Jan. 23, 1968 H. E. LYNCH ET AL 3,365,173

STATOR STRUCTURE

Original Filed Feb. 28, 1966

Fig 1

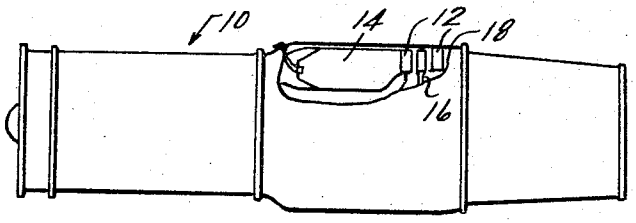


Fig 2

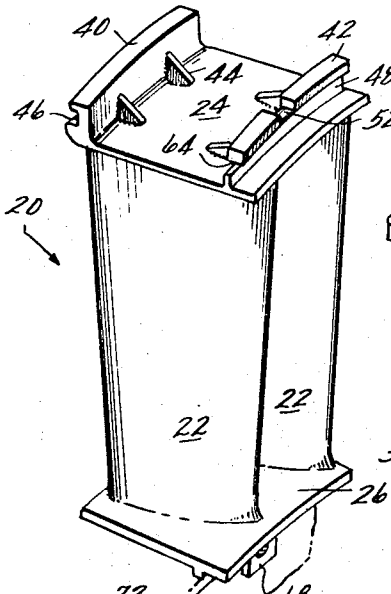


Fig 3

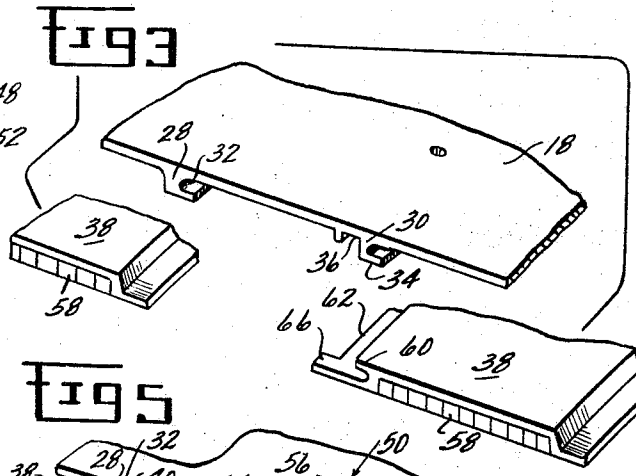


Fig 5

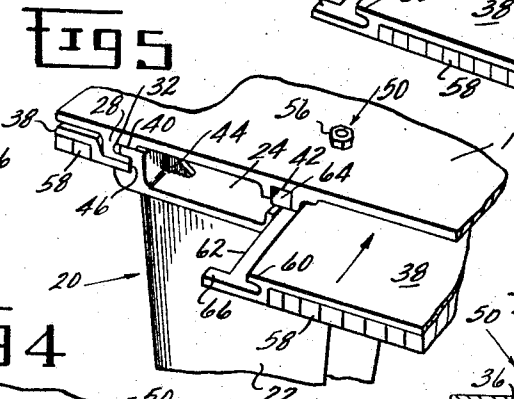


Fig 4

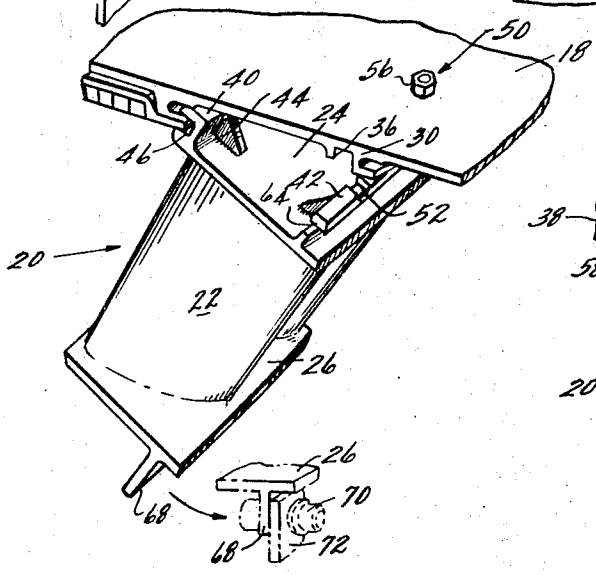


Fig 7

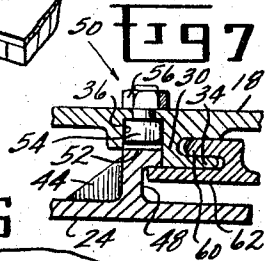
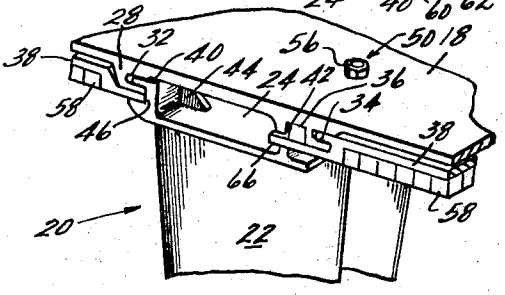


Fig 6



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STATOR STRUCTURE

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Continuation of application Ser. No. 530,432, Feb. 28, 1966. This application Dec. 16, 1966, Ser. No. 602,426
9 Claims. (Cl. 253—78)

This is a continuation-in-part of application Ser. No. 530,432 filed Feb. 28, 1966, now abandoned.

The present invention relates to turbomachinery stator structure and, more particularly, to an improved segmented turbine nozzle structure as may be used in jet engines.

One of the general nozzle diaphragm structure as used in jet engines has been to weld a series of vanes, which can be cast or fabricated, into circular bands and make large segments of vanes. Such segmented structures may employ any number of vanes secured between the complete circular bands for segmented bands. One of the problems with such a structure is the serviceability. The elements crack, the bands crack, and replacement is often necessary. When fabricated vanes are used, there are erosion problems generally of the leading edge and eating into the cavity in the center of the vanes. As a result, the serviceability and maintainability problems are severe. The segmented arrangements are difficult to disassemble and are expensive. It there is one defective in a band or segment of numerous vanes, it is costly to disassemble an replace that one vane.

In present day jet engines, where the life of the parts is required to be extremely long—up to three or four times the life of similar parts heretofore—it is necessary to have a complete new design that meets the objectives of long life, easy maintainability, and easy replacement.

The main object of the present invention therefore is to provide turbomachinery stator structure that meets the objectives of long life, easy maintainability, and easy replacement.

A further object is to provide a segmented nozzle structure which is inherently strong because of a box-like configuration and is provided in smaller elements that are easily and individually replaceable.

Another object is to provide such a segmented nozzle structure which is especially useful in a multi-stage turbomachinery environment for easy replacement of any individual stage without the necessity of tear down of all the stages.

A further object is to provide such a structure in which the nozzle segments and shrouds form an interlocking and mutually supportable arrangement allowing for easy assembly and disassembly for individual replacement.

A further object is to provide such a structure which may be assembled or disassembled with virtually no tools and in which some of the components of the nozzle segments form dual functions avoiding the need for additional complex structure.

Briefly stated, the invention discloses a turbine nozzle structure which includes a casing for the flow of the exhaust gases therethrough in the conventional manner. The casing is provided with a series of axially spaced and peripherally directed circumferential rings around the inner surface. Each of the rings has axial slots in its aft surface substantially parallel to the casing and each alternate ring also has a radial slot forward of its respective axial slot. A nozzle segment that includes at least two airfoils joined by top and bottom platforms into a box structure is provided. The top platform has forward and aft rails that extend peripherally and the forward rail has an axial slot in its forward surface parallel to the casing for engaging one of the rings aft slots and radially locate the nozzle segment. The aft rail also has an axial parallel slot in its aft surface and the aft rail is disposed in the radial slot of the alternate rings for axially locating the nozzle segment. Stop means is provided between the casing and segment for locating the segment peripherally. Shroud means is provided downstream of each segment, the shroud having a forward lip which is disposed in the aft rail slot to hold the shroud in position and radially locate the segment whereby the segments are rotatable into position in the rings in the casing and are interlocked with the shroud. The nozzle segments may be made conveniently in two airfoil sections and the interlocking shrouds may span several segments. The bottom platform of the nozzle segment is provided with a tang, that may be scalloped for lightness, that extends radially inwardly and has attachment means to carry seal structure.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed the invention will be better understood from the following description taken in connection with the accompanying drawing, in which:

FIGURE 1 is a general view of a typical gas turbine engine illustrating the environment of the invention,

FIGURE 2 is a perspective view of a typical nozzle segment,

FIGURE 3 is a partial perspective exploded view of the casing and shroud structure,

FIGURE 4 is a partial perspective illustrating the rotation of the nozzle segment into the casing,

FIGURE 5 is a partial perspective of a segment in position and the interlocking arrangement of a shroud,

FIGURE 6 is a view similar to FIGURE 5 showing the shroud in position locking the parts together, and

FIGURE 7 is a partial cross sectional view of the shroud and segment interlocked in the casing and showing the peripheral stop.

Referring first to FIGURE 1, there is illustrated a general configuration of a jet engine **10** of the usual conventional type. The stator structure of the present invention will be described in connection with a turbine nozzle diaphragm although it might be usable in the compressor structure as well. In such an engine, the turbine nozzles are located at **12** aft of the combustor **14** and spanning a turbine wheel **16** with the usual exhaust nozzle downstream. The invention is the structure **12** as it will preferably be used in a multi-stage turbine comprising several turbine wheels **16** although is not limited to multi-stage turbines. The nozzle or diaphragm structure **12** is supported from a thin casing **18**. This generally is the setting of the detailed structure to follow.

Since extremely long life is required in present engines, it is necessary to provide a structure that is strong enough to withstand thousands of hours of use and yet is easily serviced and easily replaceable when necessary. Additionally, it is desired to provide such structure with the minimum amount of tear down in multi-stage turbines and with the minimum tools required. To this end, the present invention provides individual nozzle segments as shown generally at **20** in FIGURE 2. The individual nozzle segment **20** may be made of numerous vanes, but for easy replacement and high strength as well as good serviceability, it is preferably made in pairs of airfoils as shown. Each segment then comprises a pair of spaced airfoils **22** which guide the exhaust gases to turbine buckets **16** in the usual fashion. In order to provide strength, the airfoils are joined by top and bottom platforms **24** and **26** respectively. The individual nozzle segment **20** thus comprises a box-like very rigid and strong structure with the airfoils **22** forming the sides of the box as well as the guiding nozzles for the exhaust gases. It will be appreciated that bottom platform **26** may be as shown or may have skewed

edges depending on the angle of the airfoils as is well known in the art. For simplicity, a generally rectangular platform is shown.

In order to provide attachment means for the individual segments **20**, the relatively thin casing **18**, as shown in FIGURE 3, is provided with a series of axially spaced and peripherally directed circumferential rings **28** and **30**. Each of these rings is provided with an aft directed axial slot **32** and **34** in the aft surface of the respective ring and each slot is parallel to the casing **18** as shown. For a purpose to be described, each alternate ring **30** also is provided with a radial slot **36** forward of its axial slot. This ring structure provides the primary locating structure on the casing **18** into which the individual nozzle segments **20** are to be disposed. It will be understood that upstream of ring **28** and downstream of ring **34** there may normally be rotating turbine buckets such as **16** in FIGURE 1. For good sealing of the rotating structure, shroud means **38** is provided downstream of each nozzle segment and plural shrouds are provided in multi-stage turbines as seen in the exploded view in FIGURE 3. These will be explained in more detail later.

In order to attach the individual nozzle segments **20** to the casing, each segment has its top platform **24** provided with forward and aft rails **40** and **42** respectively. These rails extend peripherally of the platform as shown and it is to be understood that a large number of the inlividual nozzle segments will be placed edge to edge to form a complete circle upstream of each turbine wheel **16**. These rails will generally form part of the casing and may be supported for extra rigidity by suitable webbing **44**. In order to support nozzle segments **20** in the casing **18** both radially and axially, the forward rail is provided with an axial slot **46** in its forward surface which slot is also parallel to the casing and which is designed to overlappingly engage with slot **32** of ring **28** as will be apparent. Similarly, the aft rail **42** has an axial parallel slot **48** in its aft surface for interlocking with the shroud **38** as will appear.

Referring to FIGURE 4, there is shown the rotation of the nozzle segment **20** into the casing. The individual segment **20** is placed in position whereby the slot **46** in the forward rail is hooked into the slot **32** in ring **28** of the casing as clearly shown. This partially locates the nozzle segment radially in the casing. The segment is rotated in the direction shown by the arrow at the bottom of FIGURE 4 up into a flush position with the casing as shown in FIGURES 5–7. Such rotation disposes the aft rail **42** in the radial slot **36** to axially locate the segment in the casing. At this point if, as is customary, the segments are installed with the casing in a vertical position, it will be apparent that the segments are now held axially in position in the casing and extend radially inward of the casing. However, in the horizontal position of the casing the segments would rotate back down to the position shown in FIGURE 4 and those on the top would drop out.

The segments, having been radially and axially located by the structure thus described, must now be peripherally located and this is done by suitable stop means **50** between the casing and nozzle segment and this may comprise any suitable stud-like member, such as the nut and bolt arrangement shown, which extends through the casing **18** at radial slot **36** and into a convenient recess **52** in the aft rail **42**. Any stop structure may be used and the nut and bolt arrangement shown merely provides a convenient execution where a square head **54** may fit recess **52** without further structure and nut **56** then completes the stop.

Each segment is now located in all three directions. radially, axially and peripherally. However, the overlapping engagement of the slots **32** and **46** provides a loose fit as will be apparent. Since shroud structure **38** is required for the rotating buckets, it is convenient to use this shroud structure as an interlocking memebr. The shroud **38** may contain the usual honeycomb or its equivalent **58** and the shroud bands **38** may extend over several segments for convenience. Each shroud **38** is provided with a forward lip **60**, as shown in FIGURES 5–7, which is disposed in the ring parallel slot **34** to overlap and engage the shroud in a tongue-and-groove arrangemnt. This holds the shroud in position in the casing and radially locates the segment by the interengagement of the bottom portion **62** of the lip with the overlapping protion of aft rail **42**. The completely assembled structure is shown in FIGURE 6 and it can be seen that the segment is rotated into position in the casing rings and is interlocked with the shroud downstream of the individual segment. Of course, this is duplicated and a similar shroud is provided as shown in FIGURE 3 for the next upstream turbine in a multi-stage arrangement.

Inasmuch as the shroud structure usually spans several segments but not a complete half casing on an engine that has a split casing, it is necessary to provide means whereby the multiple segments may all abut one another to provide a complete circular nozzle diaphragm. To this end, several segments may be rotated into position as previously described, the shroud **38** slid into its respective slot **34** to interlock the rotated segments and may span several segments. Each of the segment aft rails **42** is provided with a cut-out **64** at one end which cut-out may be merely milled into the end of the rail and the shroud lip bottom portion is provided with a tab **66** to nest flush in the cut-out as shown in FIGURE 6. For example, three nozzle segments **20** may be rotated into the casing, a shroud segment **38** spanning three segments is then slid into its recess **34** and abutted flush against the last segment with tab **66** disposed in recess **64**. Then three more segments may be abutted directly against the last segment, since there are no protrusions due to the nesting relation, and the process repeated. Depending on the squared or skewed shape of platform **26**, the recess **34** may be at one or the other end of rail **42**.

Since the nozzle segments generally support sealing structure in one form or another, the bottom platform **26** is provided with a radially extending tang **68** that is provided with any attachment means **70** as shown in FIGURE 4. The attachment means is used to connect with a ring **72** on either side thereof or its equivalent which may support sealing structure to seal between turbine stages of the rotor. For lightness, since the tang **68** is merely a support, it may be scalloped as seen in FIGURE 2 to cut away the unnecessary metal and avoid a complete ring around the bottom of the assembled segments.

It is generally customary to make the engine casing in halves bolted along a horizontal flange and the structure thus described is especially suitable to such an installation. It will be apparent that no tools are required for assembly or disassembly of the nozzle diaphragm segments. A wrench may be required to complete the installation of attachment means **70** and nut **56** but the main and complete installation is completely without tools. Also, the various slots described may be sized for snug fitting in the overlapping engagement with the shroud structure and it will be seen that, for example, the front slot **46** on rail **40** not only locates the nozzle segment radially but provides the recess for supporting the aft end of the nozzle shroud for the turbine stage upstream. The shroud, in turn, tends to lock and securely fasten the nozzle segment in position. Easy access is had to any segment by merely sliding out the necessary shrouds until the segment desired is reached which segment may then be rotated out of position as shown in FIGURE 4 and replaced with another segment and this may be accomplished without the need, in a multi-stage arrangement, of removing adjacent stages.

While there has been described a preferred form of the invention, obvious equivalent variations are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims,

the invention may be practiced otherwise than as specifically described, and the claims are intended to cover such equivalent variations.

We claim:

1. Turbomachinery stator structure comprising:

a casing for the flow of fluid therethrough,

a plurality of axially spaced-apart and peripherally directed rings extending inwardly of said casing, said plurality of rings including a first ring having a circumferentially extending aft directed slot therein and a second ring having both a circumferentially extending aft directed slot therein and a circumferentially extending radially directed slot therein forward of the aft directed slot, said second ring being located aft of said first ring,

an annular stator vane assembly disposed within said casing between said first and second rings, said stator vane assembly including a plurality of abutting stator vane segments each comprising radially disposed airfoil structure and an arcuate outer platform secured thereto,

said outer platform including forward and aft peripherally directed rails extending outwardly therefrom, said forward rail having a forwardly directed slot therein and said aft rail having an aft directed slot therein,

the slots of said first ring and said forward rail interengaging to support the forward end of said stator vane segment within said casing and the aft rail engaging the radially directed slot of said second ring to axially locate said stator vane segment,

and an arcuate shroud member extending aft of said second ring, said shroud member including forwardly directed lip means engaging the aft directed slots of both said second ring and said aft rail to support both the aft end of said stator vane segment and the forward end of said shroud member within said casing.

2. Turbomachine stator structure as defined by claim 1 further comprising stop means interconnecting said casing and said stator vane segment to prevent peripheral movement of said stator vane segment within said casing.

3. Turbomachine stator structure as defined by claim 2 wherein said shroud member aft of said second ring arcuately spans a plurality of stator vane segments.

4. Turbomachine stator structure as defined by claim 3 wherein said shroud member aft of said second ring

has a tab at one end thereof projecting forwardly therefrom and wherein the stator vane segment aligned with said tab has a cut-out at one end of its aft rail for receiving said tab to interlock said shroud member and the stator vane segment and thereby prevent peripheral movement of said shroud member within said casing, said tab and said cut-out being dimensioned for flush nesting of said tab within said cut-out to permit abutment of adjacent stator vane segments.

5. Turbomachine stator structure as defined by claim 2 wherein the aft rail of each outer platform has a recess therein, said stop means comprising a bolt extending through said casing into the radially directed slot of said second ring and said recess.

6. Turbomachine stator structure as defined by claim 5 wherein said shroud member aft of said second ring arcuately spans a plurality of stator vane segments.

7. Turbomachine stator structure as defined by claim 6 wherein said shroud member aft of said second ring has a tab at one end thereof projecting forwardly therefrom and wherein the stator vane segment aligned with said tab has a cut-out at one end of its aft rail for receiving said tab to interlock said shroud member and the stator vane segment and thereby prevent peripheral movement of said shroud member within said casing, said tab and said cut-out being dimensioned for flush nesting of said tab within said cut-out to permit abutment of adjacent stator vane segments.

8. Turbomachine stator structure as defined by claim 7 further comprising an arcuate inner platform secured to the radially disposed airfoil structure of said stator vane segment, said inner platform having a scalloped tang extending radially therefrom with attachment means thereon for supporting sealing structure.

9. Turbomachine stator structure as defined by claim 8 wherein the annular stator vane assembly is a turbine nozzle diaphragm.

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