Feb. 14, 1967 K. O. JOHNSON 3,303,992

VARIABLE VANE STATOR RING

Filed March 3, 1965 2 Sheets-Sheet 1

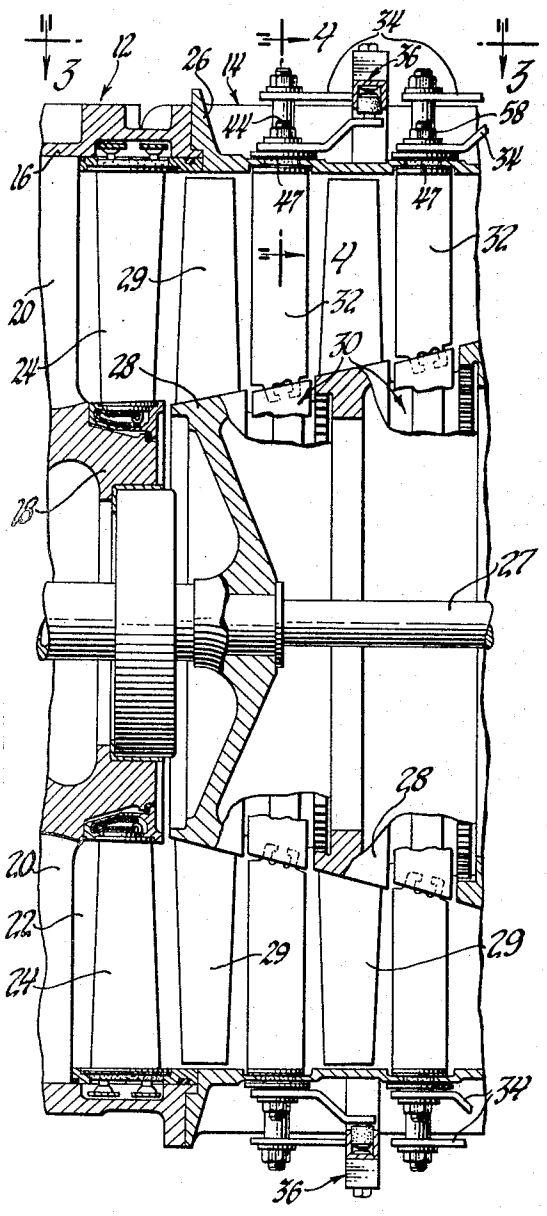


Fig. 1

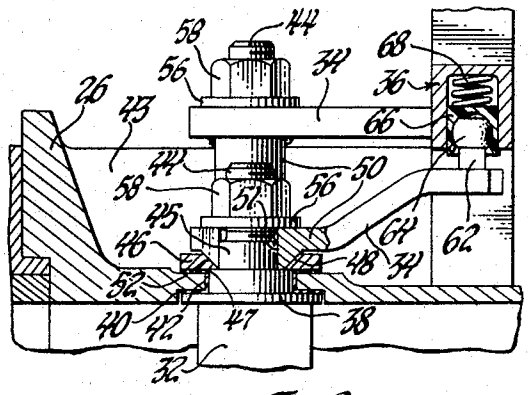


Fig. 2

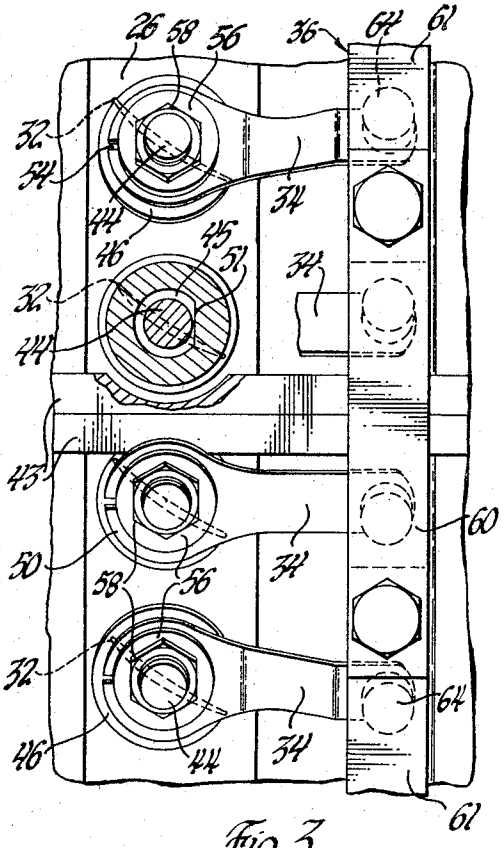


Fig. 3

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VARIABLE VANE STATOR RING

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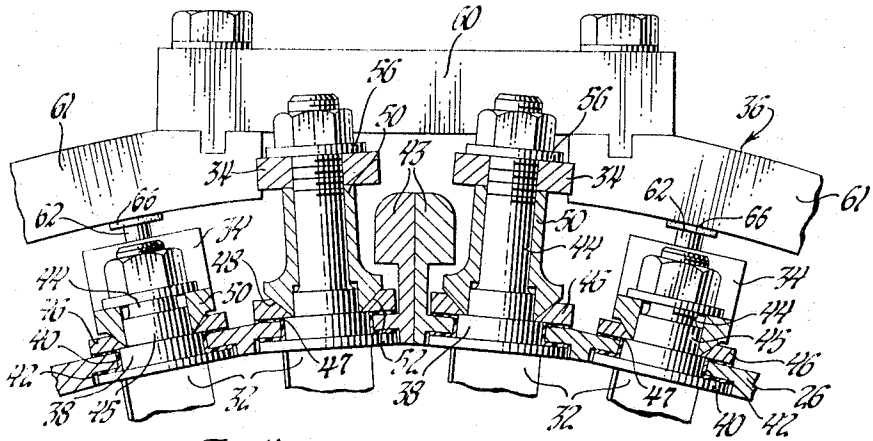


Fig. 4

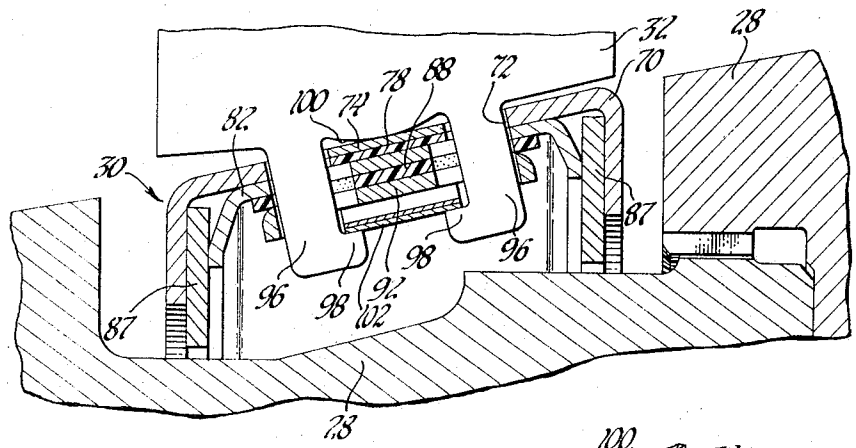


Fig. 5

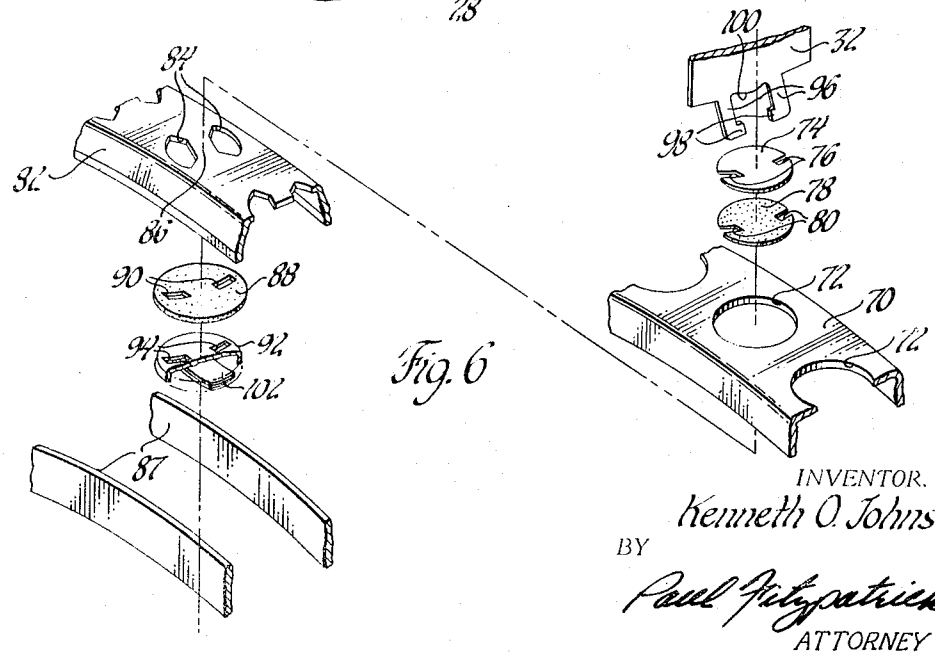


Fig. 6

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VARIABLE VANE STATOR RING

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9 Claims. (Cl. 230—114)

This invention relates generally to a variable vane stator ring and more particularly to a variable vane stator ring in which the vanes are journaled between an outer support and an inner shroud band.

One of the problems associated with this type of variable vane stator ring is that the vanes tend to deflect under air loads and thus bind in their journals. The binding at the outer end usually can be eliminated by use of a sufficiently rigid outer shroud and journals. It is desirable to construct the inner shroud as light as possible since it is at the end of a plurality of blades suspended from their outer ends and thus the inner shroud is not susceptible to this type of correction. If the outer ends of the vanes are journaled rigidly enough the blades will deflect under air loads with the maximum deflection occurring at their inner ends. This will cause the inner shroud band to be displaced axially upstream from the outer support and the vanes will bind within their journals at the inner end. The binding in turn resists rotation of the vanes about their axes. The binding at the inner end, however, can be alleviated to some extent by journaling the vanes loosely within the inner shroud ring. But this solution introduces another problem, that is, the shroud band will tend to vibrate causing noise and associated problems.

It is, therefore, an object of this invention to provide a variable vane stator ring with vanes which are easily rotatable under air loads.

Another object is to provide a variable vane stator ring with vanes which are mounted to an inner shroud ring in such a manner so that no binding occurs under air loads.

Another object is to provide a vane stator ring with vanes which are spring biased into contact with an inner shroud ring to eliminate noise and vibration.

Another object is to provide a variable vane stator ring which is rugged, light in weight, and compact.

Another object of this invention is to provide a variable vane stator ring with an improved connection between the rotatable vanes and an actuating arm used to control the vanes.

These and other objects and features of the invention will become apparent to those skilled in the art as the disclosure is made in the following detailed description of the preferred embodiment of the invention as illustrated in the accompanying drawings in which:

FIGURE 1 is an elevational view partially in cross section of a portion of a compressor in which is incorporated a preferred embodiment of the invention.

FIGURE 2 is an enlarged view of a portion of FIGURE 1.

FIGURE 3 is a section taken substantially along the line 3—3 of FIGURE 1 and looking in the direction of the arrows and with some of the parts broken away for clarity.

FIGURE 4 is a section taken substantially along the line 4—4 of FIGURE 1 and looking in the direction of the arrows.

FIGURE 5 is an enlarged view of another portion of FIGURE 1.

FIGURE 6 is an exploded view of the parts shown in FIGURE 5.

Referring to FIGURE 1, there is shown an annular inlet 12 in axial alignment with an axial flow multistage compressor indicated generally at 14. The inlet has a cylindrical housing 16 with a hub 18 held concentrically therein by a plurality of struts 20. An annular inlet passage 22 bounded by hub 18 and the housing 16 has a plurality of guide vanes 24 adjustably mounted therein. The compressor 14 comprises a casing 26 having a shaft 27 extending through it and journaled in the hub 18. A plurality of rotor elements 28 have rotor blades 29 attached to the forward portions of their peripheries. The front and rear elements 28 are discs fixed on shaft 27. The remaining element rings are splined to those next to them. The elements 28 thus rotate together as a unitary rotor. Inner stator shroud bands 30 surround the rearward non-bladed portions of the rings 28 and have blades 32 journaled therein. The outer portions of vanes 32 are journaled to the compressor casing 26 with the outer ends extending therethrough. Crank arms 34 attached to the outer ends of the vanes 32 are connected to a control ring 36.

Referring now to FIGURE 2, the manner in which the outer portions of the vanes 32 are journaled to the casing 26 is shown in greater detail. The outer portion of the vane 32 has an integral disc 38 which extends into a shouldered aperture 40 in the compressor casing 26. An L-shaped Teflon ring 42 is disposed between the disc 38 and the casing 26 and acts both as a radial and a thrust bearing. A stub shaft 44 extends outwardly from the disc 38 on the outside of the casing 26. The compressor casing 26 is fabricated in four approximately quarter-cylindrical segments with the edges of the segments flanged for purposes of assembly as shown more clearly at 43 in FIGURE 4. The stub shafts 44 which are adjacent the flanges of the compressor housing segments are larger in radial length than the remainder of the stub shafts.

A Teflon washer 47 embraces the stub shaft and abuts the casing 26 to complete the bearing and seal between it and the vane 32. A metallic washer 46 loosely fits over the stub shaft 44 atop the Teflon washer 47. The wall 48 of the aperture of the washer 46 is in the shape of a truncated conical section. The crank arm 34 has a sleeve portion 50 at one end which is disposed about the stub shaft 44. The sleeve 50 is split axially at 54 and has its inner outer end 52 in the form of a truncated conical section which mates with the wall 48 of washer 46. The crank arm adjacent the flanges on casing 26 require longer sleeve portions and are made in two pieces with a separate sleeve 50 being welded to the crank arm 34. On these longer sleeves only the lower portion is split. The bore of sleeve 50 has a flat surface 51 which mates with a flat surface on portion 45 on stub shaft 44 so that the sleeve and the stub shaft will rotate together. A washer 56 on stub shaft 44 engages the sleeve portion 50 of the crank arm 34. The outer end of the stub shaft 44 is threaded to receive a nut 58 which is tightened down to wedge the inner end of sleeve 50 within the aperture of washer 46. The inner end of sleeve 50 contracts due to axial slot 54 and the tendency of sleeve 50 to expand circumferentially aids in the wedging action.

Referring back to FIGURE 2, the opposite ends of the crank arms 34 have an outward projection 62 which terminates in a spherical head 64. This head 64 fits in a Teflon insert 66 within an annular cavity in the control ring 36. A spring 68 is disposed in the annular cavity biasing the insert 66 inwardly towards the head 64. The control ring 36 like the compressor casing 26 is segmented and has portions 60 which are spaced radially outwardly from the segments 61 to compensate for the additional height of the stub shafts 44 and crank arms 34 adjacent the flanges on the compressor housing segments. Portions 60 connect segments 61 and are bolted to them.

Referring now to FIGURES 5 and 6, the connection between the vanes 32 and the inner shroud band 30 is shown in greater detail. The inner shroud band 30 comprises an outer annular channel 70 having a plurality of circumferentially spaced circular apertures 72. A circular steel shim 74 having diametrically opposed slots 76 and and a Teflon shim 78 having aligned slots 80 abutting inner surface of shim 74 is disposed in each aperture 72. An inner annular channel 82 having a plurality of pairs of arcuate slots 84 is disposed inwardly of the outer channel 70. Nonlimiting examples of the shape of arcuate slots 84 are truncated sectors of a circle or segments of an annulus. The inner channel 82 has its outer circumferential surface abutting the inner surface of the outer channel 70. The pairs of arcuate apertures 84 are concentric with the circular apertures 72 in the outer channel 70 with the portions 86 therebetween supporting the shims 74 and 78. Forward and rearward flat annular rings 87 are disposed between the inwardly extending annular flanges on the channels 70 and 82. The rings 87 form a labyrinth seal with the reaward portion of disc 28.

A Teflon washer 88 is disposed below the inner channel 82 concentric with each of the pairs of arcuate apertures 84. The Teflon washer 88 has a pair of diametrically spaced slots 90 which together with a pair of diametrically opposed slots 94 on a cupped retainer 92 disposed inwardly therefrom are aligned with the slots 76 and 80 in the shims 74 and 78 respectively. A pair of tangs 96 extend radially inwardly from the inner edge of the vane 32 through the aligned slots in the shims, inner channel, washer and retainer. Each of the tangs 96 has a shoulder 98 in the side facing the other tang on a portion of the tang spaced inwardly from the retainer 92. The inner end 100 of vane 32 between the tangs 96 is convex. Two bowed leaf springs 102 are disposed between the retainer 92 and the shoulders 98 on the tangs 96. The outer ends of the downwardly bowed leaf springs 102 contact the inner surface of the retainer 92 while the midportions contact the shoulders 98 on the tangs 96. The vanes 32 thus connected to the inner shroud band 30 are journaled therein for rotational movement limited by the extent of the pair of segmented apertures 84 in the inner channel 82. The outer peripheries of the steel and Teflon shims 74 and 78 respectively cooperate with the apertures 72 in the outer channel 70 to form the journal bearings for the vane 32. The springs 102 urge the vanes 32 radially inwardly biasing the convex edge 100 on the vane 32 into contact with the steel shim 74 at a single point. The loose fit of the tangs 96 and the arcuate surface 100 permits a slight rocking movement of the vane 32 with respect to the inner shroud band 30 while the resilient biasing of vane 32 into position contact with shim 74 eliminates noise and vibration. As the vanes 32 are deflected under an air load, a slight rocking movement will eliminate any binding between the vanes 32 and the inner shroud band 30 with the apertures 70 and shims 74 and 78 providing an easily rotatable journal bearing.

Thus is can be seen that the applicant has invented a variable vane stator ring with vanes which are mounted to an inner shroud ring in such a manner that they are easily rotatable and will not bind under air loads. It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and was shown in connection with a compressor and that the invention is intended to cover all changes and modifications thereof and may be used where applicable such as a stator row within a turbine which do not constitute departures from the spirit and scope of the invention.

I claim:

1. In a variable vane stator ring, an inner shroud band comprising an outer annular channel having a plurality of circumferentially spaced circular apertures,
circular metallic shims having a pair of diametrically opposed slots disposed in said circular apertures,
circular, low-friction shims having diametrically opposed slots disposed in said circular apertures inwardly of said metallic shims,
an inner channel having a circumferential surface abutting the inner surface of said outer channel,
said inner channel having a plurality of diametrically opposed pairs of arcuate slots,
low-friction washers concentric with said pairs of arcuate slots abutting the inner surface of said inner channel and having diametrically opposed slots,
cup-like retainers abutting the inner surface of said washers and having diametrically opposed slots;
a plurality of vanes having a pair of spaced tangs depending from the inner edge thereof and extending through said slots in said shims, said inner channel, said washers and said retainers, said inner edges having a convex surface between said tangs contacting said metallic shims, a shoulder on the inner end of each tang facing the other tang of each of said pairs of tangs,
a plurality of inwardly bowed leaf springs having their ends abutting the inner surface of said retainers and their middle portions contacting said shoulders of said tangs whereby said vanes are journaled in said inner shroud bands, and biased inwardly,
an outer annular support member, discs at the outer ends of said vanes, said discs being journaled in said outer support member, washers adjacent the outer surface of the support member, said washers having an aperture wall in the shape of a truncated conical section, stub shafts extending from said discs through said washers, said stub shafts having a flat portion, sleeves having a flat on their inner surface mounted on said sub shafts with said flats abutting the flats on said shaft, an inner end on said sleeves in the shape of a truncated conical section, said inner ends mating with said aperture walls, an inner portion on said sleeves having an axial slit, fastening means to wedge the inner ends of said sleeves within said washers, crank arms extending from sleeves and actuating means to rotate said crank arms whereby said vanes are rotated to change their angles of attack.

2. In a variable vane stator ring, an outer annular support member, a plurality of vanes journaled in said support member and extending radially inwardly, an inner shroud band comprising an outer annular channel having a plurality of circumferentially spaced circular apertures,
circular metallic shims having a pair of diametrically opposed slots disposed in said circular apertures,
circular low-friction shims having diametrically opposed slots disposed in said circular apertures inwardly of said metallic shims,
an inner channel having a circumferential surface abutting the inner surface of said outer channel,
said inner channel having a plurality of diametrically opposed pairs of arcuate slots,
low-friction washers concentric with said pairs of arcuate slots abutting the inner surface of said inner channel and having diametrically opposed slots,
cup-like retainers abutting the inner surface of said washers and having diametrically opposed slots;
said vanes having a pair of spaced tangs depending from the inner edge thereof and extending through

said slots in said shims, said inner channel, said washers and said retainer, said inner edges having a convex surface between said tangs contacting said metallic shims, a shoulder on the inner end of each tang of said pairs of tangs facing said other tang of said pairs of tangs,

a plurality of inwardly bowed leaf springs having their ends abutting the inner surface of said retainers and their middle portions contacting said shoulders to resiliently urge said vanes radially inwardly into point contact with said inner shroud band whereby said vanes are rockably mounted in said inner shroud band as well as journaled therein so as to remain easily rotatable under all condiitons and actuating means to rotate said vanes to change their angles of attach.

3. In a variable vane stator ring, an outer annular support member, a plurality of vanes journaled in said support member and extending radially inwardly, an inner shroud band comprising an outer annular channel having a plurality of circumferentially spaced circular apertures,

circular shim means disposed in said circular apertures, said shim means having a metallic outer surface and a low-friction inner surface,

an inner channel having a circumferential surface abutting the inner surface of said outer channel,

said inner channel having a plurality of diametrically opposed pairs of arcuate slots,

low-friction washers concentric with said pairs of apertures abutting the inner surface of said inner channel and having diametrically opposed slots,

retainers abutting the inner surface of said washers and having diametrically opposed slots;

said vanes having a pair of spaced tangs depending from the inner edge thereof and extending through said shim means, said slots in said inner channel,

said washers and said retainers,

said inner edges having convex surfaces between said pairs of tangs,

spring means operatively connected to each of said retainers and said pairs of tangs to urge said tangs radially inwardly whereby said convex surfaces are biased into point contact with said shim means rockably mounting said vanes in said inner shroud band to maintain said vanes easily rotatable when deflected, and actuating means to rotate said vanes to change their angles of attack.

4. In a variable vane stator ring, an outer annular support member, a plurality of vanes journaled in said support member and extending radially inwardly, an inner shroud band, means to journal said vanes in said inner shroud band,

said inner shroud band including a channel having a plurality of diametrically opposed pairs of arcuate slots,

retainers disposed radially inwardly of said channel aligned with said arcuate slots having diametrically opposed slots;

a pair of spaced tangs depending from the inner edge of each vane extending through said slots,

each of said tangs being provided with a shoulder on the side toward said other tang,

a convex surface of said inner edges between said tangs,

a plurality of inwardly bowed leaf springs having their ends abutting the inner surface of said retainers and their middle portions contacting said shoulders of said tangs to resiliently urge said convex surfaces inwardly into point contact with said inner shroud band whereby said vanes will rock with respect to said shroud band when deflected and actuating means to rotate said vanes to change their angles of attack.

5. In a variable vane stator ring, an outer annular support member, a plurality of vanes journaled in said support member and extending radially inwardly, an inner shroud band, means to journal said vanes in said inner shroud band,

said inner shroud band including a channel having a plurality of diametrically opposed pairs of arcuate slots,

a pair of spaced tangs depending from the inner edge of each of said vanes,

said pairs of tangs extending through said slots in said channel,

a convex surface on said inner edge of said vanes between said tangs,

a plurality of spring means operatively connected to said tangs and said inner shroud to resiliently urge said convex surface inwardly into point contact with said inner shroud whereby said vanes are permitted a slight rocking movement, and actuating means to rotate said vanes to change their angles of attack.

6. In a variable vane stator ring, an outer annular support member, a plurality of vanes journaled in said support member and extending radially inwardly, an inner shroud band,

means to journal said vanes in said inner shroud band, said first means including further means to permit a slight rocking movement of said vanes whereby said vanes will rock in said inner shroud band when deflected to maintain said first means unbiased, and actuating means to rotate said vanes to change their angles of attack.

7. In a variable vane stator ring, an inner shroud band, a plurality of vanes journaled in said shroud band and extending radially outwardly, a disc at the outer ends of said vanes, an outer annular support member, said discs being journaled in said outer support member, washers adjacent the outer surface of the support member, said washers having an aperture wall in the shape of a truncated conical section, stub shafts extending from the discs through said washers, said stub shafts having a flat portion, sleeves having a flat on their inner surface mounted on said stub shafts with said flats abutting the flats on said shaft, said sleeves having an axial slit and their inner ends in the shape of a truncated conical section which mates with said aperture walls, means to urge said sleeves radially inwardly whereby their inner ends are wedged in said washers, crank arms extending from said sleeves and actuating means to rotate said crank arms whereby said vanes are rotated to change their angles of attack.

8. In a variable vane stator ring, an inner shroud band, a plurality of vanes journaled in said shroud band and extending radially outwardly,

an outer annular support member, said vanes journaled in said outer support member, washers adjacent the outer surface of the support member, said washers having an aperture with an inwardly tapered wall, stub shafts extending from said vanes through said washers, sleeves mounted on said stub shafts, said sleeves having an axial slit and an inner end tapered to mate with said aperture walls, fastening means to wedge said sleeves within said washers, means to couple said sleeves to said stub shafts and actuating means to rotate said sleeves whereby said vanes are rotated to change their angles of attack.

9. In a variable vane stator ring, an outer annular support member, a plurality of vanes journaled in said support member and extending radially, inwardly, an inner shroud band, said inner shroud band including an annular channel having a plurality of circumferentially spaced circular apertures with radial circumferential walls,

circular shim means disposed in said circular apertures and having radial circumferential walls slideably engaging said walls of said circular aperture,

means to secure said shim means to said vanes adjacent their inner ends,

said last named means including means to rockably mount said vanes with respect to said shim means whereby said vanes are rocked with respect to said shim means when deflected to maintain said shim means in sliding engagement with said aperture walls.

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