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Moskowitz et al.

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[54] **VARIABLE STATOR BLADE ASSEMBLY FOR AXIAL FLOW, FLUID EXPANSION ENGINE**

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[51] **Int. Cl.** **F01d 17/14**

[58] **Field of Search** 415/149, 147, 150, 415/151, 160, 163, 159

[56] **References Cited**

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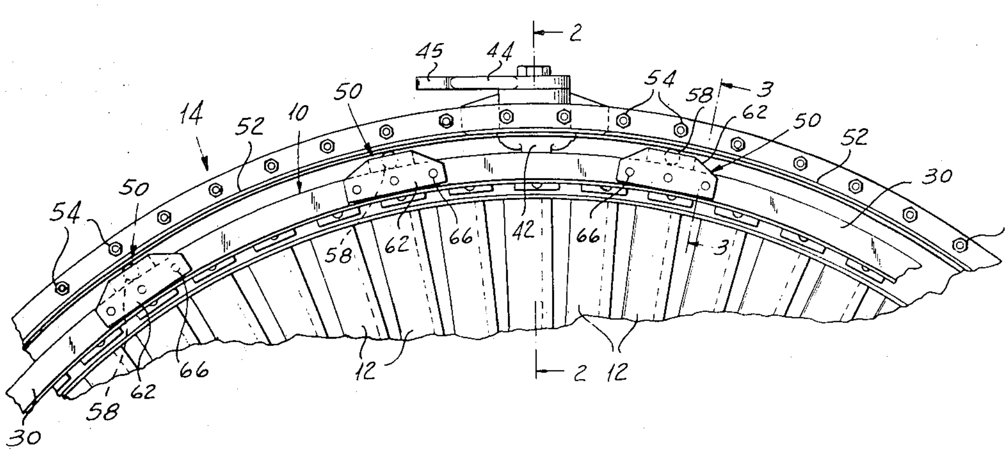
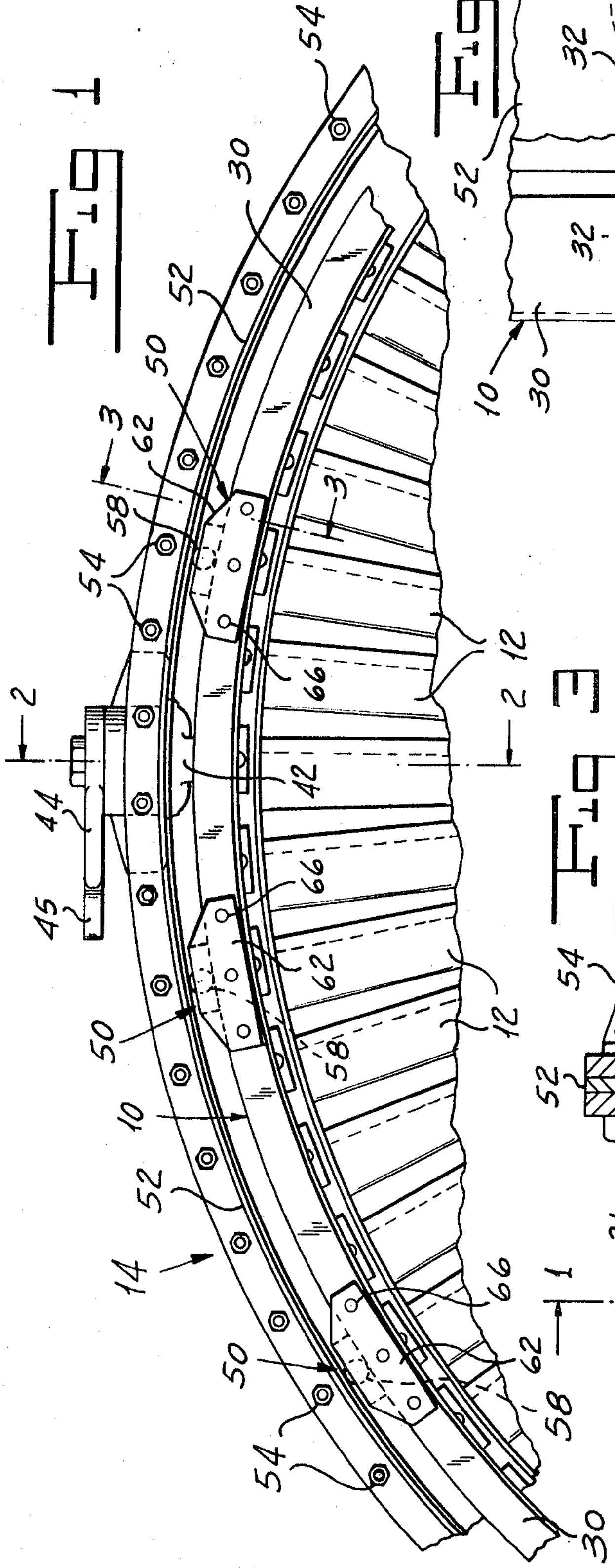
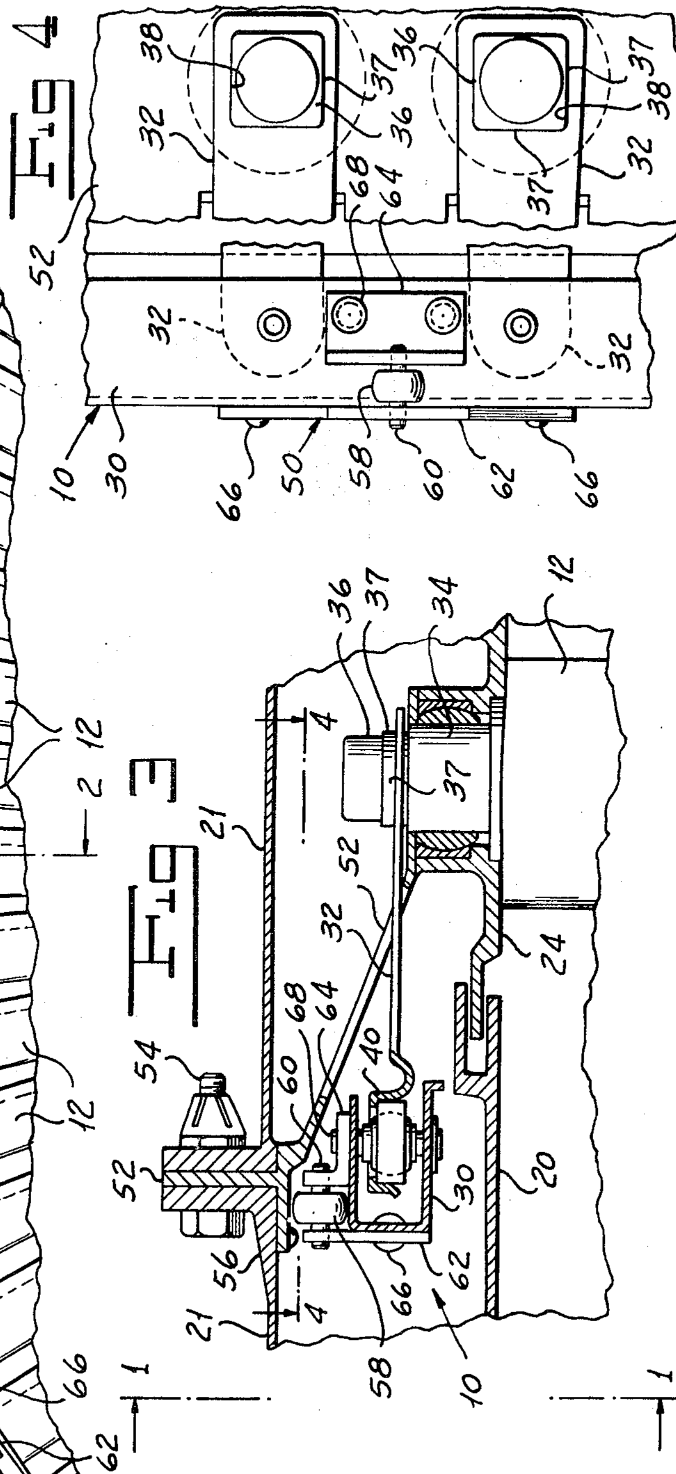
[57] **ABSTRACT**

In an axial flow, fluid expansion engine having stator vanes adjustable, through a rotatable unison ring and linkage assembly, to vary the area of the throat defined between the next adjacent stator vanes, a frame for circumferentially supporting the unison ring to prevent ovalizing of the ring and, hence, provide accurate adjustment of the size of each of the throat areas.

12 Claims, 7 Drawing Figures







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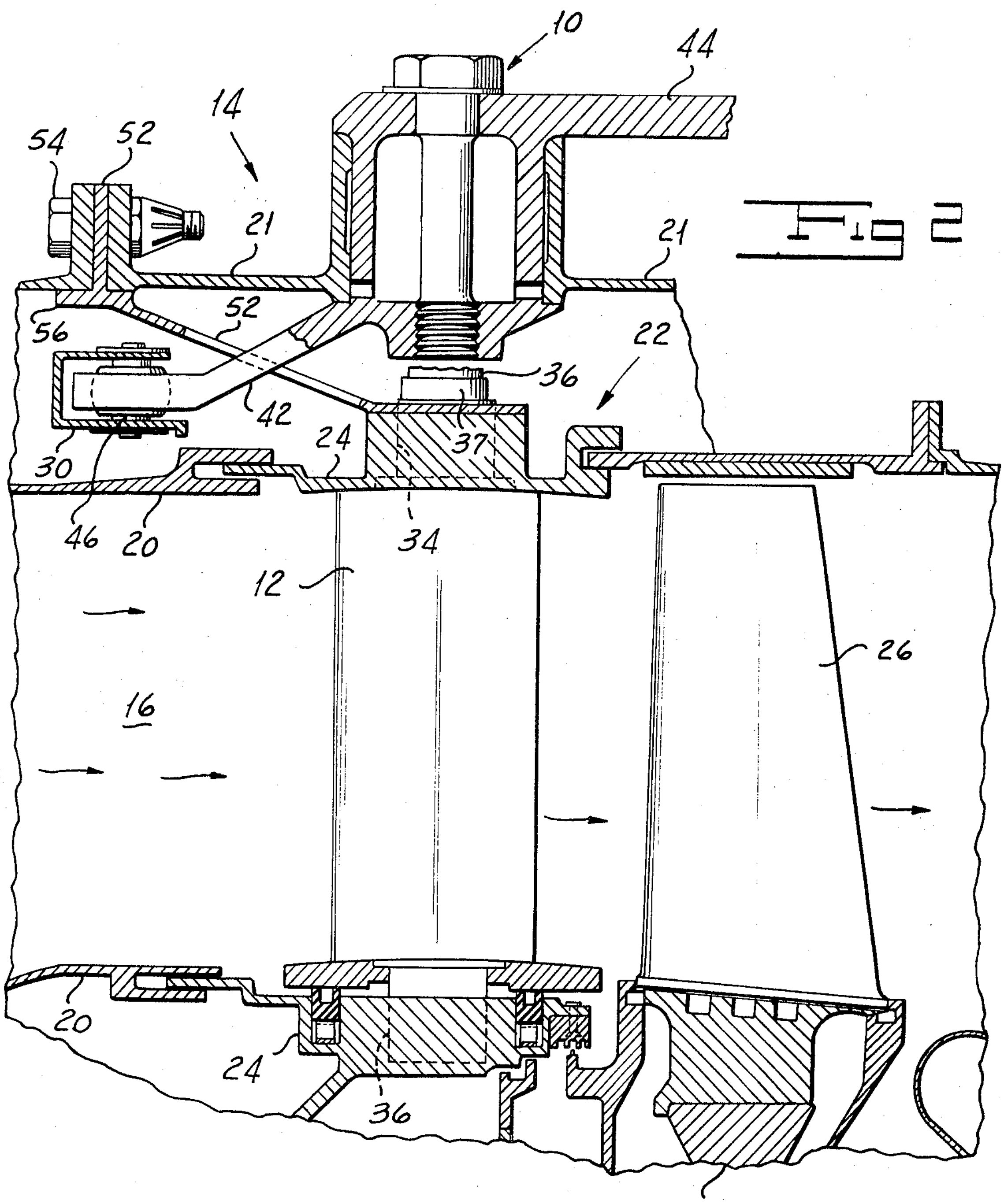

Fig 2

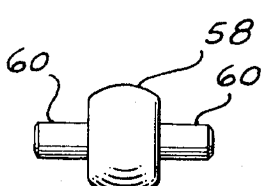

Fig 7

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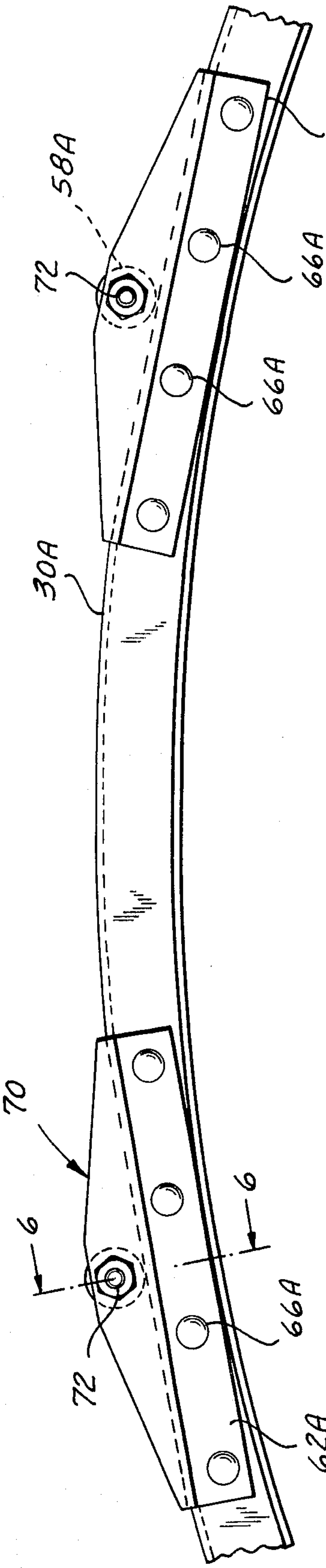

Fig 5

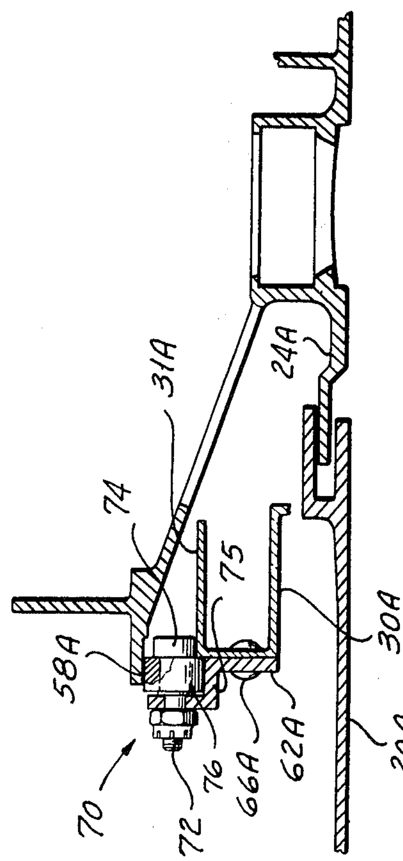

Fig 6

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VARIABLE STATOR BLADE ASSEMBLY FOR AXIAL FLOW, FLUID EXPANSION ENGINE

This invention relates to axial flow, fluid expansion engines, such as turbines and compressors, and, more particularly, to a variable stator blade assembly for such engines.

BACKGROUND OF THE INVENTION

In axial flow, fluid expansion engines, particularly engines of light-weight and operating at high temperatures, such as gas turbine engines for aircraft, the stator vanes or blades are pivotally actuatable through a control mechanism to vary the area of the throats defined by next adjacent stator vanes. The control mechanism comprises, as exemplified in U. S. Pats. to Campbell, No. 2,857,092 and De Feo et al, No. 3,224,194, a ring or band which is connected by links or arms to each stator vane and supported for rotative movement by such arms or links. The control mechanism also usually includes two external drive arms which are connected to the unison ring at diametrical opposite points and to a source of power, such as an electric or fluid motor. It has been found in this type of control mechanism that accurate throat area adjustments cannot be obtained. The combination of the high aerodynamic gas loading on the stator vanes which results in a torque force on the vanes tending to open or increase the throat area and the insufficient rigidity in the unison ring results in the ovalizing of the unison ring. This ellipsoidal shaping or radial deflection of the unison ring allows the vanes, located furthest from the diametrical connection of the drive arms, to open under the torque forces exerted by the gas pressure on the vanes. This ovalizing of the unison ring, which may be as little as 0.010 inches, produces as much as a one percent error in the stator throat area for the pairs of vanes disposed furthest from the drive arm connections. Obviously, the inaccuracy of stator vane adjustment is undesirable if efficient operation of a fluid expansion engine is to be achieved.

Accordingly, it is an object of this invention to provide a variable stator blade or vane assembly in which the throat area between the blades can be accurately adjusted.

Another object of the present invention is to provide, in a variable stator blade assembly having a unison ring, a means for preventing ovalizing of the unison ring.

A further object of this invention is to provide in a variable stator blade assembly a control mechanism having a unison ring wherein said unison ring is circumferentially supported against radial deflection or distortion and allowed to freely rotate.

SUMMARY OF THE INVENTION

It is, therefore, contemplated by the present invention to provide for an axial flow fluid expansion engine an improved variable stator vane or blade assembly of the type having a rotatable unison ring or band supported by and connected to each vane by a link or arm, such variable stator vane assembly being shown in the U. S. Pats. to Campbell, No. 2,857,092 and De Feo et al, No. 3,224,194. The improvement comprising support means for circumferentially supporting the unison ring against radial deflection or distortion. The support means may consist of an annular stationary frame member disposed in spaced concentric relation to the unison ring and a plurality of circumferentially spaced wheels or rollers disposed in the annular space between the unison ring and the annular stationary frame member to maintain the unison ring in concentricity with the frame member. The wheels may be journalled for rotation on either the unison ring or the frame member in such a manner as to bear against the other element and thereby prevent deflection and distortion of the unison ring.

In one embodiment of this invention each of the wheels or rollers is journalled in two spaced brackets secured to the unison ring, while in another embodiment each of the wheels or rollers is journalled on a shaft which is secured at one end in a single bracket and, at the opposite end, rests on the unison ring.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be more fully understood from the following detailed description thereof when considered in connection with the accompanying drawing wherein two embodiments of the invention are illustrated by way of example and, in which:

FIG. 1 is a fragmentary cross-sectional view showing the improved variable stator blade assembly according to this invention;

FIG. 2 is a cross-sectional view taken substantially along line 2—2 of FIG. 1 on a somewhat enlarged scale;

FIG. 3 is a cross-sectional view taken substantially along line 3—3 of FIG. 1, on the same scale as FIG. 2;

FIG. 4 is a fragmentary plan view of a portion of the unison ring and showing a roller assembly according to this invention taken substantially along line 4—4 of FIG. 3.

FIG. 5 is an elevational view of alternative roller assembly according to this invention;

FIG. 6 is a cross-sectional view taken substantially along line 6—6 of FIG. 5; and

FIG. 7 is a view of the roller shown in FIGS. 1, 3 and 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now referring to the drawings and more specifically FIGS. 1, 2, 3 and 4, the reference number **10** generally designates the variable stator vane assembly according to this invention which is illustrated as applied to the actuation of stator blades or vanes **12** of an axial flow, fluid expansion engine **14**, such as a gas turbine engine which may be employed to propel aircraft. The engine **14** may be of the construction schematically shown in the U. S. Pat. to Sneeden, No. 3,267,676 in which air is compressed in a compressor section (not shown) and directed into an annular combustion section (not shown) where it is mixed with fuel to burn the latter and generate gaseous products of combustion. As best shown in FIG. 2, the gaseous combustion products are conducted from the combustion section (not shown) to an annular outlet passageway **16** formed by an extension **20** of the combustion chamber liner (not shown) and spaced inwardly of the outer housing wall **21** of the engine. From outlet passageway **16** the combustion products enter the turbine section **22** which comprises stator vanes **12** which are circumferentially spaced in an annulus formed by concentrically arranged shroud rings **24**. The vanes are constructed and arranged to direct the combustion gases at accelerated velocities against rotor vanes or blades **26** to thereby effect rotation of the rotor **28** to which the rotor vanes are attached. The rotor **28** is connected, via a shaft (now shown), to the compressor section (not shown) to drive the latter.

The variable stator blade assembly, according to this invention, comprises pivotally mounting each stator vane 12 in the shroud rings 24 and providing a control mechanism of the type shown in the U. S. Pats. to Campbell, No. 2,857,092 and De Feo, No. 3,224,194. The control mechanism comprises a unison ring or annular band 30 of "U"shape in cross section disposed in the annular space formed between combustion liner extension 20 and housing 21 and axial offset from stator vanes 12. As best shown in FIG. 3 and 4 each vane 12 is connected to unison ring by a link or arm 32. As shown, the outer trunnion 34 of each vane 12 has an end portion 36 having flats or lands 37, which end portion 36 is receivable in a hole 38 in arm 32 which has complementary flats or lands so that rotative movement of arm 32 is transmitted to the trunnion 34. The opposite end, or unison ring end portion of arm 32, is pivotally connected to unison ring 30 by a spherical bearing assembly 40. The mechanism as thus far described functions, upon rotative movement of unison ring 30, to carry each of the arms 32 through an arc relative to the vanes and thus effect rotation of trunnions 36 of vanes 12 and, hence, the vanes themselves.

The rotative movement of unison ring 30 is achieved, as best shown in FIG. 2, by two drive arms 42 which are positioned diametrically opposite each other (only one such drive arm 42 being shown in the drawings). A main link or lever arm 44 is pivotally mounted on the housing wall 21 and is connected to one end of each of the drive arms 42. The opposite end of each of the drive arms 44 is pivotally connected to unison ring 30 by a spherical bearing assembly 46, similar to each of the spherical bearing assemblies 40. The distal end portion 45 (see FIG. 1) of each lever arm 44 is connected for pivotal movement through suitable elements (not shown) to a source of power, such as an electric motor or fluid motor (not shown). When lever arms 44 are pivotally moved, such motion is transmitted to unison ring 30 through drive arms 42.

It has been discovered that this herein described conventional variable stator vane assembly, does not achieve a desirable degree of accuracy of stator vane adjustment because unison ring 30 radially deflects or ovalizes as a result of the lack of structural strength in unison ring 30 and the torque force imposed on the unison ring through the force exerted on stator vanes 12 by the products of combustion. Thus, the stator vanes 12 in a direction away from drive arms 42 progressively open more than the vanes nearer the drive arms as a result of the ovalizing of unison ring 30. Therefore, a unison ring distortion or deflection of as little as 0.010 of an inch can produce a 1 percent error in the stator throat area for any pair of vanes at a nominal setting. This problem is solved by an improvement in the variable stator vane assembly, which improvement will now be fully described.

The variable stator vane assembly according to this invention is provided with means for circumferentially supporting unison ring 30 against distortion or deflection without impairment or its freedom to rotate under the urging of drive arms 42.

As shown in FIGS. 1, 3 and 4, the unison ring support means according to one embodiment of this invention comprises a plurality of circumferentially spaced wheel or roller assemblies 50 mounted on unison ring 30 and an annular bearing structure 52 which is secured by a plurality of bolts 54 (only one of which is shown) to engine housing 21. The bearing structure 52 has an annular surface 56 which is radially spaced from and concentrically disposed relative to unison ring 30.

Each of the roller assemblies 50 consists of a wheel or roller 58 having trunnions 60 which are rotatively supported by spaced brackets 62 and 64 secured to unison ring 30 in any suitable manner, such as by rivets 66 and 68, respectively. The roller 58 is dimensioned so as to engage the bearing surface 56 of bearing structure 52. The number of roller assemblies is not critical since the number of rollers required for a particular application is dependent upon the cross-sectional dimensions and shape of the unison ring, its diameter and the magnitude of the aerodynamic forces to which the unison ring is to be subjected. For illustration purposes only, FIG. 1 shows an arrangement in which about 18 roller assemblies are secured to unison ring 30 at about 20° intervals.

It is believed readily apparent that the distortional forces acting on unison ring 30 are transmitted, via roller assemblies 50, to the annular surface 56 of bearing structure 52 and thence to engine housing 21. This transmission of force to the engine housing prevents the ovalization of unison ring 30 and, therefore, provides an adjustable stator vane assembly which retains a high degree of accuracy of adjustment. At the same time, rollers 58 permit the rotative movement of unison ring 30 with minimum frictional resistance.

In FIG. 5 is shown an alternative roller assembly 70 which basically differs from roller assembly 50, illustrated in FIGS. 1 to 4, in that it has a single bracket supporting a fixed axle means on which is rotatively supported a wheel or roller rather than a roller having trunnions each of which is rotatively supported in a bracket. The parts of roller assemblies 70 corresponding to like parts of roller assemblies 50 will be designated by the same reference number but having the suffix A added thereto.

As shown in FIG. 5, each of the roller assemblies 70 comprises a single bracket 62A secured to unison ring 30A by a plurality of rivets 66A and a wheel or roller 58A supported by the bracket. The roller 58A is rotatively mounted on an axle means or shaft 72 which is fixedly secured at one end portion to bracket 62A. For added support of shaft 72, the distal end portion of shaft 72 is diametrically enlarged at 74 to engage the peripheral surface of unison ring 30A. This shaft engagement is facilitated by forming bracket 62A with an annular offset portion 75 and positioning the bracket 62A so that the offset portion 75 is located below the annular surface of the outer leg 31A of unison ring 30A. The bracket 62A and unison ring 30A cooperate to define an annular track 76 in which rollers 58A extend. The circumferentially spaced roller assemblies 70 function to prevent distortion of unison ring 30A with minimum restriction on the rotative movement of the unison ring.

While the improved variable stator vane assembly according to this invention has been shown and described as having the roller assemblies 50 and 70 secured to unison rings 30 and 30A, respectively, it is within the contemplation of this invention to mount the roller assemblies on the support structure 52 instead of on the unison ring without departing from the scope and spirit of the invention.

It is believed now readily apparent that the present invention provides an improved variable stator ring assembly for fluid expansion engines wherein the unison ring of such stator ring assemblies is supported against radial deflection or distortion so that a high degree of accuracy of adjustment of stator vanes is achievable.

Although two embodiments of the invention have been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes can be made in the arrangement of parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art.

What is claimed is:

1. In an axial flow fluid expansion engine having wall means forming an annular fluid passageway an improved variable stator vane assembly having a unison ring connected to each of a plurality of pivotally mounted stator vanes disposed in said annular fluid passageway by a link and drive means connected to the unison ring to rotatively move the latter and thereby effect pivotal movement of the stator vanes, the improvement comprising:

a. the unison ring being disposed outwardly from and in spaced relationship to said wall means;

b. an annular stationary support structure disposed in outward spaced concentric relationship with the unison ring and said wall means; and

c. load transmitting means carried by the unison ring and disposed in said annular space between the support structure and unison ring to abut the support structure for transmitting forces tending to distort the unison ring from the latter to the support structure and thereby prevent radial deflection of the unison ring.

2. The apparatus of claim **1** wherein said load transmitting means includes means permitting rotative movement of the unison ring.

3. The apparatus of claim **1** wherein said load transmitting means comprises a plurality of circumferentially spaced roller assemblies.

4. The apparatus of claim **1** wherein said load transmitting means consists of a plurality of circumferentially spaced roller assemblies mounted on said unison ring so that the rollers engage the stationary support structure.

5. The apparatus of claim **3** wherein said support structure has an annular bearing surface which is engaged by the spaced roller assemblies.

6. The apparatus of claim **4** wherein each of the roller assemblies comprises:

a–1 a roller having an axle means projecting from said roller;

b–1 a journal means secured to said unison ring for rotatively supporting said axle means of the axle.

7. The apparatus of claim **6** in which the journal means comprises two spaced brackets.

8. The apparatus of claim **6** in which the journal means comprises a single bracket.

9. The apparatus of claim **4** wherein each of the roller assemblies comprises:

a–2 a roller having a trunnion projecting from opposite sides thereof;

b–2 a bracket having means for receiving and supporting each of said trunnions for rotation.

10. The apparatus of claim **4** wherein each of the roller assemblies comprises:

a–3 a roller mounted for rotation on a shaft;

b–3 a bracket having means for receiving and supporting the shaft.

11. The apparatus of claim **1** wherein said support structure is rigidly secured to the engine housing.

12. The apparatus of claim **4** wherein said support structure is secured to the engine housing.

* * * * *