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3,075,744

TURBINE NOZZLE VANE MOUNTING MEANS

Filed Aug. 16, 1960

3 Sheets-Sheet 1

FIG. 1

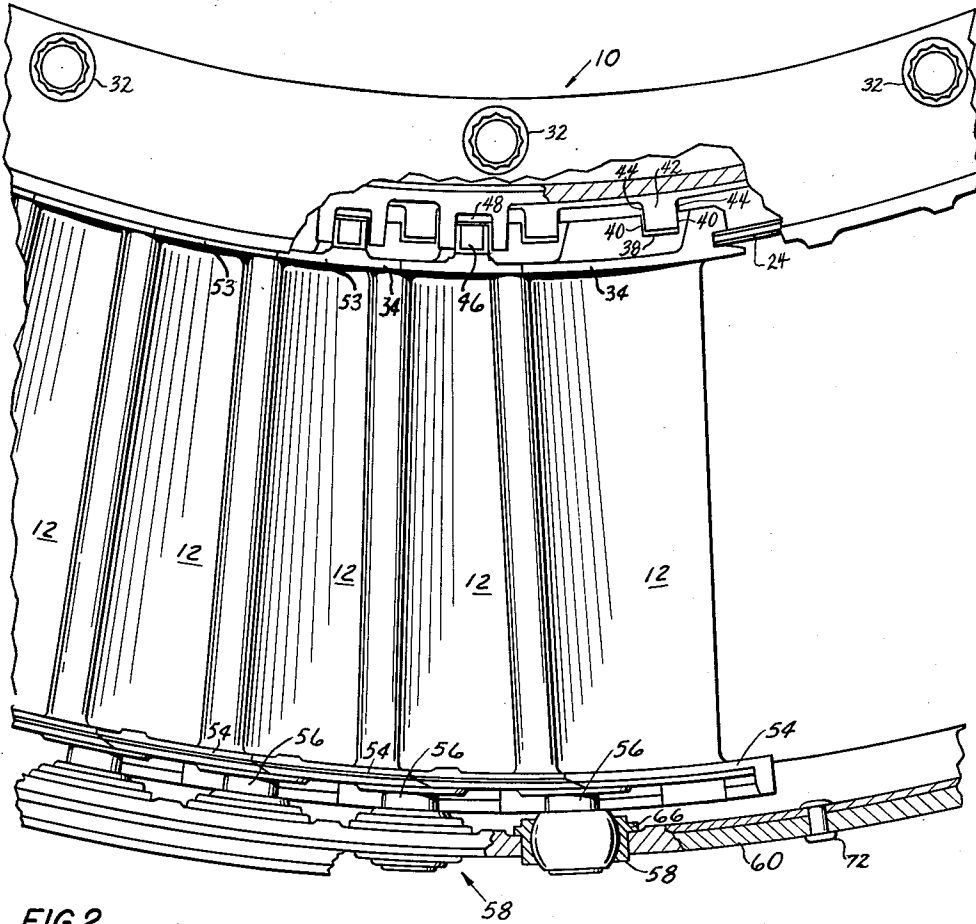
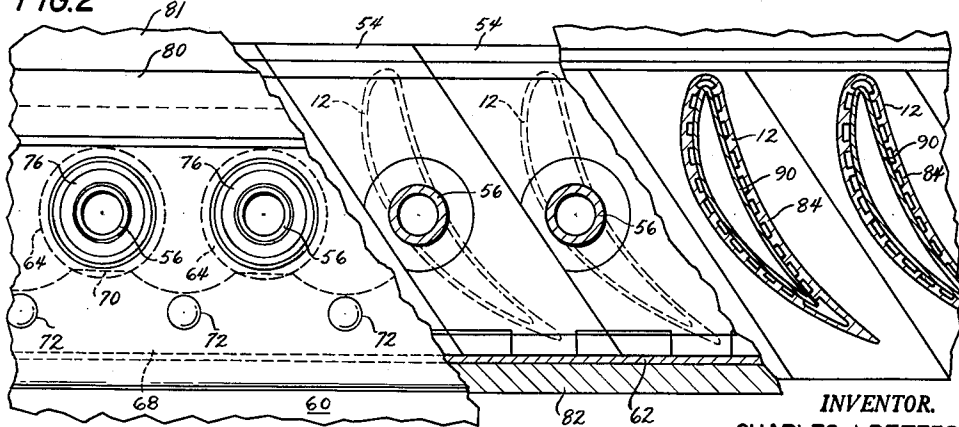


FIG. 2



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FIG. 3

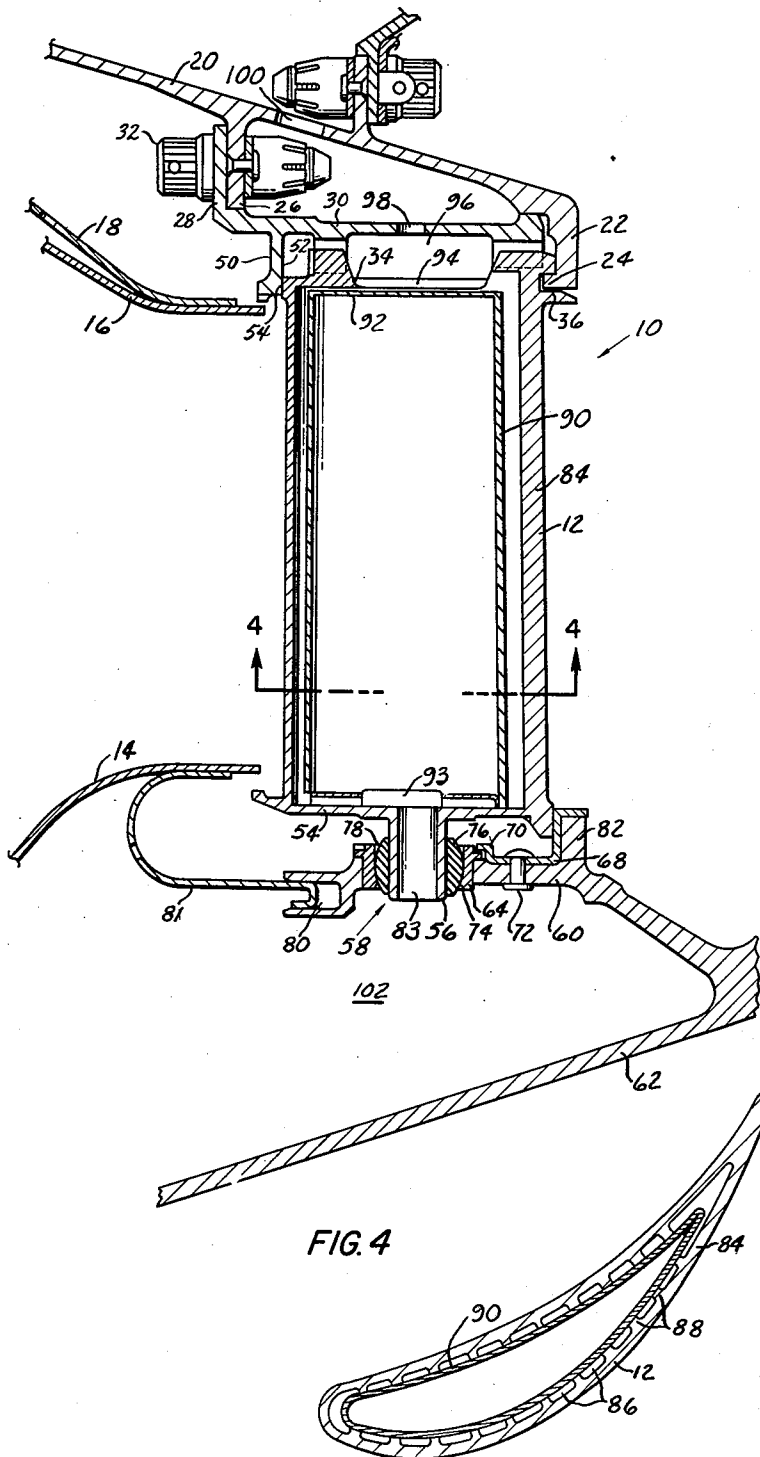


FIG. 4

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FIG. 5

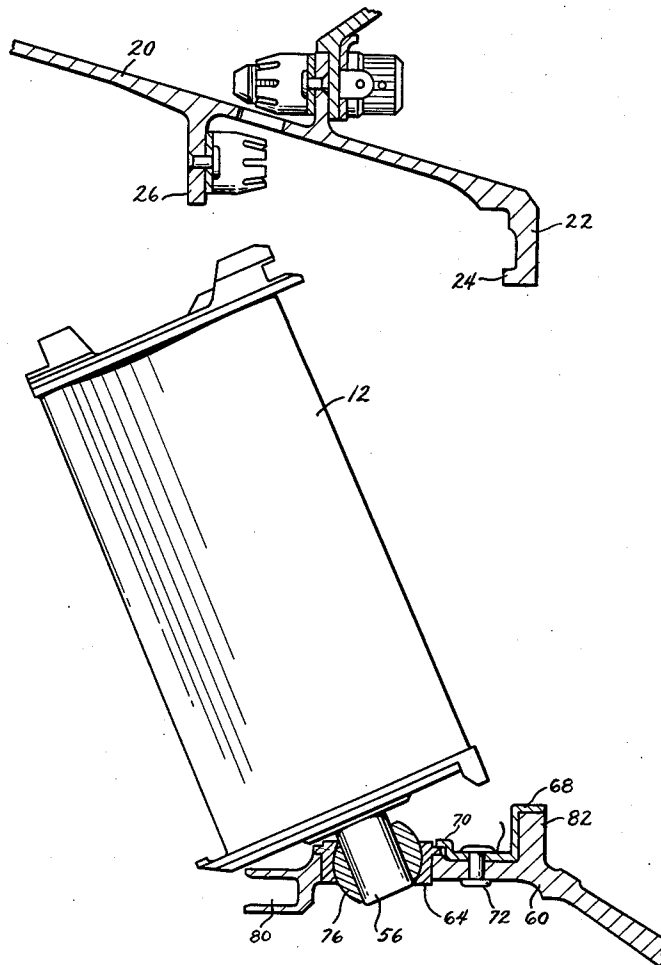
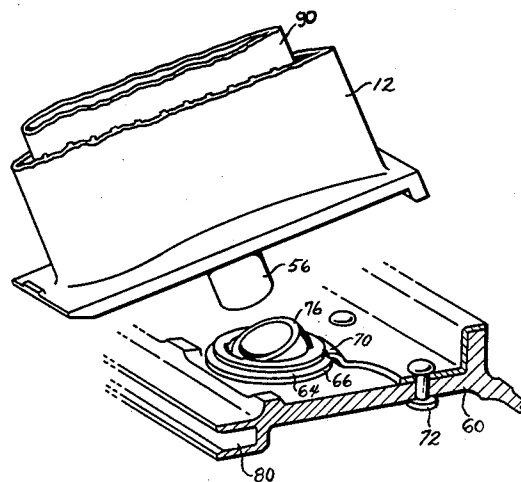


FIG. 6



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TURBINE NOZZLE VANE MOUNTING MEANS
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This invention relates to axial flow gas turbines, and deals more particularly with improved means for mounting the nozzle vanes of such a turbine.

One object of this invention is to provide an improved mounting means for the nozzle vanes of an axial flow gas turbine whereby the vanes are so supported as to be capable of moving slightly in various different directions to compensate for thermal differentials and to thus eliminate thermal stresses acting in various different directions relative to the vanes.

Another object of this invention is to provide a nozzle vane mounting means which is so constructed as to simplify the installation and removal of the individual nozzle vanes to and from the nozzle ring.

A further object of this invention is to provide an improved mounting means for turbine nozzle vanes which are cooled by air circulated through the bodies thereof, and wherein part of the mounting structure of each vane additionally serves as part of the means for supplying cooling air to the vane body.

Other objects and advantages of the invention will be apparent from the drawings and the following description.

The drawings show a preferred embodiment of the invention and such embodiment will be described, but it will be understood that various changes may be made from the construction disclosed, and that the drawings and description are not to be construed as defining or limiting the scope of the invention, the claims forming a part of this specification being relied upon for that purpose.

Of the drawings:

FIG. 1 is a fragmentary front elevational view of a turbine nozzle ring embodying the vane mounting means of the present invention, with various parts thereof being broken away to show more clearly the structure of other parts,

FIG. 2 is a developed view of the outer periphery of the nozzle ring shown in FIG. 1, with various parts being broken away to show more clearly the structure of other parts,

FIG. 3 is a sectional view of the nozzle ring shown in FIG. 1 with the view being taken generally along the longitudinal axis of the turbine and with parts appearing in back of the plane of the view being omitted for clarity,

FIG. 4 is a sectional view through a nozzle vane taken on the line 4-4 of FIG. 3,

FIG. 5 is a view generally similar to FIG. 3 but showing the inner retaining ring removed and the vane swung forwardly preparatory to its removal from the nozzle ring, and,

FIG. 6 is an exploded perspective view of the outer portion of a nozzle vane and the associated structure of the outer vane retaining member.

Referring now to the drawings, a nozzle ring embodying the present invention is indicated generally by the reference numeral 10 in FIGS. 1 and 3. The illustrated nozzle ring is incorporated in an axial flow gas turbine and cooperates with the first stage turbine wheel, not shown. The nozzle ring 10 includes a plurality of nozzle vanes 12, 12 which are arranged in an annular series about the axis of the turbine and serve to direct motive fluid to the blades of the adjacent turbine wheel. Referring to FIG. 3, it will be understood that the turbine

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wheel is located to the right of the vane 12. High pressure motive fluid is supplied to the nozzle ring 10 by an annular full admission duct which is generally a part of the outlet duct of a combustion chamber located upstream from the nozzle ring. In FIG. 3 such a duct is shown to comprise an outer combustion chamber ring 14 and an inner combustion chamber ring 16, the rings being concentrically arranged about the axis of the turbine. The inner ring 16 is supported from a suitable structure, not shown, by a support member 18.

The annular series of vanes 12, 12, as shown in FIG. 1, are of a generally uniform shape and of equal radial length, and are arranged so that their inner and outer ends are located respectively along concentrically arranged circles. The vanes are supported at both their inner and outer ends by inner and outer annular supporting structures which extend along and adjacent to the vane ends.

The supporting structure or mounting means associated with the inner ends of the vanes 12, 12 is such that these ends are held in fixed positions so as to be relatively immovable with respect to each other and with respect to other fixed parts of the turbine. As shown in FIGS. 1 and 2, this supporting structure preferably includes an annular support member 20 which in the present case comprises a part of the inner rear case of the combustion chamber and is rigidly supported with respect to the outer case of the turbine by suitable means. At its downstream end the annular member 20 is provided with a radially outwardly extending flange 22 having an annular upstream directed lip 24 formed along its outer margin. The annular support member 20 also includes another radially outwardly extending flange 26, spaced upstream from the flange 22, to which is connected the radially inwardly extending flange 28 of an annular retaining member 30. The two flanges 28 and 26 are held in connected relationship by a plurality of bolts, such as that shown at 32, and the retaining ring 30 is slidable axially upstream with respect to the member 20 for removal therefrom when the bolts 32, 32 are removed.

At its inner end each of the vanes 12, 12 is provided with an inner shroud 34 which extends generally circumferentially of the vane. The inner shrouds 34, 34 are so dimensioned and arranged that when all of the vanes 12, 12 are properly positioned in the nozzle ring 10 each shroud 34 will abut the shroud located to either side thereof so that all of the shrouds will collectively define a substantially closed shroud ring which confines the flow of motive fluid therethrough to an axial direction and prevents the same from flowing radially inwardly and out of its intended path. Along its trailing edge each of the inner shrouds 34 is radially enlarged and provided with a downstream facing recess 36 dimensioned to interfit with the annular lip 24 formed on the flange 22. This interfitting relationship between the recess 36 and the lip 24 prevents the vane 12 from moving radially with respect to the supporting member.

In addition, each vane 12, as shown best in FIG. 1, is also provided adjacent the trailing portion of its inner end with a radially inwardly extending notch 38 which provides two radially extending and circumferentially spaced surfaces 40, 40 facing in opposite directions. Interfitted with the notch 38 is a radially outwardly extending lug 42 formed on the retaining member 30. The lug 42 provides two radially extending circumferentially spaced surfaces 44, 44 which are engageable with the notch surfaces 40, 40 and cooperate therewith to prevent circumferential displacement of the vane 12 with respect to the retaining member 30 and the supporting member 20. Preferably, each vane is additionally circumferentially restrained adjacent the leading portion of its inner end and for this purpose each vane is provided on its inner

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end with a radially inwardly extending lug 46 which interfits with a corresponding notch 48 provided in the retaining member 30. The lug 46 and the notch 48 each provide cooperating radially extending and circumferentially spaced surfaces which coengage and restrain the vane against circumferential movement. The inner ends of the vanes are axially held in place by an outwardly extending annular flange 50 formed on the retaining member 30. The flange 50, as shown in FIG. 3, has a downstream facing surface 52 which engages the upstream end surfaces 53, 53 of the inner shrouds 34, 34.

At their outer ends the vanes 12, 12 and the nozzle ring 10 are supported by means which permits both radial sliding and swivelling movements of the vanes. Referring to FIGS. 1 and 3, each of the vanes 12, 12 is provided with an outer shroud 54 which, similarly to the inner shrouds 34, 34, and as shown best in FIG. 2, extends circumferentially of the associated vane 12 and abuts the shrouds 54, 54 to either side thereof so that all of the shrouds 54, 54 collectively define a substantially closed shroud ring surrounding the outer ends of the vanes. Connected with each of the outer shrouds 54, 54 is a radially outwardly extending stem 56 which is in turn slidably received by a ball and socket bearing indicated generally at 58. The bearings 58, 58 are carried by an annular retaining member 60 which comprises a part of the outer annular supporting structure for the vanes and which is preferably formed integral with the turbine case 62, as shown.

Each of the bearings 58, 58 comprises an outer race or socket member 64 which fits into a corresponding opening formed through the retaining member 60, as shown in FIGS. 1 and 3. On its inner end each socket member 64 is provided with a peripheral flange 66 which abuts the inner surface of the retaining member 60, and the socket members 64, 64 are held in place in the retaining member 60 by an annular seal ring 68 having a plurality of fingers 70, 70 which respectively engage the bearing flanges 66, 66, as shown in FIGS. 3 and 6. The seal ring is secured to the retaining member 60 by a number of rivets 72, 72 extending through the seal ring and the retaining member. The socket member 64 of each bearing is provided with a spherical bore 74 which receives a ball member 76 having a corresponding spherical surface 78. The ball member 76 is retained in the socket member by engagement with the spherical bore and is supported thereby for swivelling movement relative to the socket and the retaining member 60. That is, the ball member is free to rotate about a radial axis passing through the socket member 64 and is also free to pivot in any direction about a pivot point located centrally of the ball member. The ball member of each bearing is provided with an opening for slidably receiving the associated vane stem, and preferably both the opening and the stem are cylindrical and of circular cross section so that the stem may slide both axially and angularly with respect to the ball member. This is not essential to the invention, however, and the stems and the ball member openings could be made with noncircular cross sections if desired.

In addition to serving as a support for the bearings 58, 58, the retaining member 60 is also preferably provided adjacent its upstream edge with an annular recess 80 which serves to receive and hold in place a part of an annular ring 81 which is connected to, and serves as a support and seal for, the outer combustion chamber ring 14, as shown in FIG. 3. The retaining member 60 also includes a radially inwardly extending annular flange 82 and the seal ring 68 is so bent and shaped as to engage the flange 82 and the downstream edges of the outer shrouds 54, 54 for sealing purposes, as shown in FIG. 3.

From FIGS. 1 and 3 it will be apparent that the stems 56, 56 and the ball and socket bearings 58, 58 function to support the outer ends of the vanes 12, 12 in such a manner that the latter ends are free to move in various directions to compensate for thermal differentials exist-

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ing between the various parts of the nozzle ring and various parts of the vanes themselves. For example, the sliding engagement between the stems 56, 56 and the ball members 76, 76 of the bearings permits the outer ends of the vanes to expand or contract in a generally radial direction. This sliding engagement, and in addition the sliding engagement between the ball members 76, 76 and the socket members 64, 64, also permits the outer ends of the vanes to twist relative to the fixed inner ends thereof so as to eliminate thermal torsional stresses which may occur in the vanes. Furthermore, the swivably movable ball members 76, 76 permit the stems 56, 56 to move pivotally in any direction relative to the centers of the ball members and thereby eliminate thermal stresses which tend to produce such pivotal movements. Thus, the support provided for the outer ends of the vanes gives the vanes a high degree of flexibility which is advantageously employed for the elimination of stresses in the nozzle ring assembly. More particularly, any tendency of a vane to twist about its longitudinal axis, causing one end of the vane to move angularly relative to the other, is accommodated by rotation of the vane stem 56 relative to the associated ball member 76 or by rotation of the ball member relative to the associated socket member 64. Any lengthening or shortening of the vane is accommodated by a sliding motion of the stem relative to the ball member. And, any tendency of the outer shroud 54 to cock or move angularly from the position shown, as by a bowing of the vane in any direction or by different parts of the vane changing in length by different degrees, is accommodated by rotation of the ball member relative to the socket member about an axis generally normal to the axis of the stem. The engagement of the shroud 54 with adjacent shrouds and with the seal ring 68 may impose some forces on the shroud tending to resist some of these motions, depending on the size and directions of the deformations involved. Nevertheless, the shrouds are not force fitted in relation to neighboring shrouds and the seal ring, and therefore some degree of motion of the shroud in the various manners described is possible before the reaction forces imposed thereon by the neighboring shrouds and sealing ring become very great. The illustrated ball and socket joint thus provides a degree of flexibility which is lacking in a completely rigid connection.

The vanes 12, 12 shown in the drawings are of a type which are air cooled. As far as certain of the broader aspects of the invention are concerned, the vanes need not necessarily be air cooled, but when they are so cooled one of the important features of the invention is that the vane mounting means hereinbefore described functions in a novel manner to provide part of a system for circulating the cooling air through the vanes 12, 12. In accordance with this feature of the invention, the illustrated vanes are of a hollow construction, as shown in FIGS. 3 and 4, and the stems 56, 56 are also provided with hollow bores, such as shown at 83 in FIG. 3, which communicate with the hollow interiors of the vanes to supply cooling air thereto. Various different constructions of hollow vanes may be used with this invention, however, for purposes of illustration the vane 12 shown in FIGS. 3 and 4 includes a hollow body 84 which has a series of longitudinally extending grooves 86, 86 formed in its inner surface, the grooves 86, 86 being separated by longitudinally extending ribs 88, 88. Positioned within the hollow interior of the vane body is a baffle member 90 which engages the ribs 88, 88 and closes the grooves 86, 86 so as to define longitudinal passageways for directing the flow of cooling air along the inner surface of the vane body. The baffle member 90 is closed at its upper end by a cover plate 92 and at its outer end is provided with a plurality of openings, such as shown at 93, which openings provide communication between the bore 83 of the associated stem 56 and the passageways provided by the longitudinal grooves 86, 86. Thus, the air introduced to the vane through the bore 83 of its stem is directed to the various

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passageways provided by the grooves 86, 86. The inner shroud 34 of each is provided with an opening 94 through which the air passing through the vane body is discharged, the opening 94 being in communication with all of the passageways defined by the grooves 86, 86. After leaving the openings 94, 94 of the vanes 12, 12, the cooling air enters a chamber 96 defined by the retaining member 30 and the inner shrouds 34, 34, and then flows through one or more openings such as that shown at 98 in the retaining member 30, and through one or more openings, such as that shown at 100 in the annular member 20, toward the axis of the turbine from which location it is exhausted by other suitable means, not shown.

As shown best in FIG. 3, the turbine case 62 surrounds the retaining member 60 and, together with the retaining member, the ring 81 and the outer combustion chamber ring 14, defines a manifold 102 which communicates with the outer ends of all of the stems 56, 56 so as to simultaneously supply cooling air to the stems. Cooling air under pressure is supplied to the manifold 102 by any suitable means and may comprise air which is diverted from a compressor stage located upstream of the combustion chamber and bypassed around the combustion chamber. In regard to the cooling of the vanes 12, 12 it will be observed that the stems 56, 56 in this invention serve the double purposes of both providing for the introduction of air to the vanes and also of providing a support for the outer ends thereof.

Another feature of the present invention is that the mounting means provided for the vanes 12, 12 is also of a construction whereby the vanes are easily installed and removed to and from the nozzle ring. As mentioned previously, the inner retaining member 30, which forms a part of the mounting means or supporting structure for the inner ends of the vanes 12, 12, is removably connected to the annular member 20 by the bolts 32, 32. When the member 30 is removed from connected relationship with the annular supporting member 20 the vanes 12, 12 are freed for pivoting movement about the centers of the ball and socket bearings 58, 58. Thus, when the retaining member 30 is removed each of the vanes 12, 12 may be pivoted axially upstream from the upright position shown in FIG. 3, at which the inner end thereof is located adjacent the supporting member 20, to an inclined position, such as shown in FIG. 5, at which the inner end of the vane is spaced a substantial distance from the annular member 20. The spacing between the inner end of the inclined vane and the supporting member is sufficient to permit the vane to be pulled or slid out of engagement with the ball member 76 of the bearing 58 to remove the vane from the nozzle ring, as shown in FIG. 6. Likewise, when a vane is to be replaced in a nozzle ring, this operation is easily performed by first fitting the stem 56 into the opening of the associated ball member 76 while the vane is at an inclined angle with the axis of the turbine and by then swinging the vane to the upright position shown in FIG. 3 and adjusting the same to bring the groove 36 thereof into interfitted relationship with the lip 24. After all of the vanes are so positioned in place in the nozzle ring, the retaining member 30 is replaced and reconnected with the support member 20 by the bolts 32, 32.

As used herein and in the claims which follow the term "swivelling movement" refers to a movement of one part relative to another which movement is universal in nature in that it may occur about any axis passing through a point common to the two parts. The movement of the ball in a ball and socket joint, wherein the ball may rotate relative to the socket about any axis passing through its center, is an example of such movement although other types of joints allowing the same type of motion are also possible. Likewise, the term "swivable" or "swivably movable" refers to a part capable of such swivelling or universal movement.

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The invention claimed is:

1. A nozzle ring for an axial flow turbine, said nozzle ring comprising a plurality of generally similar and radially extending vanes arranged in an annular series so that their inner and outer ends are disposed respectively along inner and outer concentric circles, mounting means located adjacent one of said concentric circles and serving to hold in fixed and nonadjustable positions the associated ends of the said vanes, radially extending stems formed on the ends of the vanes defining the other of said concentric circles, an annular retaining member located along and adjacent the latter ends of said vanes, means independent of said vanes for supporting said annular retaining member in a fixed position relative to the axis of said turbine and a plurality of ball and socket bearings carried by said annular retaining member, each of said bearings having a ball member provided with an opening which slidably receives a respective one of said vane stems so as to permit radial sliding movement of said vane stem relative to said retaining member.

2. A nozzle ring for an axial flow turbine having a case, said nozzle ring comprising concentrically arranged inner and outer annular supporting structures, a plurality of vanes arranged in an annular series between said supporting structures, means independent of said vanes for holding said annular supporting structures in fixed positions relative to said case, said vanes having their inner ends held in fixed and nonadjustable positions by connection with said inner supporting structure, a plurality of radially outwardly extending stems formed respectively on the outer ends of said vanes, and a plurality of ball and socket bearings carried by said outer supporting structure, each of said bearings having a swivable ball member provided with an opening which slidably receives a respective one of said vane stems so as to permit radial sliding movement of said vane stem relative to said outer supporting structure.

3. A nozzle ring for an axial flow turbine having a case, said nozzle ring comprising concentrically arranged inner and outer annular supporting structures, a plurality of hollow vanes arranged in an annular series between said supporting structures, means independent of said vanes for holding said annular supporting structures in fixed positions relative to said case, said vanes having their inner ends held in fixed and nonadjustable positions by connection with said inner supporting structure, a plurality of radially outwardly extending stems formed respectively on the outer ends of said vanes which stems are hollow and provide conduits for the flow of cooling air to the interiors of said vanes, a plurality of ball and socket bearings carried by said outer supporting structure, each of said bearings having a swivable ball member provided with an opening which extends therethrough and which slidably receives a respective one of said vane stems so as to permit radial sliding movement of said vane stem relative to said outer supporting structure, and means providing a manifold adjacent the outer ends of said vane stems for simultaneously supplying cooling air thereto.

4. In an axial flow turbine having a case the combination of inner and outer annular supporting structure, a plurality of nozzle vanes arranged in an annular series between said supporting structures, means independent of said vanes for holding said annular supporting structures in fixed positions relative to said case, means for fixedly and nonadjustably securing the inner ends of said vanes to said inner supporting structure and which means includes at least one part which is removable to permit axial movement of said inner vane ends relative to said inner supporting structure during installation and removal of the said vanes, said outer supporting structure including an outer annular retaining member surrounding the outer ends of said vanes, a plurality of radially outwardly extending stems formed respectively on the outer ends of said vanes, and a plurality of bearings car-

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ried by said outer retaining member each of which bearings includes a socket member fixed to said outer retaining member and a ball member which is swivably movable relative to the said socket member, each of said ball members having a radially extending opening therein which slidably receives a respective one of said vane stems so as to support the outer end of the associated vane for swivelling and radial sliding movement with respect to said outer retaining member.

5. In an axial flow turbine having a case the combination of inner and outer annular supporting structures, a plurality of nozzle vanes arranged in an annular series between said supporting structures, means independent of said vanes for holding said annular supporting structures in fixed positions relative to said case, mounting means for fixedly and nonadjustably securing the inner ends of said vanes to said inner supporting structure and which mounting means includes at least one part which is removable to permit axial movement of said inner vane ends relative to said inner supporting structure during installation and removal of the vanes, said outer supporting structure including an outer annular retaining member surrounding the outer ends of said vanes, a plurality of radially outwardly extending stems formed respectively on the outer ends of said vanes, and a plurality of stem supporting means carried by said outer retaining member, each of said stem supporting means including an apertured member for receiving a respective one of said vane stems for sliding movement of the vane relative thereto along the longitudinal axis of the vane and means connecting said apertured member to said outer retaining member for pivotal movement relative thereto so as to permit the associated vane to be pivoted in a generally axial direction during installation and removal thereof between a normal upright position at which the inner end of the vane is located adjacent said inner supporting structure and an inclined position at which the inner end of the vane is spaced from said inner supporting structure, said stems being freely received in said apertured member so that said stems may be slid into or out of said apertured members to connect or disconnect the vanes from said outer retaining member when said vanes are in their inclined positions.

6. In an axial flow turbine having a case the combination of inner and outer annular supporting structures, a plurality of hollow nozzle vanes arranged in an annular series between said supporting structures, means independent of said vanes for holding said annular supporting structures in fixed positions relative to said case, mounting means for fixedly and nonadjustably securing the inner ends of said vanes to said inner supporting structure and which mounting means includes at least one part which is removable to permit axial movement of said inner vane ends relative to said inner supporting structure during installation and removal of the vanes, said outer supporting structure including an outer annular retaining member surrounding the outer ends of said vanes, a plurality of bearings carried by said outer retaining member each of which bearings includes a socket member fixed to said outer retaining member and a ball member which is swivably movable relative to the said socket member, each of said ball members having a radially extending opening therethrough, a plurality of

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radially outwardly extending stems formed respectively on the outer ends of said vanes and which stems are hollow and communicate with the hollow interiors of said vanes to provide for the flow of cooling air to said vanes, said stems being slidably received respectively by said openings in said ball members so as to be in communication with the space surrounding the outer side of said outer retaining member and so as to support the outer ends of the associated vane for sliding and swivelling movement with respect to said outer retaining member, and means providing a manifold surrounding said outer retaining member for simultaneously supplying cooling air to said stems.

7. In an axial flow turbine the combination of inner and outer annular case structures, an outwardly extending annular flange connected with said inner case structure and having an upstream facing lip located along the outer margin thereof, a plurality of nozzle vanes arranged in an annular series between said inner and outer annular case structures, each of said vanes having means on its inner end defining a downstream facing recess adapted to interfit with said upstream facing lip and also having means on its inner end defining at least two radially extending faces which are circumferentially spaced and facing in opposite circumferential directions, an inner retaining ring removably connected with said inner case structure and having means defining a downstream facing surface which engages said vanes and holds the same axially in place with the recesses thereof in inter-fitted relation with said lip to prevent axial and radial movement of said vanes relative to said inner case structure, said retaining ring also having means defining a plurality of radially extending surfaces with the surfaces being circumferentially spaced and facing in opposite circumferential directions and interfitting with the two radially extending faces on said vanes so as to hold the associated vanes circumferentially in place relative to said inner case structure, an outer annular retaining member fixedly connected with said outer case structure and surrounding the outer ends of said vanes, a plurality of radially outwardly extending stems formed respectively on the outer ends of said vanes, and a plurality of bearings carried by said outer retaining member each of which bearings includes a socket member fixed to said outer retaining member and a ball member which is swivably movable relative to the said socket member, each of said ball members having a radially extending opening therein which slidably receives a respective one of said vane stems so as to support the outer end of the associated vane for sliding and swivelling movement relative to said outer retaining member.

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