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(54) Turbine rotor and blade assembly with blind holes and corresponding steam turbine

(57) The present application provides a turbine rotor and blade assembly for a steam turbine. The turbine rotor and blade assembly may include a rotor 120, a number of buckets 140 positioned about the rotor 120, a locking blade 170 positioned about the rotor 120, and a blind hole 210 positioned about the rotor 120 adjacent to the locking blade 170.

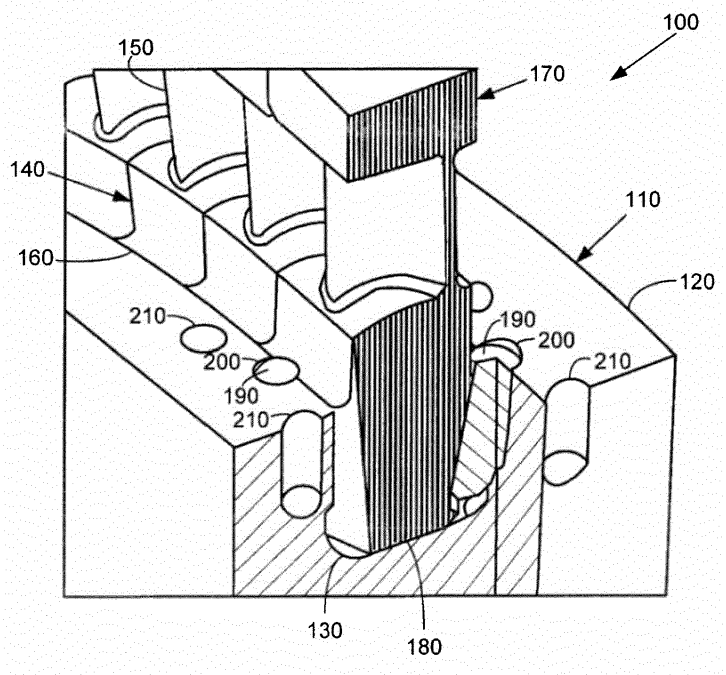

Fig. 2

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Description

[0001] The present application and the resultant patent relate generally to turbo-machinery and more particularly relate to a turbine rotor and blade assembly for use with a steam turbine having redundant locking blade retention screw holes for reduced tangential stress.

[0002] Steam turbine airfoils or buckets generally are positioned about a rotor at regular intervals in a bucket assembly. The bucket assembly may be created by inserting the buckets one at a time tangentially into an opening on the rotor and then sliding the buckets circumferentially about the rotor. The buckets may be attached to the rotor by complementary male and female dovetails and other configurations. In order to close the bucket assembly, however, the last bucket must be restrained by a feature other than a dovetail. This last bucket, generally called the locking blade or the closure bucket, may be affixed to the rotor via one or more blade retention screws and the like tapped or screwed into the rotor. Other types of connection means and other types of bucket assemblies also may be used.

[0003] Large centrifugal loads may be placed on the buckets and the rotor during operation. Such centrifugal loads and coincident thermally induced loads associated with loading transients may induce stresses in the dovetails and adjacent areas that attach the buckets to the rotor. These stresses may be of sufficient magnitude to impact adversely rotor cycle fatigue life. Of particular concern may be rotor stress concentrations associated with blade retention screws that may be tapped or otherwise inserted directly into the rotor.

[0004] There is thus a desire for an improved turbine rotor and blade assembly for a steam turbine and the like. Preferably such an improved turbine rotor and blade assembly may reduce tangential thermal stresses therein for an improved overall rotor fatigue life.

[0005] The present application and the resultant patent thus provide a turbine rotor and blade assembly for a steam turbine. The turbine rotor and blade assembly may include a rotor, a number of buckets positioned about the rotor, a locking blade positioned about the rotor, and a blind hole positioned about the rotor adjacent to the locking blade.

[0006] The present application and the resultant patent further provide a turbine rotor and blade assembly for a steam turbine. The turbine rotor and blade assembly described herein may include a rotor, a number of buckets positioned about the rotor, a locking blade positioned about the rotor, a locking blade retention screw securing the locking blade to the rotor, and a blind hole positioned about the rotor adjacent to the locking blade.

[0007] The present application and the resultant patent further provide a steam turbine. The steam turbine described herein may include a rotor, a number of buckets positioned about the rotor, a locking blade positioned about the rotor, a locking blade retention hole positioned about the locking blade, a locking blade retention screw positioned in the locking blade retention hole so as to secure the locking blade to the rotor, and one or more blind holes positioned about the rotor adjacent to the locking blade.

[0008] These and other features and improvements of the present application and the resultant patent will become apparent to one of ordinary skill in the art upon review of the following detailed description when taken in conjunction with the several drawings and the appended claims.

Fig. 1 is a schematic diagram of an example of a steam turbine with a number of sections.

Fig. 2 is a partial perspective view of a turbine rotor and blade assembly as may be described herein.

[0009] Referring now to the drawings, in which like numerals refer to like elements throughout the several views, Fig. 1 is a schematic diagram of an example of a steam turbine 10 as may be used herein. The steam turbine 10 may include a first section 15 and a second section 20. The sections 15, 20 may be high pressure sections, intermediate pressure sections, and/or low pressure sections. Each of the sections 15, 20 may have a number of stages therein. An outer shell or casing 25 may be divided axially into upper and lower half sections 30, 35, respectively. A rotor shaft 40 may extend through the casing 25 and may be supported by a number of journal bearings 45. A number of seals 50 also may surround the rotor shaft 40 about the ends and elsewhere. A central section 55 may include one or more steam inlets 60. A flow splitter 65 may extend between the sections 15, 20.

[0010] In use, a flow of steam 70 passes through the steam inlets 60 and into the sections 15, 20 such that mechanical work may be extracted from the steam by the stages therein so as to rotate the rotor shaft 40. The flow of steam 70 then may exit the sections 15, 20 for further processing and the like. The steam turbine 10 described herein is for the purpose of example only. Steam turbines and/or other types of turbo-machinery in many other configurations and with many other or different components also may be used herein.

[0011] Fig. 2 shows a portion of a steam turbine 100 as may be described herein. Specifically, the steam turbine 100 may include a turbine rotor and blade assembly 110. The turbine rotor and blade assembly 110 includes a turbine rotor 120. The turbine rotor 120 includes a dovetail slot 130 formed therein. A number of buckets 140 may be mounted on the rotor 120 via tangential entry and the like. Each of the buckets 140 may include a blade 150 and a dovetail 160. The dovetail 160 may be configured to mate with the conforming dovetail slot 130 (or vice versa) of the rotor 120. The rotor 120 and the buckets 140 may have any size, shape, or configuration. Other components and other configurations may be used herein.

[0012] The turbine rotor and blade assembly 110 also may include a locking blade 170. As described above, the locking blade 170 lacks the dovetail 160. Rather, a base 180 of the locking blade 170 may be retained within the rotor 120 via a number of blade retention screws 190 and the like. The blade retention screws 190 may be grub screws or other types of set screws and the like with or without a head on one end. Each blade retention screw 190 may be positioned in a blade retention hole 200. The blade retention hole 200 may extend into the rotor 120 adjacent to the locking blade 170 as well as into the base 180 of the locking blade 170 so as to retain the locking blade 170 therein. Any number of the blade retention screws 190 may be used. The respective components described herein may have any size, shape, or configuration. Other components and other configurations also may be used herein.

[0013] As was described above, tangential thermal stresses may tend to develop about the blade retention holes 200 during operation. The turbine rotor and blade assembly 110 therefore may have a number of blind holes 210 formed therein. The blind holes 210 may be positioned in the rotor 120 on either or both sides of the blade retention hole 200. The blind holes 210 may be placed about the locking blade 170 on both axial and radial sides thereof. The blind holes 210 may have a similar size, shape, and configuration as compared to the blade retention holes 200. The blind holes 210, however, also may have any size, shape, or configuration. Blind holes 210 of differing sizes, shapes, or configurations also may be used herein together. Any number of the blind holes 210 may be used herein.

[0014] The blind holes 210 thus may improve the fatigue life of the turbine rotor and blade assembly 110 by "shielding" the blade retention holes 200 from local stress fields and the like. The blind holes 210 may straddle the blade retention holes 200 tangentially so as to protect the blade retention holes 200 from potentially damaging tangential stresses. The blind holes 200 thus may improve the fatigue life of the rotor 120 and related components for an extended component lifetime.

[0015] It should be apparent that the foregoing relates only to certain embodiments of the present application and the resultant patent. Numerous changes and modifications may be made herein by one of ordinary skill in the art without departing from the general spirit and scope of the invention as defined by the following claims and the equivalents thereof.

[0016] Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. A turbine rotor and blade assembly for a steam turbine, comprising:

a rotor;

a plurality of buckets positioned about the rotor;

a locking blade positioned about the rotor; and

a blind hole positioned about the rotor adjacent to the locking blade.

2. The turbine rotor and blade assembly of clause 1, wherein the locking blade comprises a base.

3. The turbine rotor and blade assembly of clause 1 or clause 2, further comprising one or more blade retention holes extending into the rotor and the base of the locking blade.

4. The turbine rotor and blade assembly of any preceding clause, further comprising a blade retention screw extending into each blade retention hole so as to secure the locking blade to the rotor.

5. The turbine rotor and blade assembly of any preceding clause, wherein the blind hole and the one or more blade retention holes comprise a similar depth.

6. The turbine rotor and blade assembly of any preceding clause, wherein the rotor comprises a dovetail slot and wherein the plurality of buckets is positioned therein.

7. The turbine rotor and blade assembly of any preceding clause, wherein each of the plurality of buckets comprises a dovetail for mating with the dovetail slot.

8. The turbine rotor and blade assembly of any preceding clause, wherein each of the plurality of buckets comprises a blade extending from the dovetail.

9. The turbine rotor and blade assembly of any preceding clause, further comprising a plurality of blind holes.

10. The turbine rotor and blade assembly of any preceding clause, further comprising a first blind hole on a first axial side of the locking blade and a second blind hole on a second axial side of the locking blade.

11. The turbine rotor and blade assembly of any preceding clause, further comprising a first blind hole on a first radial side of the locking blade and a second blind hole on a second radial side of the locking blade.

12. A turbine rotor and blade assembly for a steam turbine, comprising:

a rotor;

a plurality of buckets positioned about the rotor;

a locking blade positioned about the rotor;

a locking blade retention screw securing the locking blade to the rotor; and

a blind hole positioned about the rotor adjacent to the locking blade.

13. The turbine rotor and blade assembly of any preceding clause, wherein the locking blade comprises a base and wherein the locking blade retention screw extends into the base.

14. The turbine rotor and blade assembly of any preceding clause, further comprising one or more blade retention holes extending into the rotor and the base of the locking blade for the blade retention screw.

15. The turbine rotor and blade assembly of any preceding clause, wherein the blind hole and the one or more blade retention holes comprise a similar depth.

16. The turbine rotor and blade assembly of any preceding clause, wherein the rotor comprises a dovetail slot and wherein the plurality of buckets is positioned therein.

17. The turbine rotor and blade assembly of any preceding clause, further comprising a plurality of blind holes.

18. The turbine rotor and blade assembly of any preceding clause, further comprising a first blind hole on a first axial side of the locking blade and a second blind hole on a second axial side of the locking blade.

19. The turbine rotor and blade assembly of any preceding clause, further comprising a first blind hole on a first radial side of the locking blade and a second blind hole on a second radial side of the locking blade.

20. A steam turbine, comprising:

a rotor;

a plurality of buckets positioned about the rotor;

a locking blade positioned about the rotor;

a locking blade retention hole positioned about the locking blade;

a locking blade retention screw positioned in the locking blade retention hole to secure the locking blade to the rotor; and

one or more blind holes positioned about the rotor adjacent to the locking blade.

Claims

1. A turbine rotor and blade assembly for a steam turbine, comprising:

   a rotor (120);
   a plurality of buckets (140) positioned about the rotor;
   a locking blade (170) positioned about the rotor; and
   a blind hole (210) positioned about the rotor adjacent to the locking blade.

2. The turbine rotor and blade assembly of claim 1, wherein the locking blade (170) comprises a base.

3. The turbine rotor and blade assembly of claim 1 or claim 2, further comprising one or more blade retention holes extending into the rotor and the base of the locking blade.

4. The turbine rotor and blade assembly of any preceding claim, further comprising a blade retention screw extending into each blade retention hole so as to secure the locking blade to the rotor.

5. The turbine rotor and blade assembly of any preceding claim, wherein the blind hole and the one or more blade retention holes comprise a similar depth.

6. The turbine rotor and blade assembly of any preceding claim, wherein the rotor comprises a dovetail slot and wherein the plurality of buckets is positioned therein.

7. The turbine rotor and blade assembly of any preceding claim, wherein each of the plurality of buckets comprises a dovetail for mating with the dovetail slot.

8. The turbine rotor and blade assembly of any preceding claim, wherein each of the plurality of buckets comprises a blade extending from the dovetail.

9. The turbine rotor and blade assembly of any preceding claim, further comprising a plurality of blind holes.

10. The turbine rotor and blade assembly of any preceding claim, further comprising a first blind hole on a first axial side of the locking blade and a second blind hole on a second axial side of the locking blade.

11. The turbine rotor and blade assembly of any preceding claim, further comprising a first blind hole on a first radial side of the locking blade and a second blind hole on a second radial side of the locking

blade.

12. The turbine rotor and blade assembly of any preceding claim, further comprising a locking blade retention screw securing the locking blade to the rotor.

13. The turbine rotor and blade assembly of claim 12, wherein the locking blade comprises a base and wherein the locking blade retention screw extends into the base.

14. The turbine rotor and blade assembly of claim 12 or claim 13, further comprising one or more blade retention holes extending into the rotor and the base of the locking blade for the blade retention screw.

15. A steam turbine, comprising a turbine rotor and blade assembly according to any one of the preceding claims.

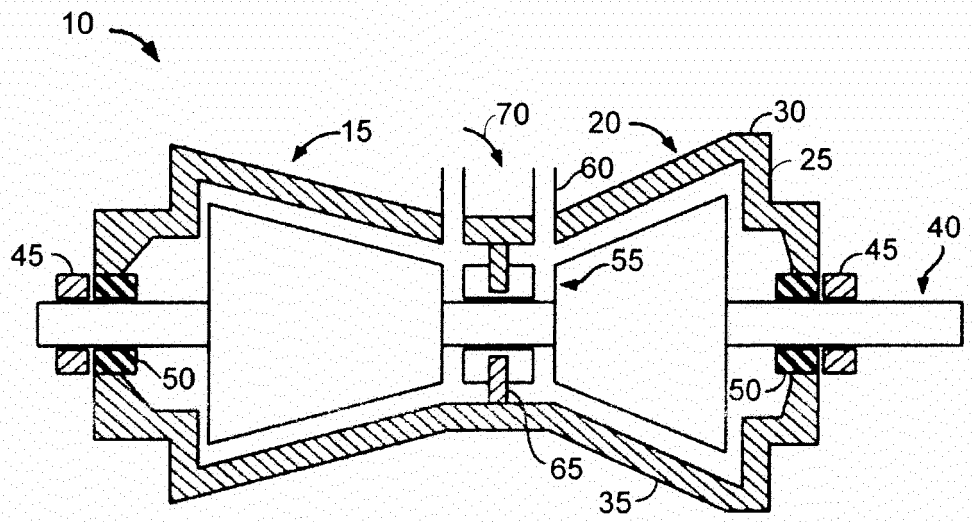
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Fig. 1

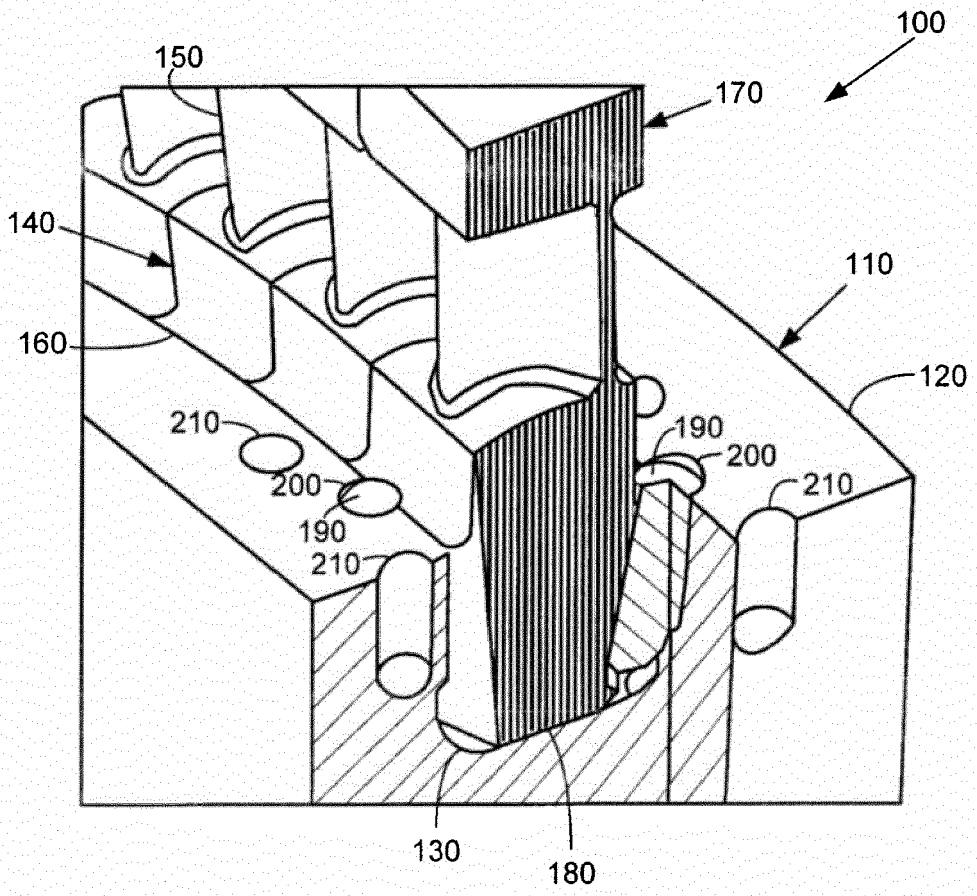
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Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 0089

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 122 455 A (CHARLES ALGERNON PARSONS; COOK STANLEY SMITH; ALDIS ARTHUR JOHN) 21 January 1919 (1919-01-21) * figures 7,8 *	1,2,6-8	INV. F01D5/30 F01D5/32
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TECHNICAL FIELDS SEARCHED (IPC)

F01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 August 2013	Raspo, Fabrice

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 17 0089

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