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SEALING AND SECURING MEANS FOR TURBOMACHINE BLADING

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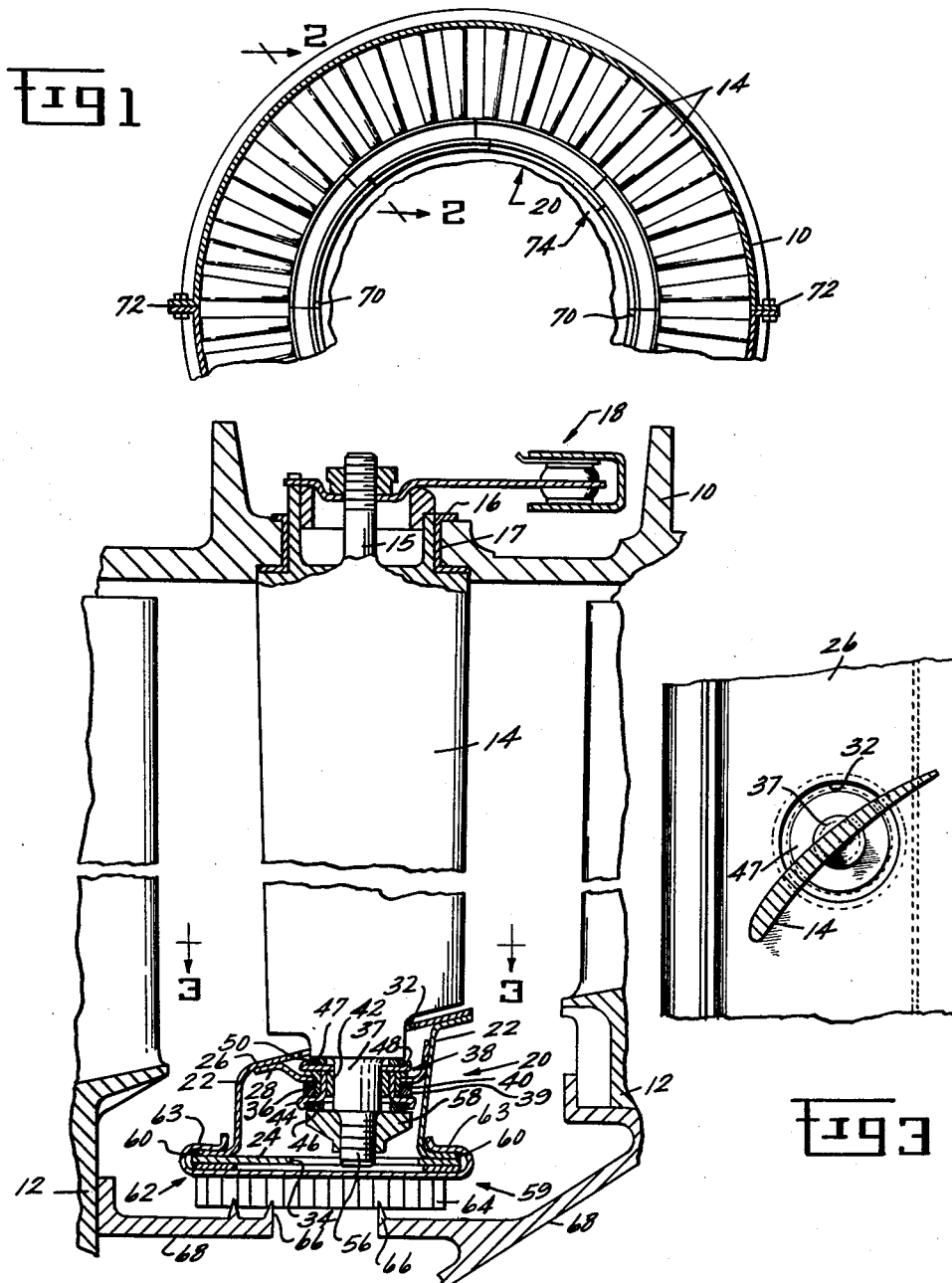


Fig 2

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3,079,128 SEALING AND SECURING MEANS FOR TURBO- MACHINE BLADING

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2 Claims. (Cl. 253-78)

This invention relates to blading for turbomachines and, in particular, to an improved sealing and securing means for the free ends of rotor and stator blading for use in gas turbine engines, although it is not necessarily limited thereto.

Previous practice in turbomachine construction has included utilizing means for securing spacers between adjacent blade or vane supporting disks or rings in such fashion as to provide a smooth and relatively stiff drum-like structure. In this type of construction the free end portions of the blading are sometimes left unsupported and in close clearance with the turbomachinery structure positioned between the rows of blading. Some of the problems associated with this arrangement have resulted from: (a) close radial and axial clearances and the related effect of differential thermal expansion between rotating and stationary parts; and (b) high vibrational and bending stresses.

To avoid these problems, through ruggedizing and stiffening of the blading end structure and the blade ring, blading end constructions are often utilized wherein all the blade ends of each stage of blading are securely tied together by attachment to a common ring structure usually termed a "shroud." This shroud often is used also to support an abradable or deformable seal element designed to engage and seal against contiguous rotating parts. With use of such a construction frequently the entire shroud structure had to be discarded because of wear or damage to the seal element. In addition, where the securing means at the inner ends of the blades or vanes included a comparatively large number of relatively small parts, which is sometimes true for variable stator vanes, for example, it was possible for damage to the shroud to require a time-consuming disassembling operation in order to replace the damaged or worn parts. Furthermore, if a rotating part contacted the seal to the extent that portions of the shroud or vane retention means were torn loose, these parts could interfere with the rotor and severe damage to the compressor could result. Finally, in addition to the obvious advantages to be gained from improving the design of a shroud in order to enhance vane rigidity and blade dampening, with the advent of multi-stage axial flow compressors having upwards of eighteen to twenty stages it has necessitated blading end structures small enough to fit into the limited space available between the rims of the rotating wheel disks and, at the same time, provide efficient interstage sealing.

Accordingly, it is an object of my invention to provide an improved blade-end securing and interstage sealing means for a turbomachine.

It is a more specific object of my invention to provide an improved sealing and securing means for a compressor stator vane assembly.

Still another object of my invention is to provide an improved stator vane shroud member having a separate sealing means easily removable therefrom when worn or damaged.

It is another object of my invention to provide an improved stator vane shroud member having separate sealing means removably supported thereon which aids in providing vane rigidity and dampening.

It is still another object of my invention to provide

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an improved variable stator vane shroud assembly for a turbomachine compressor having removable sealing means which improves vane rigidity and acts to prevent loose vane securing parts from interfering with adjacent compressor rotating structure.

It is a further object of my invention to provide an improved variable stator vane shroud assembly for a turbomachine compressor, including an easily removable, efficient interstage sealing element which aids in improving vane rigidity and prevents loose vane securing parts from interfering with adjacent compressor rotating structure, which assembly is adapted to fit into the relatively small spaces between multi-stage compressor rotor wheel rims.

Briefly, a preferred embodiment of my invention comprises a shroud member for securing the free end portions of a variable blading of a turbomachine, said shroud member including means for receiving the free end portions of the vanes, and sealing means removably attached to the shroud ring for ease of replacement.

The invention will become more apparent and its various objects, features, and advantages more fully appreciated by reference to the appended claims and the following detailed description taken in conjunction with the disclosure of the accompanying drawings which form a part of this specification and in which:

FIGURE 1 is a fragmentary end view of a turbomachine compressor embodying a preferred form of my invention;

FIGURE 2 is a side elevation view, partially in cross section, of a turbomachine compressor having variable stator vanes and including the preferred embodiment of my novel securing and sealing assembly; and

FIGURE 3 is a view taken along line 3-3 of FIGURE 2.

In the drawings, 10 designates an external turbomachine casing member enclosing a rotor comprised of a plurality of rotor disks 12 rigidly connected to each other. The external casing member or stator is provided with a plurality of radially-directed variable stator blades or vanes 14. Each vane is adapted for rotation about its centerline by inclusion of an outer vane trunnion 15 located in the external casing by a bearing or bushing 16 positioned in a circular aperture 17 in the stator wall. Suitable actuating means, indicated generally at 18, is securely attached to the outer vane trunnion to cause rotation of each variable stator vane 14 about the vane centerline in response to movement of suitable control means (not shown).

Referring now more specifically to the inner end of the variable stator vane shown in FIGURE 2, a preferred embodiment of my improved sealing and securing means will be described. The blade end securing portion of my invention consists of an annular shroud ring which may be comprised of a number of arcuate assemblies, indicated generally at 20. The shroud assemblies are preferably box-like in cross section, having a pair of radially-extending side walls 22-22 and inner and outer walls 24 and 26, respectively. The assemblies 20 may consist of one or more sheetmetal pieces bent and secured in any suitable manner, such as by brazing, to form the arcuate box-like structures which, in the embodiment shown in FIGURE 1, are segments of a shroud "half-ring." In the embodiment shown, a partition or web member 28 is located within each channel assembly 20 so as to extend substantially between the side walls 22-22, and coextensively therewith, the web being secured to the walls by being brazed or otherwise permanently attached.

The web member 28 is preferably attached to the side walls of the shroud segments in such a manner that its

plane, in cross section, is generally parallel to the axis of the engine, i.e., the web is coaxial with the casing 10 and perpendicular to the longitudinal axis of the stator vane. The outer and inner walls of the arcuate shroud assemblies 20, and the web 28, are provided with a plurality of radially aligned—with respect to the turbomachine axis—circular apertures 32, 34, and 36, respectively. Thus there is a series of three apertures—in line radially—for each stator vane. In order to securely position the inner trunnion 37 of each variable stator vane 14 within the shroud assembly, a shroud bushing or bearing member, indicated generally at 38, is located within the web aperture 36. The shroud bearing member 38 may be constructed of two pieces 39 and 40 for ease of assembly with the web member. Preferably the shroud bearing member 38 is permanently attached to the web 28 prior to installation of the complete shroud assembly in the compressor. Positioned coaxially within the shroud bearing member is a journal bearing member 42, preferably constructed of carbon or like material, as are the other bearing members. The journal bearing member is held in place by a generally cylindrical retainer ring or back-up 44 which may be constructed of steel or similar material. It will be noted from the drawing that the inner portion of the retainer or back-up 44 is crimped over at its outer circumference to enable it to retain a carbon washer 46. Positioned between the shroud bearing 38 and the blade platform 47 is a second retainer ring or back-up 48 which is crimped over in a like manner to contain a second, or inner, carbon washer 50. The retainers 44 and 48, and their respective bearings and washers are preferably first formed into sub-assemblies prior to assembly and installation of the complete shroud ring.

To assemble the annular stator vane shroud segments 20 into the "half-rings" of the horizontally split compressor shown in FIGURE 1, assume that the variable stator vanes have already been inserted through the circular apertures 17 in the external casing member 10. Initially, the retainer 48 and washer 50 sub-assemblies are placed over the inner vane trunnions 37 and allowed to rest against the blade platforms 47 of the vanes of each stator half, the stator half being in an inverted position for ease of assembly. Then the shroud segments, which may encompass 45° of each 180° "half-ring," for example, as shown in FIGURE 1, are placed over the inner trunnions of the variable stator vanes with the threaded ends 56 of the trunnions passing through the radially aligned holes 32, 36, 34, in sequence, in the box-like structures. As stated above, preferably the two-piece shroud bearings 38 are already located in the web apertures 36, being brazed, or otherwise permanently attached, for ease of assembly. After the inner vane trunnions have all been located in the aligned apertures with the blade platforms abutting the washers 50, the journal bearings 42 and the sub-assemblies consisting of retainers 44 and washers 46 are inserted through apertures 34 and onto the inner vane trunnions. Finally, a nut 58 is engaged with each of the threaded trunnion ends and tightened down upon the inner carbon washer 46. Insertion of the journal bearing and washer sub-assemblies and the placement of the nuts is facilitated by making the openings 34 relatively large as compared to the vane trunnion. The process is then repeated for the other shroud "half" ring.

In addition to the simplified, easily-installed blade-end shroud structure described above, one of the primary features of my invention concerns the provision for separate, easily removable interstage sealing means, indicated generally at 59. It will be noted from FIGURE 2, that the side walls 22—22 of the arcuate shroud assemblies 20 are provided with extension or "feet" 60 which project fore and aft of the basic structure. A base plate or seal supporting member, indicated gen-

erally at 62, bent over to form resilient, clip-like flanges 63—63 at either end, is adapted to be sprung or slid over the annular box "feet" extensions, the plate or band 62 thus being supported by, or suspended from, the shroud ring. Instead of the clip arrangement shown, other detachable means suitable for use in the present environment, which would suggest themselves to those skilled in the art, could, of course, be utilized. A seal element 64, which may be constructed of honeycomb material, is brazed or otherwise permanently attached to the inner surface of the band 62. This abradable or deformable seal material is adapted to be contacted by teeth 66, which are part of labyrinth seal members 68 attached to the rotor disks 12, in any suitable manner. It will be noted that, in the embodiment described above, the base plate or supporting members 62, when in end-to-end abutment, form an inner "cover" for the shroud ring, thus completely sealing the "box" and enclosing the vane retention means and bearings.

Referring now in particular to FIGURE 1, it will be seen from the drawing that each "half-ring" of the assembled shroud is provided with a stop means 70. In assembling my improved stator vane sealing and securing means, the first seal assembly 59 that is clipped onto the "feet" of an abutting shroud assembly 20 is positioned against the left-hand stop (in the drawing). The second seal element is likewise clipped over a shroud box assembly and into end-to-end abutment with the first sealing means, and so on until the four segments making up the 180° arc are in abutment and against the stop. The process is then repeated for the other 180° portion of the horizontally split stator casing. When both halves of the compressor shroud ring are completely assembled the entire compressor assembly is bolted together by means of suitable flange means indicated at 72—72.

It will also be noted in the embodiment shown in FIGURE 1 that all but one of the sealing assemblies 59 in each shroud "half-ring" extend beyond or overlap their associated shroud assemblies 20 by an amount indicated generally at 74. By providing the overlap strength is added to the segmented shroud "half-rings" since the joints where the shroud segments abut are not in radial alignment with the joints of the sealing means segments 59. This arrangement aids in the improved vane dampening provided by the shroud ring assembly and also provides a more efficient seal. This feature also helps to insure that should any of the portions of the inner vane trunnion bearing and retainer sub-assemblies loosen and become disengaged from the web 28 or the trunnion, they cannot fall down into the rotating components of the engine as the overlapping base plates 62 provide a continuous inner cover over the enlarged shroud holes 34.

It will therefore be obvious from the above description that my novel sealing and securing means occupies relatively little space between the rotating disks 12. In addition, since the seal assemblies 59 are not part of the basic shroud member structure 20, it will be easier and less expensive to remove a worn, damaged or unsatisfactory seal, or segment thereof, since the seals can be discarded without disassembly of any of the shroud segments 20 from the stator casing. Moreover, the basic shroud structure can be made of lightweight material (e.g., titanium) with the base segments 62 being made of steel. This is advantageous since it is less expensive and more reliable to braze honeycomb, or other abradable seal materials, to steel than it is to braze such to titanium, for example.

While my improved sealing and securing means can be applied to either the tips of stator vanes or rotor blades, or buckets, it is adapted particularly for use on the free ends of stator vanes.

While only a preferred embodiment of the invention has been described and illustrated, many modifications will

occur to those skilled in the art, and therefore it is understood that the appended claims are intended to cover all such modifications as fall in the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A turbomachine having at least two separate rotary disk members forming a plurality of stages, each disk member having a rim portion, a row of stator vanes having normally unsecured end portions interposed between said rim portions, securing means for the unsecured vane end portions, said securing means including a plurality of arcuate members, said members being in abutment end-to-end to form a shroud ring for said vanes, each of the arcuate members being box-like in cross section and having an inner partition, bearing means supported by said partition, said bearing means receiving said normally unsecured vane end portions to permit variation of said stator vanes, vane retention means for maintaining the end portions of said vanes in said bearing means, and interstage sealing means removably attached to said arcuate shroud ring members, said sealing means including a plurality of band members, and a seal element affixed to an inner surface of each of said band members, said seal elements being adapted to contact portions of the rotary disk members during operation of the turbomachine, the band members being in end-to-end abutment with the joints formed by the abutting ends of said band members being offset from the joints of said abutting shroud members in order to stiffen said securing means.

2. A turbomachine having at least two separate rotary disk members forming a plurality of stages, each disk member having a rim portion, a row of stator vanes having normally unsupported end portions interposed between said rim portions, securing means for said normally unsupported end portions, said securing means including a plurality of arcuate assemblies, said assemblies being in abutment end-to-end to form an annular shroud, said shroud being box-like in cross section having an outer wall, an inner wall, and a partition located between said walls, a series of aligned apertures in said walls and said

partition, bearing means positioned in the aperture in said partition, said bearing means receiving said unsupported end portions to permit variation of said stator vanes, retention means for maintaining the end portions of said vanes in said bearing means, the aperture in said inner wall being enlarged to receive said bearing means and said vane retention means, and interstage sealing means, said sealing means including a plurality of arcuate supporting members forming a band, said band members having resilient means to enable the members to be removably engageable with said shroud and abradable seal material affixed to the band members, said seal material being adapted to contact portions of the rotary disk members during operation of the turbomachine for interstage sealing thereof, the joints of said band members being offset from the joints of said arcuate assemblies so as to stiffen said shroud, said sealing means preventing loose vane retention means from interfering with said rotary disk members during operation of said turbomachine by substantially closing the enlarged aperture in said inner wall.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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Patent No. 3,079,128

February 26, 1963

Joseph Burge

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the grant, lines 1 to 3, for "Joseph Burge, of Cincinnati, Ohio," read -- Joseph Burge, of Cincinnati, Ohio, assignor to General Electric Company, a corporation of New York --; line 12, for "Joseph Burge, his heirs" read -- General Electric Company, its successors --; in the heading to the printed specification, lines 4 and 5, for "Joseph Burge, 1035 Vacationland Drive, Cincinnati 31, Ohio" read -- Joseph Burge, Cincinnati, Ohio, assignor to General Electric Company, a corporation of New York --.

Signed and sealed this 19th day of November 1963.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWIN L. REYNOLDS

Acting Commissioner of Patents