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Corsmeier et al.

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[45] **Oct. 30, 1973**

[54] **BOLTLESS BLADE AND SEAL RETAINER**

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[52] **U.S. Cl.** **416/95,** 416/220

[51] **Int. Cl.** **F01d 5/32**

[58] **Field of Search** 416/219, 220, 221, 416/92, 96, 97, 95

[56] **References Cited**

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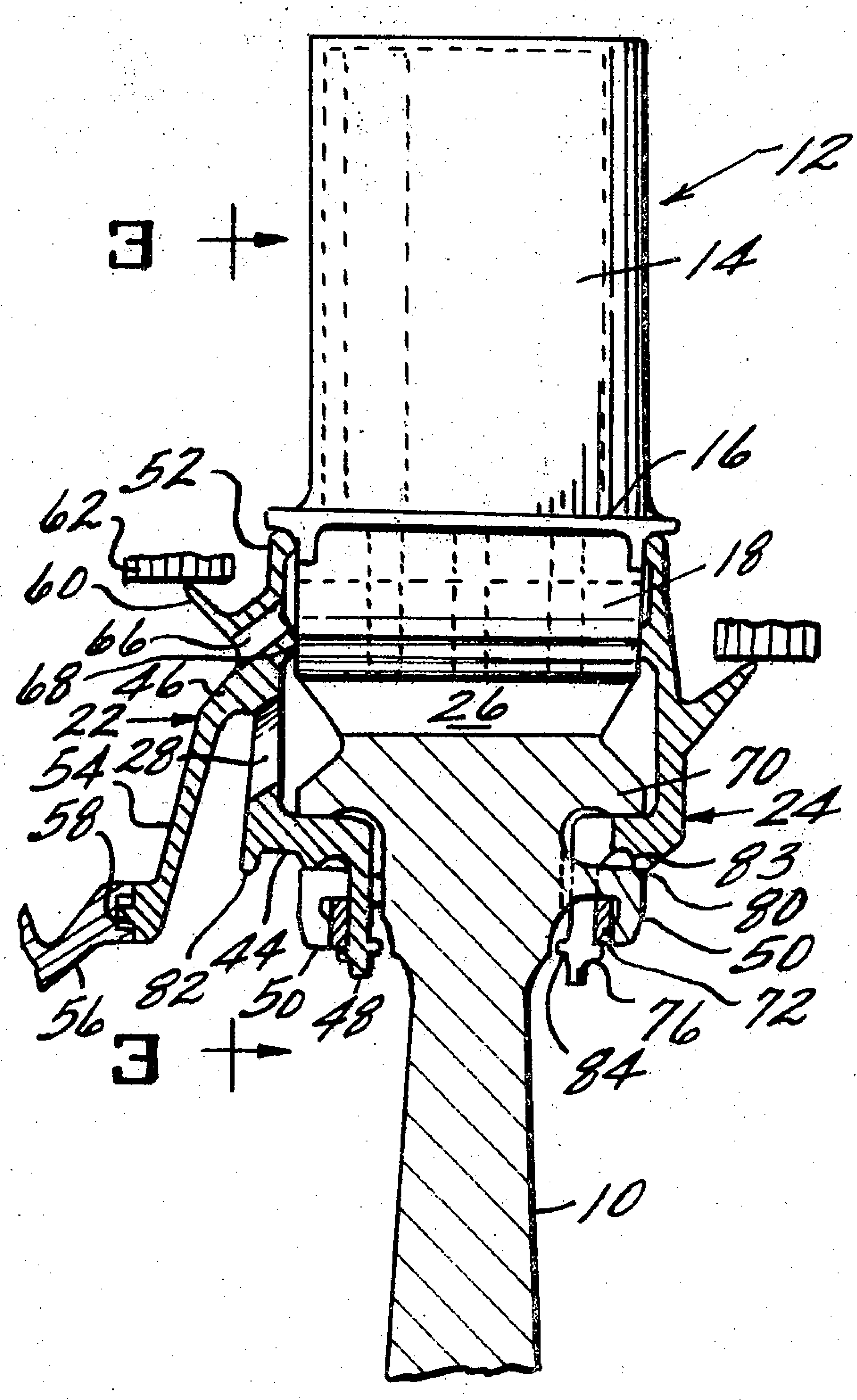
[57] **ABSTRACT**

A boltless blade retainer which provides a cooling air chamber around the dovetail slots of a turbomachinery rotor is disclosed to include a continuous annular ring which has a portion extending radially outwardly therefrom to radially position the rotor blades within the dovetail slots and to preclude axial movement of the rotor blades within the dovetail slots. The blade retainer further includes a plurality of tabs which fit between fingers which extend from a face of the rotor disc near the rim thereof. The tabs and fingers hook together in an interlocking manner which prevents relative rotation of the blade retainer and the disc. After the retainer is positioned on the disc, a split retaining ring is installed under the hook-shaped disc fingers thus securing the blade retainer to the disc. A rabbet is provided near the rim of the rotor disc to support the retainer in the radial direction.

14 Claims, 3 Drawing Figures



Patented Oct. 30, 1973 | 3,768,924

Fig 1

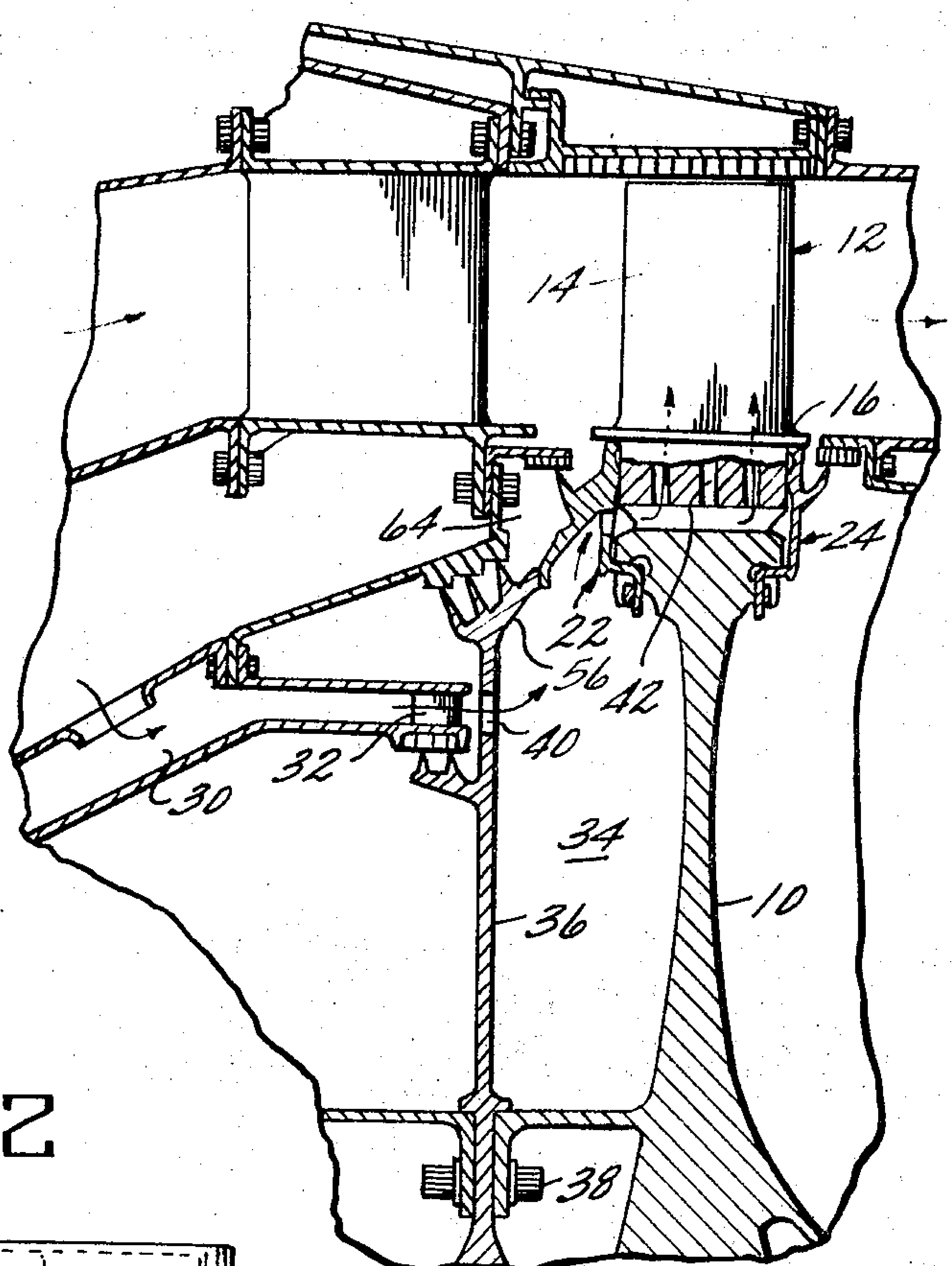


Fig 2

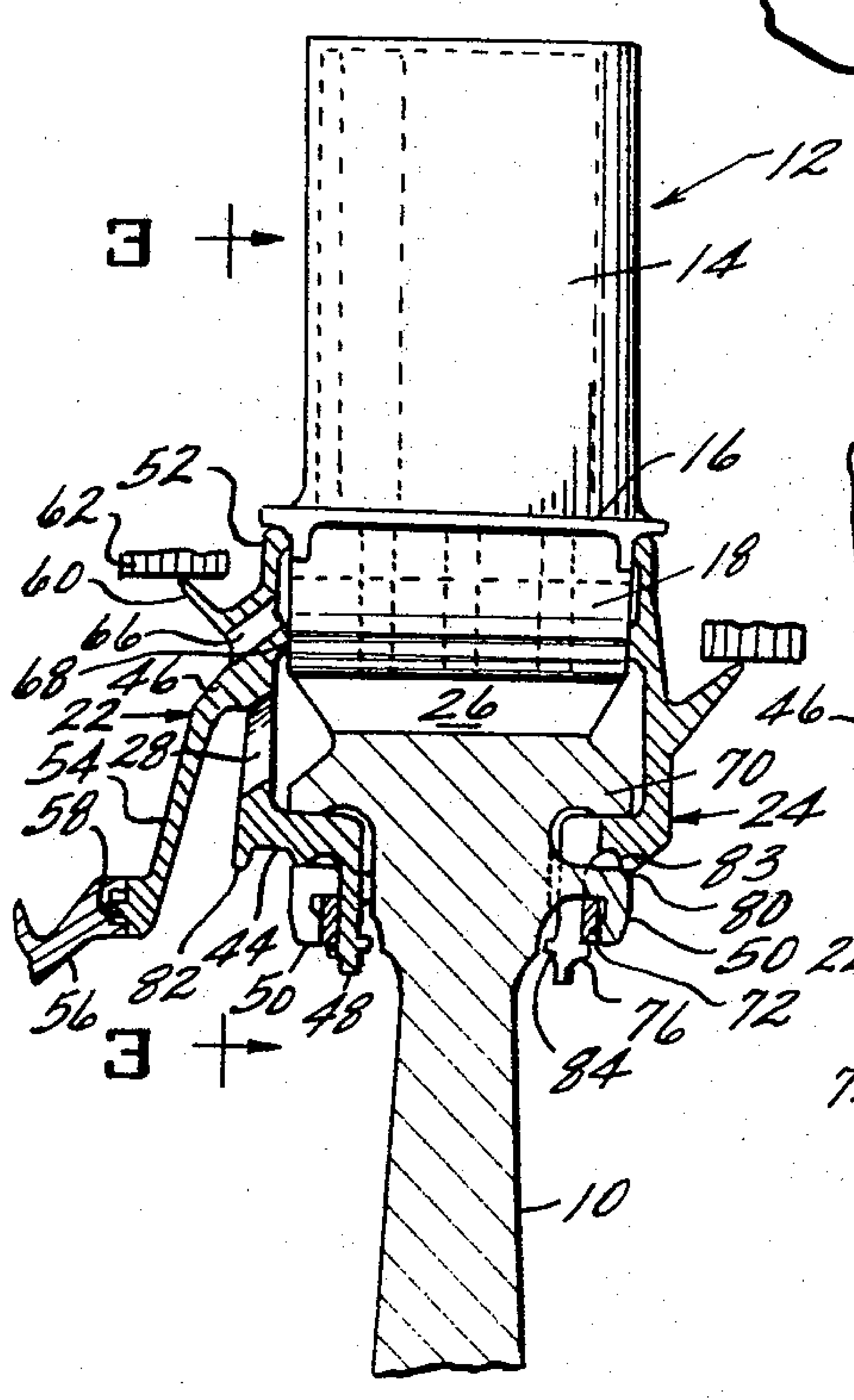
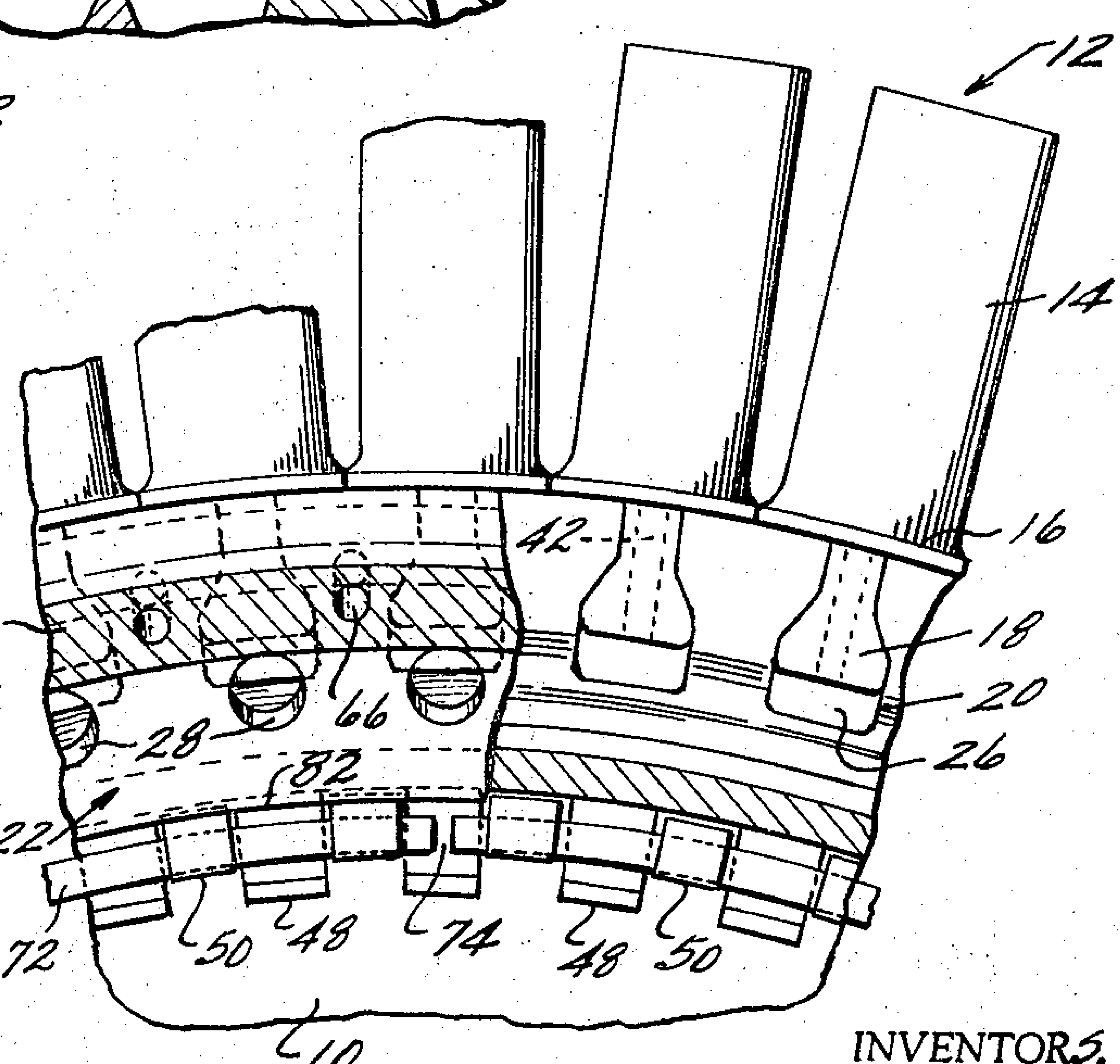


Fig 3



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BOLTLESS BLADE AND SEAL RETAINER

Background of the Invention

This invention relates generally to turbomachinery rotor construction and, more particularly, to improved structure for retaining and positioning rotor blades on a turbomachinery rotor disc.

The invention herein described was made in the course of or under a contract, or a subcontract thereunder, with the United States Department of the Air Force.

In high performance gas turbine engines, the temperature of the hot gas stream, which is generated within a combustion section, exceeds the operating temperature capabilities of any practical material from which the turbine vanes and blades could be fabricated. In order to reduce the metal temperatures to a point where sufficient strength is maintained, it has become an accepted practice to duct lower temperature, pressurized air from the engine's compressor to the turbine components which operate in the hot gas stream environment.

The cooling air thus derived is employed in various ways to reduce the metal temperatures of such components. As a general rule, this cooling air is introduced into hollow blades or vanes and then discharged into the hot gas stream. This cooling air reduces the component metal temperatures through various heat transfer mechanisms, such as convective, impingement, or film cooling action. To enhance the cooling, the interior of rotating blades and stationary vanes may be equipped with inserts having a large number of small holes provided therein through which air is impinged on the interior surfaces of the blades or vanes.

The provision of such inserts for impingement cooling of static vanes is relatively straightforward from an assembly standpoint. However, in rotating components, and particularly in the blades of turbine rotors, great difficulties may be encountered in attempting to provide such inserts. The problem is further complicated when one considers that the cooling air must be delivered to the interiors of the rotor blades while these blades are rotating at extremely high speeds. To overcome these problems, a number of designs have evolved in recent years. One such design which has proven successful is shown and claimed in U.S. Pat. No. 3,715,170, issued Feb. 6, 1973 in the name of J. W. Savage et al., and assigned to the same assignee as the present invention.

As described in the Savage et al. application, a turbine blade is provided having a thin-walled, cambered airfoil portion, and a single, circular arc dovetail formed integrally therewith. Impingement inserts extend outwardly from and through radial passageways formed in the dovetail into the cavity of the airfoil portion. The inserts are insertable through this passageway and include a multiplicity of holes directed toward internal surfaces of the airfoil portion. An inlet opening at the bottom end of the insert admits cooling air which is discharged from the insert holes to impinge the airfoil surfaces and cool the same. As further shown in the Savage et al. application, the impingement inserts are maintained in place by means of a hollow spacer which fits within the dovetail slot of the rotor disc beneath the blade dovetail. This spacer is supplied with cooling air by means of a passageway formed along the surface of the rotor disc. As also shown in the application, the tur-

bine rotor blades are prevented from axial movement within the dovetail slots by means of annular plates secured to the upstream and downstream sides of the rotor discs by a plurality of bolts. The upstream plate further helps to form the flow path for delivery of the cooling air to the spacers beneath the blade dovetails.

The use of a plurality of bolts to secure the annular plates to the upstream and downstream sides of the rotor disc presents certain disadvantages, however, in that any protrusion from the rotating disc causes windage within the chamber partially formed by the rotor disc side walls. This windage not only increases the temperature of the air within the chamber but also adds to the overall drag on the turbine rotor, both of which reduce engine performance. The use of bolts causes an additional problem in that bolt holes located within the rotor disc increase the rim loading and result in stress concentration areas. To help overcome these problems, designers normally call for a large number of small bolts to be equally spaced around the rim of the turbine disc. This large number of bolts, of course, adds both to the weight of the engine and to the time required for assembly or disassembly.

The use of the spacers beneath the blade dovetails to radially position the blades and to provide space for the delivery of cooling air to the inserts somewhat complicates assembly procedures and adds to the time required for assembly. The spacers themselves also add to the overall materials cost of the engine. Therefore, if the spacers could be eliminated, the cost of the turbine rotor assembly would decrease.

It is desirable, therefore, to provide a blade retainer design which includes provisions for not only retaining but also for radially positioning the rotor blades within the dovetail slots and further includes provision for delivery of cooling air to the blade dovetails without the requirement for a number of bolts extending from either the upstream or downstream sides of the turbine rotor discs.

Boltless blade retainers per se are not new. For example, it is known to provide mating grooves in a lip extending from the rim of a turbine rotor disc and in the blade dovetails. A locking wire is then positioned within the groove thereby precluding axial movement of the dovetails within the dovetail slots. An example of this type of design is shown in U.S. Pat. No. 2,713,991 — Secord et al. Designs similar to this, however, are concerned merely with precluding axial movement of the blades and not with providing cooling air to the blade nor with connecting a sealing member of any type to the rotor disc.

It is further known to provide individual cover plates for each rotor blade, which plates serve not only to retain the blades within the dovetail slots but also to block off the gas flow between elongated blade shanks or to serve as gas seals with adjacent stationary members of the turbine. Such a design is shown in U.S. Pat. No. 3,137,478 — Farrell. These designs also are not concerned with providing cooling flow to the turbine dovetails, dovertails, and the potential leakage between the individual cover plates would appear to preclude their use in such a manner. Furthermore, the problems associated with assembling a design which requires two separate cover plates for each individual turbine blade hardly need mentioning.

SUMMARY OF THE INVENTION

It is a primary object of this invention, therefore, to provide a boltless blade retainer for turbomachinery rotor blades which includes provisions for the delivery of cooling air to the blade dovetail area.

It is a further object of this invention to provide such a retainer which includes provisions for radially positioning the rotor blades and for connecting ring-type parts such as seals, retainers, etc. to a rotor disc.

Briefly stated, the above and similarly related objects are achieved providing a turbomachinery rotor in which a rotor disc includes a series of equally spaced, hook-shaped fingers near the rim thereof. A continuous, annular ring blade retainer is designed to include a plurality of tabs which fit between the rotor disc fingers in an interlocking manner which prevents relative rotation between the blade retainer and the disc. After the retainer is positioned on the disc, a split retaining ring is installed under the hook-shaped disc fingers, thus securing the blade retainer to the disc. A rabbet is provided near the rim of the rotor disc to support the retainer in the radial direction.

Other preferred features are found in sizing the blade retainer such that a portion thereof rests beneath the platforms of the rotor blades and prevents the blades from dropping down into the dovetail slots when the turbomachinery is stationary. Safety stops are provided integrally with the blade retainer to preclude bending of the rotor disc fingers beyond their yield point during operation. In addition, a lip on the blade retainer tabs is provided to secure the retaining ring should it break or become weak and attempt to fall out when the engine is idle. An installation stop is provided to preclude the blade retainer tabs from being bent beyond their yield points during assembly or disassembly thereof. Finally, shoulders are provided on the retaining ring to enable assembly and disassembly of the overall structure.

DESCRIPTION OF THE DRAWINGS

While the specification concludes with a series of claims which distinctly claim and particularly point out the subject matter which Applicants regard to be their invention, a complete understanding of the invention will be gained from the following detailed description, given in connection with the accompanying drawing, in which:

FIG. 1 is a fragmentary, generally longitudinal section through a turbine rotor and blade embodying the present invention;

FIG. 2 is an enlarged sectional view showing a portion of FIG. 1; and

FIG. 3 is a fragmentary, axial section taken in the direction of line 3—3 of FIG. 2.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawings wherein like numerals correspond to like elements throughout, reference is directed initially to FIGS. 1 and 3 wherein a turbine rotor disc 10 is illustrated as having radially projecting turbine blades 12 mounted in a circumferential row thereon. Each blade comprises a cambered airfoil portion 14 which projects into the hot gas stream of the turbine as is well known in the art. A platform 16 is provided at the base of each airfoil portion to compositely define the inner bounds of the hot gas flow through the blade row. A tang 18 extends inwardly of the platform 16 to attach the blade to the rotor disc 10.

The tangs 18 are of the single dovetail, circular arc type and are preferably formed with their opposite sides defined by radii formed from different centers as taught in U.S. Pat. No. 3,378,230, which is of common assignment with the present application. The disc 10 has correspondingly shaped dovetail slots 20 formed across its circumferential face, which slots receive the tangs to mount the blades 12 to the disc 10.

The slots 20 have a depth greater than the dovetail height of the tangs 18 to facilitate insertion of the tangs therein and to facilitate delivery of cooling air to the tangs 18 in a manner to be discussed. Since the dovetail slots 20 and the dovetail tangs 18 are not respectively formed on radii swung from a common center, the tangs must be inserted in the lower portion of the slots and then shifted radially outwardly to lock the blades in place. The blades 12 are held in this radial position by boltless blade retainers 22 and 24 located on the upstream and downstream faces of the turbine rotor disc 10, respectively.

The space between the bottom of the tangs 18 and the bottom of the dovetail slots 20 is generally designated by the numeral 26 (FIGS. 2 and 3) and is supplied with cooling air by means of a plurality of holes 28 formed in the upstream blade retainer 22. As shown in FIG. 1, the cooling air is delivered to the dovetail slots 20 (or the space 26) from the compressor (not shown) by a passageway 30, which includes a stationary expander nozzle 32 to further cool the air as is well known in the art. Air flows through the expander 32 into a chamber 34 formed by the upstream face of the turbine rotor disc 10, a second rotating disc 36, and the upstream blade retainer 22. The disc 36 is coupled for rotation with the turbine rotor disc 10 by means of a plurality of bolts 38.

The cooling air flows from the expander nozzle 32 into the chamber 34 through a plurality of holes 40 formed within the disc 36. This cooling air then flows from the chamber 34 through the holes 28 in the upstream blade retainer 22 and into the space 26 within the dovetail slots 20. From the slots 20 the air is delivered to the interior portions of the blades 12 in any known manner. In the present example, the air is delivered through a plurality of passages 42 formed within the dovetail tangs 18. As previously mentioned, the passages 42 may be equipped with impingement inserts (not shown) to enhance the cooling capabilities. These inserts could be held in place by a slight interference fit between the insert and the passage 42; and the spacers shown in the Savage et al application could be eliminated, thus further simplifying and reducing the cost of the rotor.

As discussed above, the blades 12 are held in their desired radial position within the dovetail slots 20 by means of the blade retainers 22 and 24 (thus permitting removal of the spacers). When assembled, the blade retainers 22 and 24 not only provide this function but also preclude axial movement of the blades 12 within the dovetail slots 20 and, furthermore, provide a sealed cooling air chamber around the dovetail slots and blade tangs, as will now be described. (For clarity, the following description will be limited to that necessary to describe the upstream blade retainer 22 in that the basic structure of the retainer 22 and retainer 24 is similar.)

The blade retainer 22 is comprised basically of a continuous, annular ring 44 (FIG. 2) having a leg 46 extending radially outwardly therefrom and a plurality of tabs 48 extending radially inwardly therefrom, as shown in FIGS. 2 and 3. The tabs 48 fit between a plurality of equally spaced, hook-shaped fingers 50 which are formed integrally with and extend from the turbine rotor disc 10. When assembled as shown in FIGS. 2 and 3, the tabs 48 and the fingers 50 provide an interlock which prevents the retainer 22 from rotating with respect to the disc 10. As further shown in FIG. 2, the leg 46 is provided with means for radially positioning the blades 12 within the dovetail slots 20. For this purpose, the top of the leg 46 includes an enlarged head portion 52 upon which the blade platform 16 rests. In this manner, the blades 12 are prevented from moving radially inwardly when the rotor disc 10 is stationary.

As previously described, the blade retainer 22 cooperates with the rotor disc 10 and the disc 36 to form the chamber 34. For this reason the retainer 22 includes a conical arm 54 which mates with a rim 56 of the disc 36 as shown in FIGS. 1 and 2. If desirable, a suitable seal 58 can be provided between the conical arm 54 and the disc rim 56. Located between the enlarged head portion 52 and the conical arm 54 of the retainer 22 is a seal tooth 60 which cooperates with a stationary sealing member 62 to prevent leakage of the hot gas stream into a chamber 64 (FIG. 1).

As shown most clearly in FIGS. 2 and 3, the radial leg 46 of the blade retainer 22 includes a plurality of the cooling air holes 28, previously discussed, which permit the delivery of cooling air from the chamber 34 to the spaces 26 within the dovetail slots 20. If desirable, a second row of cooling air holes 66 can be positioned radially outwardly from the cooling air holes 28 as shown in FIG. 2 to deliver cooling air from the chamber 64 to the rim of the turbine rotor disc 10. In an alternative design, the cooling air holes 66 can be eliminated and any necessary cooling air for the turbine rotor disc rim can be allowed to leak between a projection 68 (FIG. 2), which abuts the face of the turbine rotor blade shanks, and the turbine rotor disc rim. If necessary, radial slots (not shown) could be formed in the projection 68 to meter a proper amount of cooling air to the rim area. In either case, the projection 68 provides the basic function of preventing axial movement of the blades 12 within the dovetail slots 20 when the rotor assembly is complete.

As further shown in the drawings, the ring portion 44 of the blade retainer 22 fits between the hook-shaped fingers 50 of the turbine rotor disc 10 and a continuous, annular rabbet 70 formed integrally with the rotor disc 10. The rabbet 70 is provided to support the retainer 22 radial load. After the retainer 22 is positioned on the disc 10, a split retaining ring 72 is installed between the hook-shaped fingers 50 and the tabs 48. In this manner, the retainer 22 is completely secured to the disc 10. The ring 72 is split in at least one location, as shown at 74 (FIG. 3) to permit assembly thereof. When assembled as shown in FIGS. 2 and 3, the ring 72 is captured between the hook-shaped fingers 50 and a projecting lip 76 formed integrally with the tabs 48. In this manner, the ring 72 is secured should it break or become weak and attempt to fall out when the engine is stationary.

An overspeed safety stop is incorporated in the design to prevent the hook-shaped fingers 50 from being bent beyond their yield points during operation of the rotor disc 10. This overspeed safety stop is provided by holding a close clearance between the inner diameter of the ring portion 44 of the retainer 22 and the outer diameter of the fingers 50 at location 80 (FIG. 2). Critical loads which would otherwise occur in the fingers 50 are thus transferred directly to the rabbets 70 of the disc 10.

In assembling the turbine rotor as shown in the drawings, the retainer tabs 48 are indexed between the disc fingers 50. The retainers are pushed axially onto the disc until projection 68 contacts the disc 10. A simple installation tool is then used to push the tabs 48 toward the rotor disc 10. The split ring 72 is then positioned between the fingers 50 and the tabs 48, and the tabs 48 are permitted to return to their normal position thus securing the ring 72 as described above. A shoulder 84 is formed integrally with the tabs 48 to preclude the tabs 48 from being bent beyond their yield points during assembly. Once assembly of the blade retainer 22 is completed, the rotor blades 12 are positioned within the dovetail slot 20 and the blade retainer 24 is then assembled on the opposite side of the rotor disc 10 in a manner similar to that described above for the blade retainer 22. Disassembly of the rotor is accomplished by merely reversing the above-described steps. Shoulders 82 and 83 are provided for pulling the retainers off the disc.

When assembled as described above, the blade retainers 22 and 24 secure the blades 12 in their desired radial positions and preclude axial movement of the blades 12 within the dovetail slots 20. In addition, the blade retainers 22 and 24 provide a sealed chamber around the bottom of the dovetail slots for the delivery of cooling air thereto in the manner described above. This sealed chamber is provided by the close fit between the projecting portions 68 of the retainers and the rim of the rotor disc 10 and, furthermore, by the continuous seal between the ring portion 44 and the rabbets 70.

The construction shown in the drawings and described above provides a number of advantages over previously used retainer systems. For example, the large number of bolts normally associated with attaching blade retainers to the upstream and downstream sides of the turbine rotor disc have been eliminated. This significantly reduces the number of parts involved, and thus the time associated with assembly of the turbine rotor. The elimination of the bolts also provides for a much lighter weight rotor not only because of the elimination of the bolts and nuts but also because the rim of the rotor disc 10 need not be as thick due to elimination of possible stress concentration areas associated with bolt holes. Finally, the elimination of the bolts reduces windage losses which could occur on both sides of the turbine rotor disc. These windage losses not only increase the temperature of the cooling air but also cause added work to be done by the turbine rotor, thereby decreasing the overall efficiency of the engine.

From the preceding discussion it will be apparent that deviations from the preferred embodiments described will occur to those skilled in the art. For example, the disclosed structure could easily be modified to provide for the attachment of any ring type part, such as a seal or cover plate, to a comparable mating part such as a rotor disc or rotor shaft or even to a stationary member such as a frame within a gas turbine engine. The spirit and scope of the present invention are therefore to be derived fully from the appended claims.

Having thus described the invention, what is claimed as novel and desired to be secured by Letters Patent of the United States is:

1. A boltless blade retainer for a turbomachinery rotor which includes a rotor disc having a plurality of blade dovetail slots therein and a plurality of rotor blades positioned within the slots, said blade retainer comprising:

a continuous annular ring,

means for securing said ring to a face of the rotor disc,

a leg extending radially outwardly from said ring, said leg including means for radially positioning the rotor blades within the dovetail slots and means for preventing axial movement of the rotor blades within the slots, and

said leg defining a cooling air chamber around at least a portion of the dovetail slots of the rotor disc.

2. A boltless blade retainer as recited in claim **1** wherein said ring securing means include a plurality of tabs which extend radially inwardly from said ring.

3. A boltless blade retainer as recited in claim **2** wherein said leg further includes means for passing cooling air to said cooling air chamber.

4. A boltless blade retainer as recited in claim **3** in combination with a rotor disc, said rotor disc including a plurality of hook-shaped fingers formed integrally therewith and extending from the face of said disc, said fingers being spaced so as to receive said blade retainer tabs therebetween.

5. The combination recited in claim **4** wherein said hook-shaped fingers include a first portion extending axially from the face of said disc and a second portion extending radially inwardly from said first portion, said combination further including a locking strip positioned between said tabs and said second portion of said fingers.

6. The combination recited in claim **5** wherein said rotor disc includes a rabbet located radially outwardly of said hook-shaped fingers, and said blade retainer ring is positioned between said rabbet and said fingers.

7. A combination as recited in claim **6** further including a plurality of rotor blades positioned within the dovetail slots, said blades including platforms forming the inner bounds of a gas flow passage, said blade retainers being further characterized in that said means for radially positioning said blades comprise an enlarged head portion at the top of said blade retainer leg, and said head portion lies beneath and supports said blade platforms.

8. A turbomachinery rotor which includes at least one rotor disc having a plurality of blade dovetail slots located in the rim thereof, a rotor blade positioned within each of said blade dovetail slots, and a boltless blade retainer, said blade retainer comprising:

a continuous annular ring,

means for securing said ring to a face of said rotor disc,

a leg extending radially outwardly from said ring, said leg including means for radially positioning said rotor blades within said dovetail slots and means for preventing axial movement of said rotor blades within said slots, and

said leg defining a cooling air chamber around at least a portion of said dovetail slots of said rotor disc.

9. A turbomachinery rotor as recited in claim **8** wherein said blade retainer is further characterized in that said means for securing said blade retainer ring to a face of said rotor disc includes a plurality of tabs which extend radially inwardly from said blade retainer ring.

10. A turbomachinery rotor as recited in claim **9** wherein said blade retainer leg further includes means for passing cooling air to said cooling air chamber.

11. A turbomachinery rotor as recited in claim **10** wherein said rotor disc includes a plurality of hook-shaped fingers formed integrally therewith and extending from a face thereof, said fingers being spaced so as to receive said blade retainer tabs therebetween.

12. A turbomachinery rotor as recited in claim **11** including a second blade retainer, said first blade retainer being secured to a first face of said rotor disc and said second blade retainer being secured to the opposite face of said rotor disc.

13. A turbomachinery rotor as recited in claim **12** wherein said second blade retainer comprises:

a continuous annular ring,

means for securing said ring to a face of the rotor disc,

a leg extending radially outwardly from said ring, said leg including means for radially positioning the rotor blades within the dovetail slots and means for preventing axial movement of the rotor blades within the slots, and

said leg defining a cooling air chamber around at least a portion of the dovetail slots of the rotor disc.

14. A turbomachinery rotor as recited in claim **12** including a first locking strip positioned between said blade retainer tabs and said hooked-shaped fingers of said first face, and a second locking strip positioned between said blade retainer tabs of said second blade retainer and hook-shaped fingers formed integrally with and extending from said opposite face of said rotor disc.

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