Figure 2 is closed. This prevents the formation of vortices resulting from passage of air between opposite sides of each vane about the tip of the vane and hence entirely eliminates vortex bursting and potential resultant sympathetic vibration.

[0010] In another aspect of the present invention as illustrated in Figures 4 and 5, the vanes 46 extend between a fixed outer casing 48 and a fixed inner part 50. Each vane 46 may comprise one of a plurality of vanes of a compressor vane segment generally designated 52 in Figure 5. The segment 52 includes an outer shroud or band 54 and an inner shroud or band 56. The vanes 46 extend between the two bands 54 and 56. Each segment 52 may comprise any number of vanes dependent upon the total blade count in the stage. Consequently, and referring back to Figure 4, the segment 52 is secured to the outer casing 48 with the vanes and inner band 56 cantilevered from the outer casing 48. The radial outer surface of the inner band 56 is preferably contoured. That is, the radially outer surface 58 of the inner band 56 converges in a radial outward and downstream direction relative to the flowpath of the compressed air defined between the outer and inner casings.

[0011] While it will be appreciated that each stator vane 46 may be fixed to both the outer and inner bands and hence tip leakage is avoided thereby also eliminating the excitation source, i.e., the tip leakage vortex, it is also possible to minimize the occurrence of stator vane tip leakage vortex vibration induced vane failure notwithstanding a gap between tips of cantilevered stator vanes and the opposed inner casing. That is, the stator vanes 46 can remain cantilevered with tips spaced from the inner casing provided the inner casing is contoured to preclude lift off of the tip leakage vortex. Thus, if the tip leakage vortex cannot lift off the contoured surface because of the convergent flow in the downstream direction, and remains attached to the inner and outer flow path defining surfaces, vibration induced by tip leakage vortex bursting is minimized or eliminated. In Figure 6, the inner casing 60 has an inner flow surface 62 shaped to converge the flow in a radial outward and downstream direction. The flow convergence prevents lift off of the tip leakage vortex notwithstanding that the tip of stator blade 64 is spaced from casing 60. This minimizes the excitation source which otherwise may potentially cause stator blade failure.

[0012] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

Compressor 10

Turbine 12

Plurality of Combustor Cans 14 Rotor 16

Plurality of Buckets 18

Stator Vanes 20

Outer Casing 22

Stator Blades 24

Inner Casing 26

Vanes 40

Outer Fixed Stationary Casing 42

Inner Fixed Cylindrical Casing 44

Vanes 46

Casing 48

Compressor Vane Segment 52

Outer Shroud or Band 54

Inner Shroud or Band 56

Inner Casing 60

Inner Flow Surface 62

Stator Blade 64

Claims

1. A compressor (10) comprising:

inner and outer stationary casings (44, 42); and a plurality of stator vanes (40) extending between and secured at radially opposite ends to said inner and outer casings thereby eliminating tip leakage between opposite sides of each stator vane and stator vane vibration induced by tip leakage vortex bursting.

2. A compressor comprising:

a stator vane segment (52) including a plurality of stator blades (46) and inner and outer stationary shrouds (54, 56) about the blades secured to inner and outer ends of the blades respectively, thereby eliminating tip leakage along the inner shroud and between opposite sides of inner ends of the stator blades.

3. A compressor according to claim 2 wherein the inner and outer shrouds define a convergent flow path between adjacent stator blades to minimize or eliminate flow lift off from at least one of said inner and outer surfaces.

4. A compressor according to claim 3 wherein the inner shroud (54) has upstream and downstream surfaces, said downstream surfaces extending radially outwardly relative to an axis of the compressor a greater distance than upstream surfaces enabling a convergent flow path.

5. A compressor comprising:

a stator vane segment including a plurality of stator blades (64) and a radial outer shroud, and a stationary inner casing (60) spaced from a tip of the stator blades and having a contoured surface (62) exposed to the flow path for converging the flow in a downstream direction.

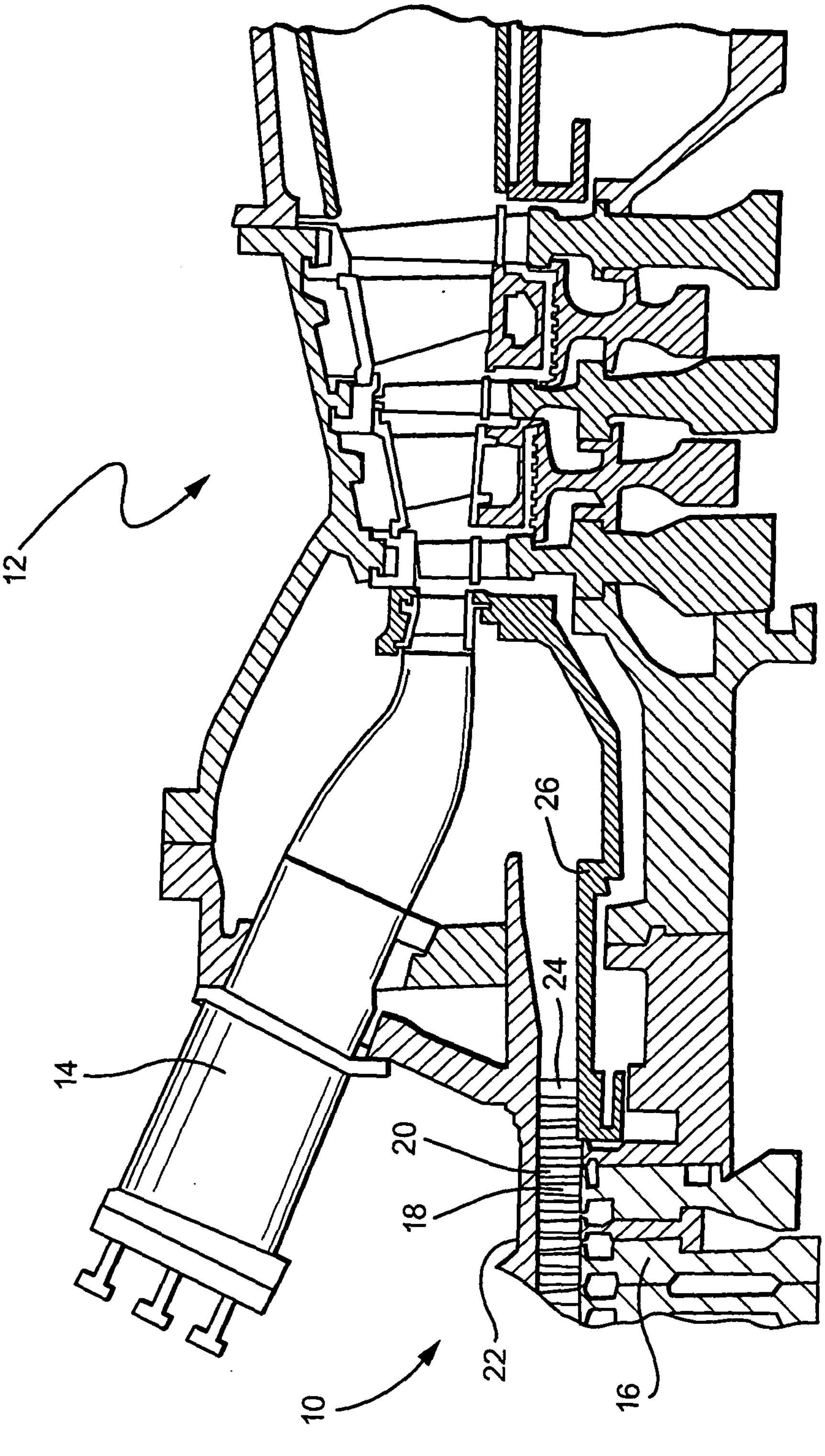

Fig. 1 (Prior Art)

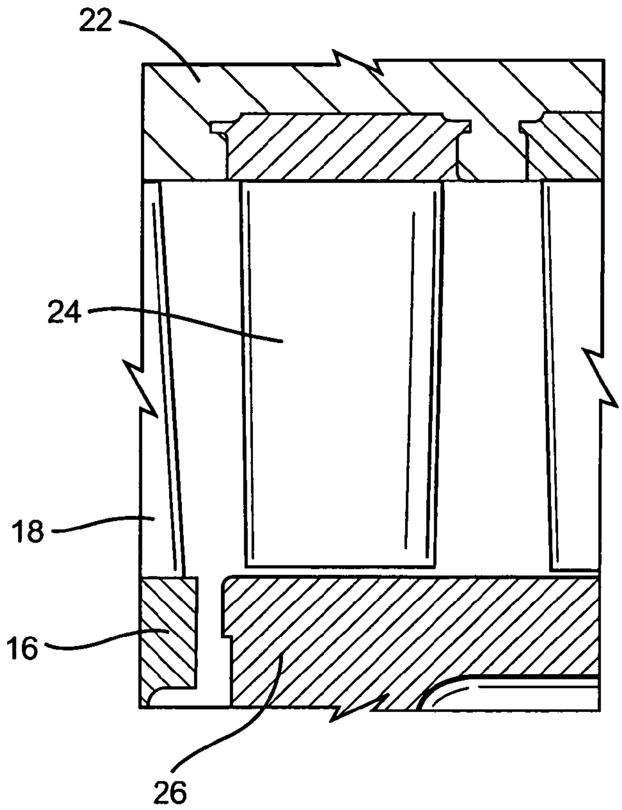

Fig. 2
(Prior Art)

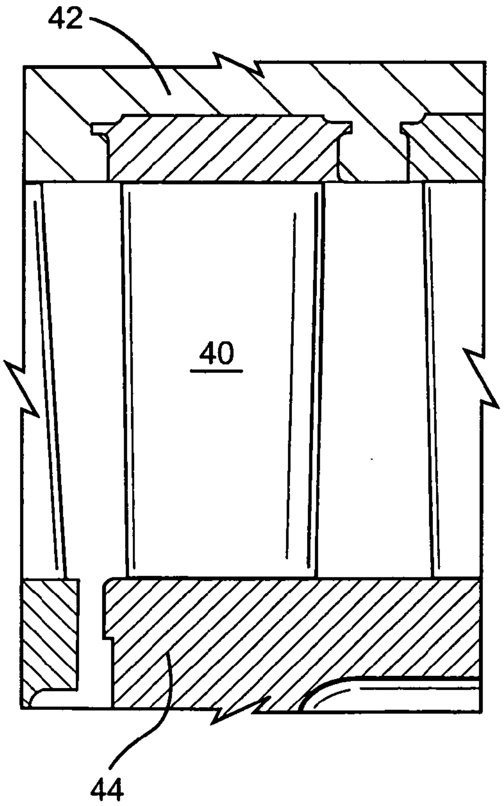

Fig. 3

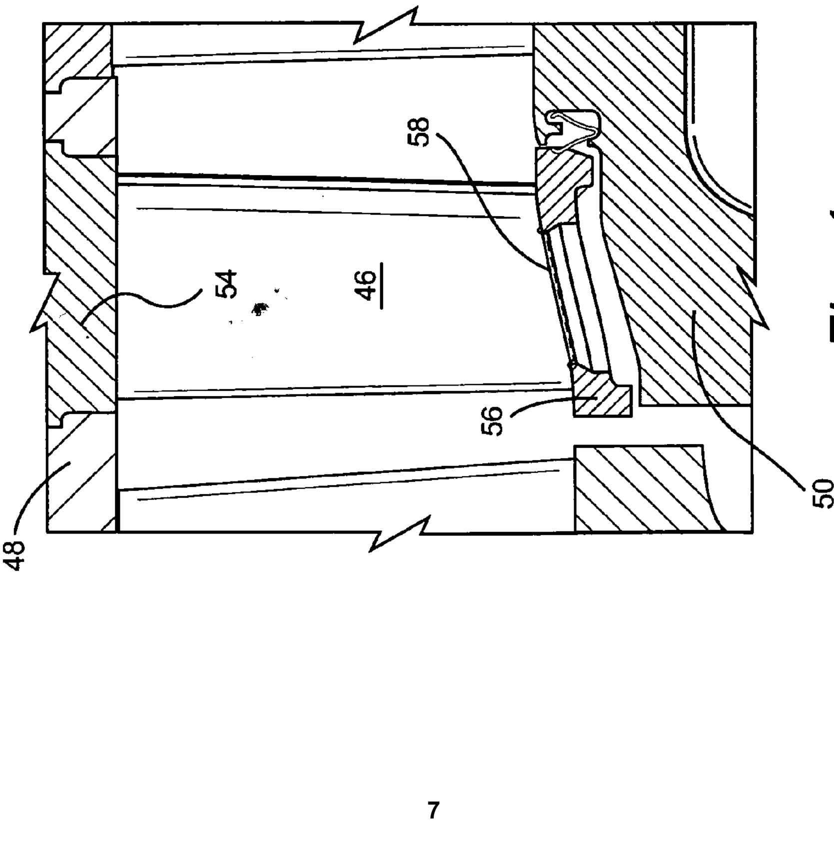

Fig. 4

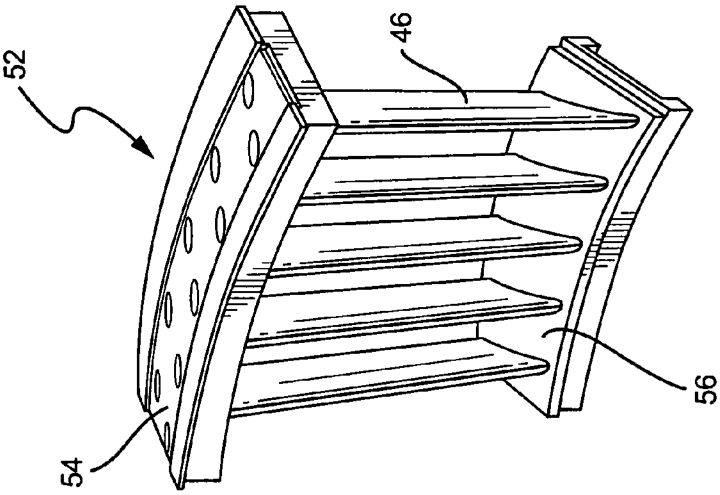

Fig. 5

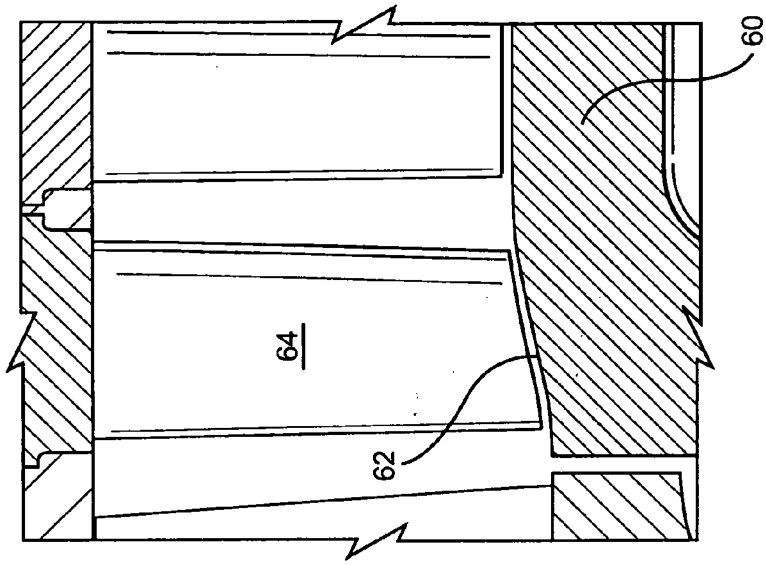

Fig. 6