May 16, 1961 B. M. FIORI 2,984,454

STATOR UNITS

Filed Aug. 22, 1957 2 Sheets-Sheet 1

FIG. 1

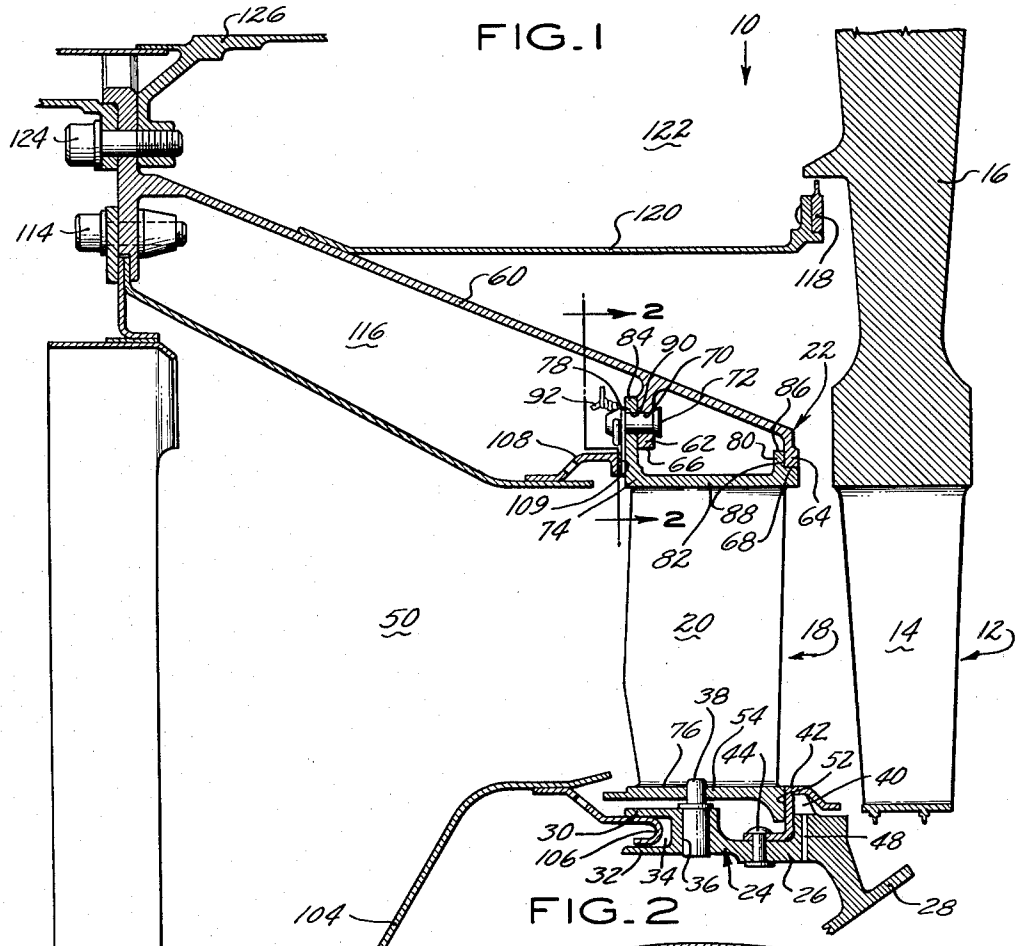


FIG. 2

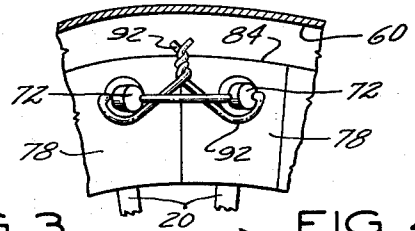


FIG. 3

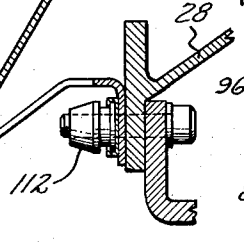
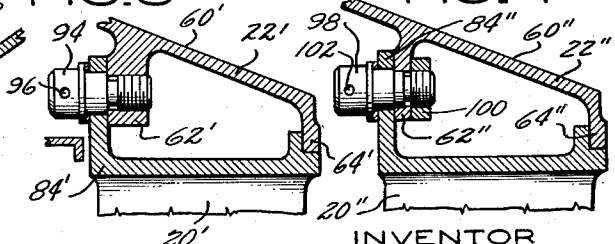


FIG. 4



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STATOR UNITS

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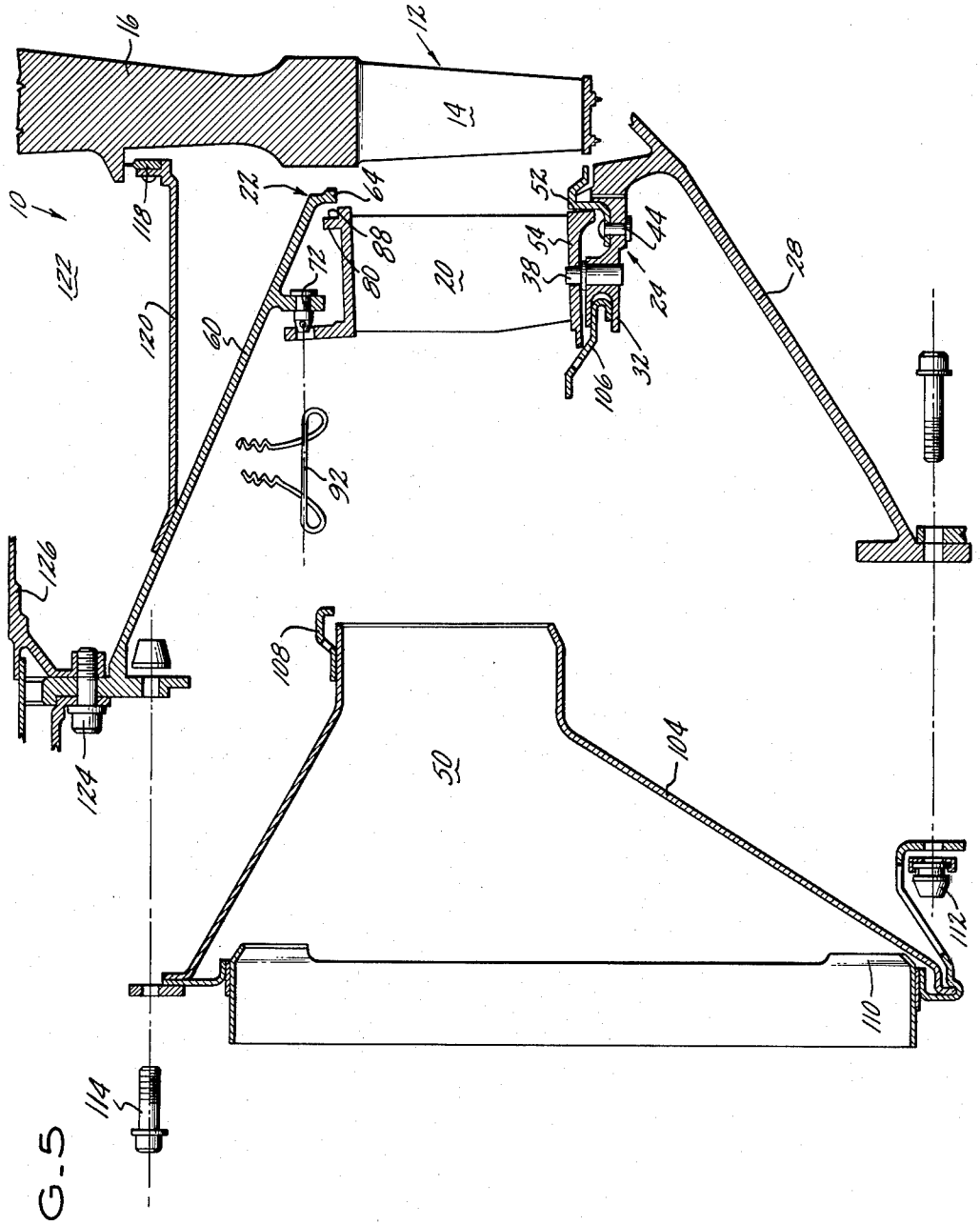

FIG. 5

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STATOR UNITS

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7 Claims. (Cl. 253—78)

This invention relates to stator units of the type used in the turbine and the compressor of modern aircraft turbojet engines and more particularly to stator units which permit individual vane release and removal from one side of the stator.

In the past, stator units have been so constructed that substantial disassembly of the powerplant was necessary to remove the stator unit from the powerplant and further, such that either the entire stator unit or a substantial portion thereof had to be replaced when a single vane was damaged. A more recent practice has been to permit stator vane removal, once the powerplant combustion chambers have been removed, thru an access path axially forward or upstream of the vanes as taught in application Serial No. 637,492, filed January 31, 1957, now Patent No. 2,916,874, in the name of John Worobel. While this is a definite improvement over the fabrications which preceded it, it was necessary to use a rig or fixture to maintain all stator vanes in place while the damaged vane was removed and replaced.

It is an important object of this invention to teach a stator construction in which each vane is individually supported within the stator, independent of all other vanes.

It is a further object of this invention to teach a stator construction in which both the inner vane support and the outer vane support are one-piece units.

It is still a further object of this invention to teach a stator construction in which the individual vanes may be locked in their particular position by a mechanism which, if it should break loose, would not enter the powerplant gas stream and further, in which the stator unit fabrication is such that gas loading would tend to maintain the component parts of the stator assembled, should the lock mechanism disengage.

It is still a further object of this invention to provide a stator unit which will permit release and removal of a particular stator vane thru an access path entirely on one side of the stator unit and preferably upstream thereof, without disturbing the other stator vanes.

It is a further object of this invention to provide a stator unit in which anti-erosion and thrust strips made of hard metals may be placed against the downstream inner surface of the vane support where it will be subjected to the vane thrust load and to the erosion effect of the hot gases. Further, cooling air may be passed adjacent this thrust strip.

It is still a further object of this invention to permit turbine rotor blade inspection and removal by baring the rotor blades thru removal of the vanes of the adjacent stator unit.

Other objects and advantages will be apparent from the following specification and the attached drawing in which:

Fig. 1 is a cross-sectional showing of my stator unit.

Fig. 2 is a view taken along line 2—2 of Fig. 1.

Figs. 3 and 4 show alternate connecting and locking means which may be used to fasten the vane inner end to the vane inner support.

Fig. 5 is an exploded view of my stator unit illustrating vane assembly and disassembly.

While my invention will be described as embodied in the axial flow turbine of a modern aircraft turbojet engine, it should be borne in mind that such is done for the purpose of description only, and the embodiment is usable in numerable other applications.

In well known fashion and as fully described in U.S. Patent No. 2,770,946, atmospheric air is introduced into the compressor of a modern aircraft turbojet engine and passed in compressed form into the combustion chamber for heating. The heated and compressed air is then passed thru the turbine which performs a power extraction function to drive the compressor and possibly a propeller, and after passing thru the turbine the engine gases are discharged to atmosphere thru an exhaust outlet, thereby performing a propulsion function.

Both the axial flow compressor and the axial flow turbine consist basically of alternate rows of stationary vanes and moveable vanes, sometimes called blades. The stationary vanes are supported in position as part of a stator unit while the moveable blades rotate with a revolving disc. The stator unit and the vanes thereon perform the function of turning the powerplant gas such that it is directed against the rotating blades immediately downstream thereof at the proper angle.

Referring to Fig. 1, we see a partial showing of axial flow turbine **10** having an axis or centerline and rotor unit **12** which comprises a plurality of radially extending blades **14** attached to and equally spaced circumferentially about the periphery of disc **16** for rotation therewith. Stator unit **18** comprises a plurality of stationary vanes **20** which are individually supported at their inner end by vane inner support **22** and at their outer end by vane outer support **24**. Vane outer support **24** comprises axially directed ring **26** which forms a circle about turbine and powerplant axis or centerline (not shown) and which is supported by and may be integral with one-piece outer turbine case **28**. Ring **26** carries axially extending and radially spaced lips **30** and **32** at its forward end which form forwardly opening U-shaped channel **34**. Ring **26** includes a plurality of radially directed holes **36** which are spaced equally circumferentially thereabout to receive, in positive fashion such as a pinch-fit, or interlocking threads, radially directed outer vane support pins or lugs **38**. Ring **26** further comprises radially directed flange **40** against which anti-erosion and thrust strip **42** bears. Connecting means **44** attaches strip **42** to ring **26** and may be in the form of a rivet. Cooling air from passage **46** is directed thru line **48** and into engine gas path **50** to perform the function of cooling strip **42**. The after or axially downstream end or surface **52** of vane platform **54** bears against strip **42** and transmits a thrust load thereto, caused by the flow of hot exhaust gases across vane **20**.

One-piece vane inner support **22** comprises conical case **60** from which axially spaced and radially directed flanges **62** and **64** project. Flanges **62** and **64** are circular, forming circles about the turbine axis and it will be noted that the outer surface **66** of axially forward flange **62** is of less radius than the outer surface **68** of the axially downstream flange **64**. Flange **62** has a plurality of axially directed apertures **70** passing therethru to receive in positive fashion, such as a pinch-fit or interlocking thread, axially extending inner vane support pin or lug **72**.

A plurality of stationary vanes **20** are radially directed and equally spaced circumferentially between vane inner support **22** and vane outer support **24** and each vane **20** is positively positioned in stator unit **18**, both at its inner end **74** and at its outer end **76**, independently of all other vanes **20**. It will be noted that inner end **74** of vane

20 comprises two axially spaced and radially directed flanges or lugs 78 and 80 which are joined by member 82 and which are fabricated such that the inner surface 84 of the axially forward flange 78 is of greater height and of lesser radial distance from the turbine axis than is inner surface 86 of axially downstream flange 80. It will further be noted that surface 68 of support flange 64 engages right angle notch 88 of flange 80 in supporting fashion. In assembled position, see Fig. 1, vane flange 78 is juxtapositioned to support flange 62, while vane flange 80 is juxtapositioned to support flange 64 so that the gas loading tends to seat vanes 20. With vane 20 so positioned, inner pin or rivet 72, which is firmly fixed in axially forward support flange 62 passes thru aperture 90 of vane flange 78 and extends axially forward thereof and carries the necessary hole therethru to permit locking the parts in this position by the use of lock wire 92 such that the lock wire passes thru the two adjacent pins or rivets 72, as best shown in Fig. 2.

Figs. 3 and 4 show alternate vane inner end attaching and locking means. Fig. 3 shows bolt 94 passing thru vane flange 84' and support flange 62', into which it is fixedly threaded. Aperture 96 is provided to permit locking bolt 94 in position by lock wire (not shown). Fig. 4 shows bolt 98 projecting thru vane flange 84'' and support flange 62'' and threadedly engaging insert 100 which is attached in any convenient fashion to support flange 62''. Aperture 102 is provided to permit the locking of bolt 98 in position by means of lock wire (not shown).

By referring to Fig. 1, it will be noted that vane inner end 74 is axially positioned by support flanges 62 and 64 and is circumferentially and radially fixed by rivet, lug or pin 72. At the outer end 76 of vane 20, axially extending platform 54 is received loosely by pin or lug 38 to axially and circumferentially position outer end 76 of vane 20 and a substantial radial distance exists between vane platform 54 and ring 26 of vane outer support 24, thereby permitting relative radial movement therebetween. Lug 38 preferably passes thru platform 54 in a location to be substantially equidistant between the side walls of vane 20.

As shown in Fig. 1, transition duct 104 is located immediately upstream or axially forward of stator unit 18 and engages outer vane support 24 in sealing relation by seal 106 and engages inner vane flange 78 in sealing relation by seal 108. Surface 109 of seal 108 is positioned to provide axial support to the vane inner end thru flange 78 in case of back pressure or backfire. Reverse axial loading goes from flange 78 to seal 108, to transition duct 104 and to support member 126. Transition duct 104 and combustion chamber support 110 may be removed by disengaging connecting means 112 and 114 after the combustion chamber (not shown) has been removed. This bares lock wire 92 for removal, which will permit the removal of bolts 94 and 98 in Figs. 3 and 4, respectively, to free the inner ends 74 of vane 20 in the configurations shown in Figs. 1, 3 and 4, thereby permitting same to be moved radially inward, if desired, and then pivoted axially forward about pin 38 or merely pivoted axially forward about pin 38 due to the loose fit existing between pin 38 and platform 54, thereby releasing the outer end 76 of vane 20 to free the vane for removal from stator unit 18.

It will be noted that a single vane 20 may be released, removed and replaced thru access from the upstream or axially forward side of stator unit 18 only, without disturbing the other vanes in any way.

As best shown in Fig. 5, it is possible to assemble and disassemble any number of vanes 20 or an individual vane 20 without disturbing any of the remaining vanes. In assembling the entire unit, rotor 16, outer case 28 and inner case 60 are fastened in position. Each vane will be assembled in turn by utilizing the access hole defined between cases 28 and 60 on the forward side of rotor 16 by introducing the vane to outer vane support 24 with the vane inner end 74 axially forward of the vane outer end 76, in tilted fashion, such that a preliminary connection may be made between lug 38 and platform 54, whereupon vane 20 will be pivoted clockwise about pin 38 into the position shown in Fig. 1 in which vane flange 78 engages lug 72. This assembly is possible since pin 72 is held in position by a tight fit in flange 62 and extends loosely through aperture 90 in flange 94 while in like manner pin 83 passes loosely through the aperture in vane platform 54. Lock wire 92 will then be fastened in position as shown in Fig. 2 and the transition duct 104, the burner after support 110 and the combustion chambers will be assembled. It will be noted that lock wire 92 is confined within chamber 116 such that if a rupture should occur therein and a piece break loose therefrom during operation, the piece would not fall into gas passage 50. Seal 118 is carried by cylindrical support 120 and performs the function of preventing air flow between gas passage 50 and chamber 122. Support 120 is fastened to vane inner support 22 by any convenient means such as welding or brazing, and vane inner support 22 is attached to structural members 126 of turbine 10 by connecting means 124. In known fashion, the engine case or combustion chamber case may then be placed in position to envelop the series of combustion chambers.

To replace a single vane 20, it is merely necessary to remove the combustion chamber case (not shown), to remove the combustion chamber and transition duct 104 and thereby gain access to vanes 20 from the axially forward side thereof. Lockwire 94 is then removed, whereupon vane 20 may be tilted forwardly in its inner end to pivot slightly about pin 38. This pivot action frees the inner end of the vane from flange 64, whereupon the vane may be moved radially inwardly to clear pin 38 and then moved axially forwardly in complete freedom.

Although the preferred embodiments have been shown and described, it will be apparent that various changes and modifications may be made in the construction and arrangement of the various parts without departing from the scope of this novel concept.

I claim:

1. A stator unit of circular cross-section for use in a powerplant having an axis comprising a plurality of vanes, each having a hole in one end thereof, means for supporting each of said vanes in its operative position to be substantially radially extending and substantially an equal radial distance from and equally spaced in a circle about said axis, means providing access to one side of said vanes and support means, and said support means including a plurality of substantially radially extending pins each received loosely in one of said holes in said vanes and a plurality of readily releasable means each accessible from said one side and each fully supporting the other end of one of said vanes thereby permitting the removal and replacement of any vane in said plurality from said one side while maintaining all other vanes in operative position.

2. A stator unit of circular cross-section for use in a powerplant having an axis comprising a plurality of vanes, each having a hole in the outer end thereof, means to support said vanes to be substantially radially extending and substantially an equal radial distance from and equally spaced in a circle about said axis including first means supporting the outer end of each of said vanes individually and independently of all other vanes and second means independent of said first means supporting the inner end of each of said vanes individually and independently of all other vanes said first means including a ring enveloping said vanes and having a plurality of substantially radially inwardly directed pins each received loosely in one of said holes in said vanes and said second means including a plurality of readily releasable means

each accessible from said one side and each fully supporting the inner end of one of said vanes so that said first and second means cooperate to permit the removal and replacement of any vane in said plurality from said one side while maintaining all other vanes in operative position.

3. A stator unit for use in a powerplant having an axis comprising a plurality of vanes, means readily releasable and attachable from one side of said vanes supporting each of said vanes in its operative position to be substantially radially extending and substantially an equal radial distance from and equally spaced in a circle about said axis, and means providing access to said side of said vanes and support means.

4. A stator unit comprising a vane outer support comprising a ring, a vane inner support comprising at least one radially extending circular flange, a plurality of vanes each having an axially extending platform at its outer end and at least one radially extending flange at its inner end and with said vanes extending radially between and spaced circumferentially about said vane supports and each located with respect thereto such that said radially extending flanges are juxtapositioned and further such that said vane outer support ring and each of said vane platforms is spaced a preselected distance apart radially, a plurality of radially directed lugs each connected to said vane outer support ring and projecting loosely thru one of said vane platforms to position the vane outer end, a plurality of axially directed lugs each connected to said vane inner support flange and projecting thru the inner end flange of one of said vanes and projecting therebeyond to position said vane inner end, and means removable from one side of said stator unit locking each of said vane flanges in position individually against said support flange and on one of said axial lugs thereby permitting one of said vanes to be released, removed and replaced thru access from one side of said stator unit only while all other vanes are maintained in position.

5. A stator unit having an axis and comprising a vane outer support comprising a ring, a vane inner support comprising two axially spaced rings forming radially extending circular flanges of different inner diameters such that the axially forward flange is of lesser diameter, a plurality of vanes each having an axially extending platform at its outer end and two axially spaced radially extending flanges at its inner end and with the axially forward vane flange of greater height and with said vanes extending radially between and spaced circumferentially about said vane supports and each located with respect thereto such that said radially extending flanges are juxtapositioned with said axially forward vane flange engaging the axially forward support flange on the axially forward side thereof and with the other flanges engaging in the same relative axial positions and further such that said vane outer support ring and each of said vane platforms is spaced a preselected distance apart radially, a plurality of radially directed lugs each connected to said vane outer support ring and projecting loosely thru one of said vane platforms to position the vane outer end, a plurality of axially directed lugs each connected to said axially forward inner support flange and projecting thru the axially forward inner end flange of one of said vanes and projecting therebeyond to position said vane inner end, and means removable from one side of said stator unit locking each of said vane flanges in position individually against said support flange and on one of said axial lugs thereby permitting one of said vanes to be released, removed and replaced thru access from one side of said stator unit only while all other vanes are maintained in position.

6. A stator unit having an axis and comprising a vane outer support comprising an axially extending ring forming a circle about said axis, an anti-erosion and thrust ring attached to said vane outer support ring, cooling gas passages in said outer support ring positioned to direct

cooling gas over said anti-erosion and thrust ring, a vane inner support comprising two axially spaced rings forming radially extending circular flanges of different inner diameters such that the axially forward flange is of lesser diameter, a plurality of vanes each having an axially extending platform at its outer end and two axially spaced radially extending flanges at its inner end and with the axially forward vane flange of greater height and with said vanes extending radially between and spaced circumferentially about said vane supports and each located with respect thereto such that said radially extending flanges are juxtapositioned with said axially forward vane flange engaging the axially forward support flange on the axially forward side thereof and with the other flanges engaging in the same relative axial positions and further such that said vane outer support ring and each of said vane platforms is spaced a preselected distance apart radially, and further such that the after end of said platform bears against said anti-erosion and thrust ring, a plurality of radially directed lugs each connected to said vane outer support ring and projecting loosely thru one of said vane platforms to position the vane outer end, a plurality of axially directed lugs each connected to said axially forward vane inner support flange and projecting thru the axially forward inner end flange of one of said vanes and projecting therebeyond to position said vane inner end, and means removable from one side of said stator unit locking each of said vane flanges in position individually against said support flange and on one of said axial lugs thereby permitting one of said vanes to be released, removed and replaced thru access from one side of said stator unit only while all other vanes are maintained in position.

7. A turbine or compressor unit having an axis and comprising a rotor unit and a stator unit coaxial therewith and positioned axially forward thereof, said rotor unit comprising a plurality of removable radially extending blades attached to the periphery of a rotatable disc and equally spaced thereabout, said stator unit comprising a vane outer support comprising an axially extending ring forming a circle about said axis, an anti-erosion and thrust ring attached to said vane outer support ring, cooling gas passages in said outer support ring positioned to direct cooling gas over said anti-erosion and thrust ring, a vane inner support comprising two axially spaced rings forming radially extending circular flanges of different inner diameters such that the axially forward flange is of lesser diameter, a plurality of vanes aligned with said blades each having an axially extending platform at its outer end and two axially spaced radially extending flanges at its inner end and with the axially forward vane flange of greater height and with said vanes extending radially between and spaced circumferentially about said vane supports and each located with respect thereto such that said radially extending flanges are juxtapositioned with said axially forward vane flange engaging the axially forward support flange on the axially forward side thereof and with the other flanges engaging in the same relative axial positions and further such that said vane outer support ring and each of said vane platforms is spaced a preselected distance apart radially and further such that the after end of said platform bears against said anti-erosion and thrust ring, a plurality of radially directed lugs each connected to said vane outer support ring and projecting loosely thru one of said vane platforms to position the vane outer end, a plurality of axially directed lugs each connected to said axially forward vane inner support flange and projecting thru the axially forward inner end flange of one of said vanes and projecting therebeyond to position said vane inner end, and means removable from one side of said stator unit locking each of said vane flanges in position individually against said support flange and on one of said axial lugs thereby permitting one of said vanes to be released and removed individually and independently of all other vanes thru access from one side

of said stator unit only, thereby baring said blades for inspection and removal while all other vanes are maintained in position.

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