US008221083B2

(12) **United States Patent**
Alvanos et al.

(10) **Patent No.: US 8,221,083 B2**
(45) **Date of Patent: Jul. 17, 2012**

(54) **ASYMMETRICAL ROTOR BLADE FIR-TREE ATTACHMENT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1128 days.

(21) Appl. No.: **12/103,673**

(22) Filed: **Apr. 15, 2008**

(65) **Prior Publication Data**

US 2009/0257877 A1 Oct. 15, 2009

(51) **Int. Cl.**
F01D 5/30 (2006.01)

(52) **U.S. Cl.** .... **416/219 R**; 416/248

(58) **Field of Classification Search** .... 416/219 R, 416/248, 500

See application file for complete search history.

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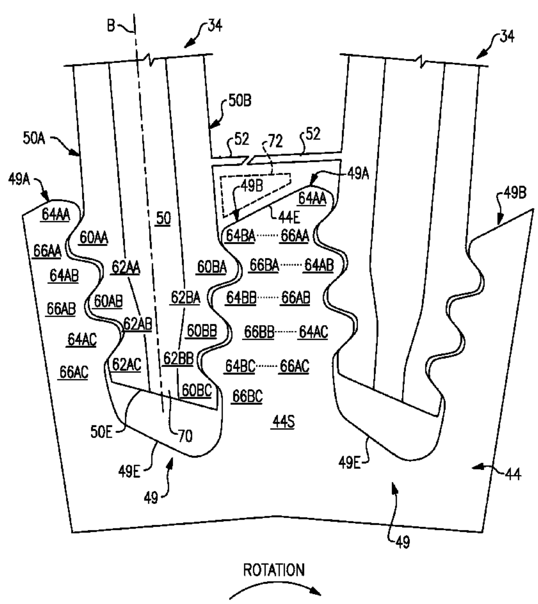
(57) **ABSTRACT**

A rotor blade for a gas turbine engine includes an asymmetric attachment section received within a rotor disk rim with an asymmetric slot.

16 Claims, 6 Drawing Sheets



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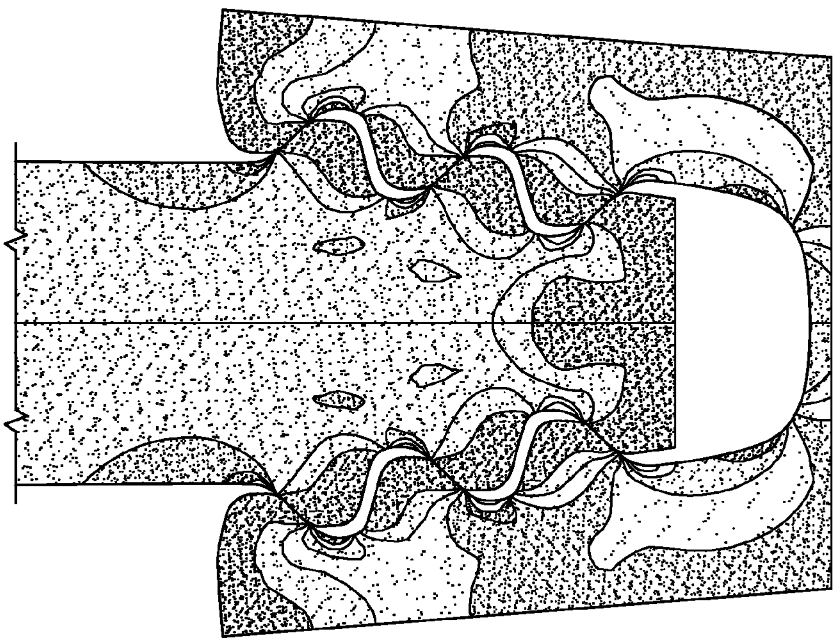


FIG.1B
Prior Art

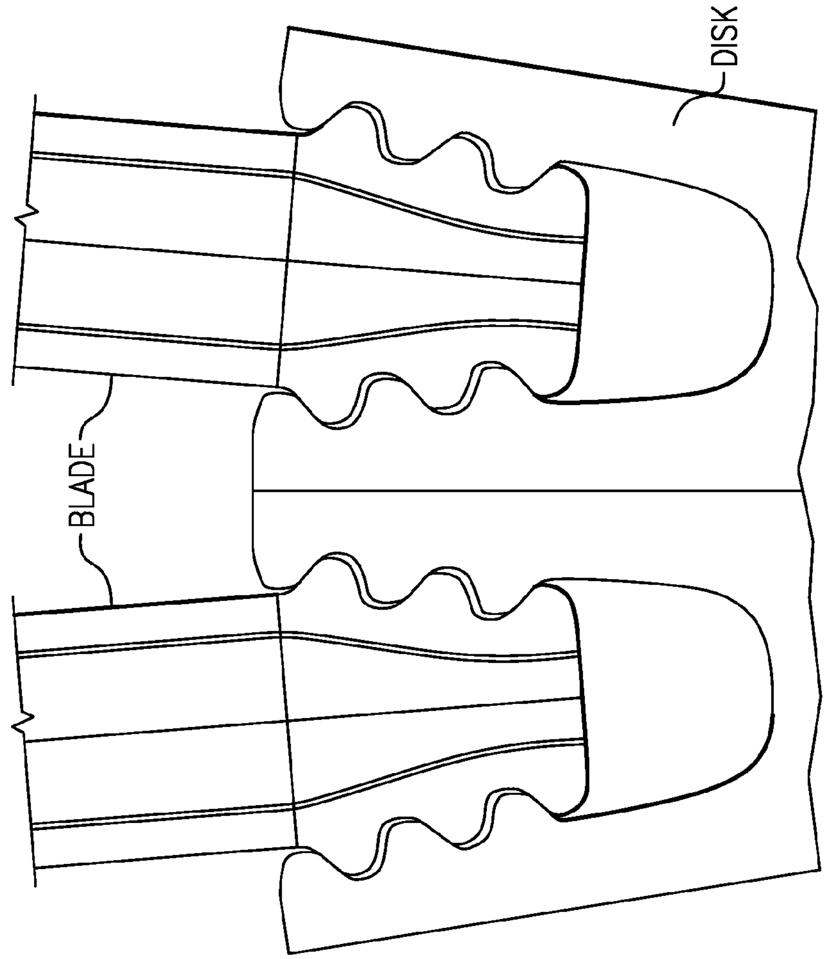


FIG.1A
Prior Art

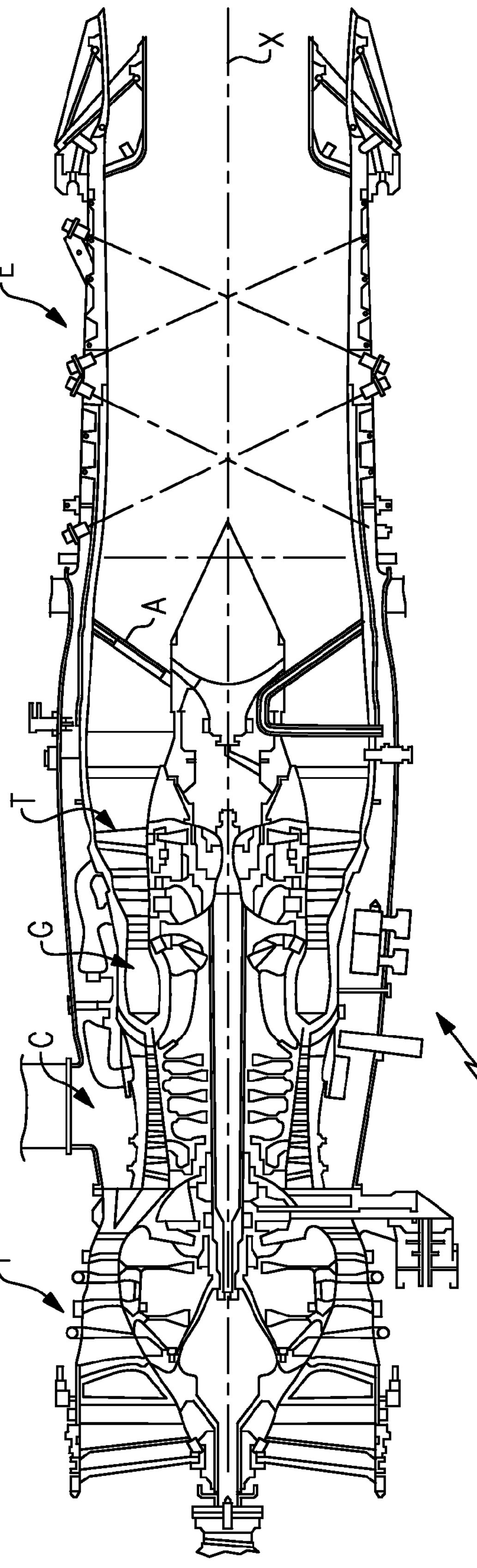


FIG.2

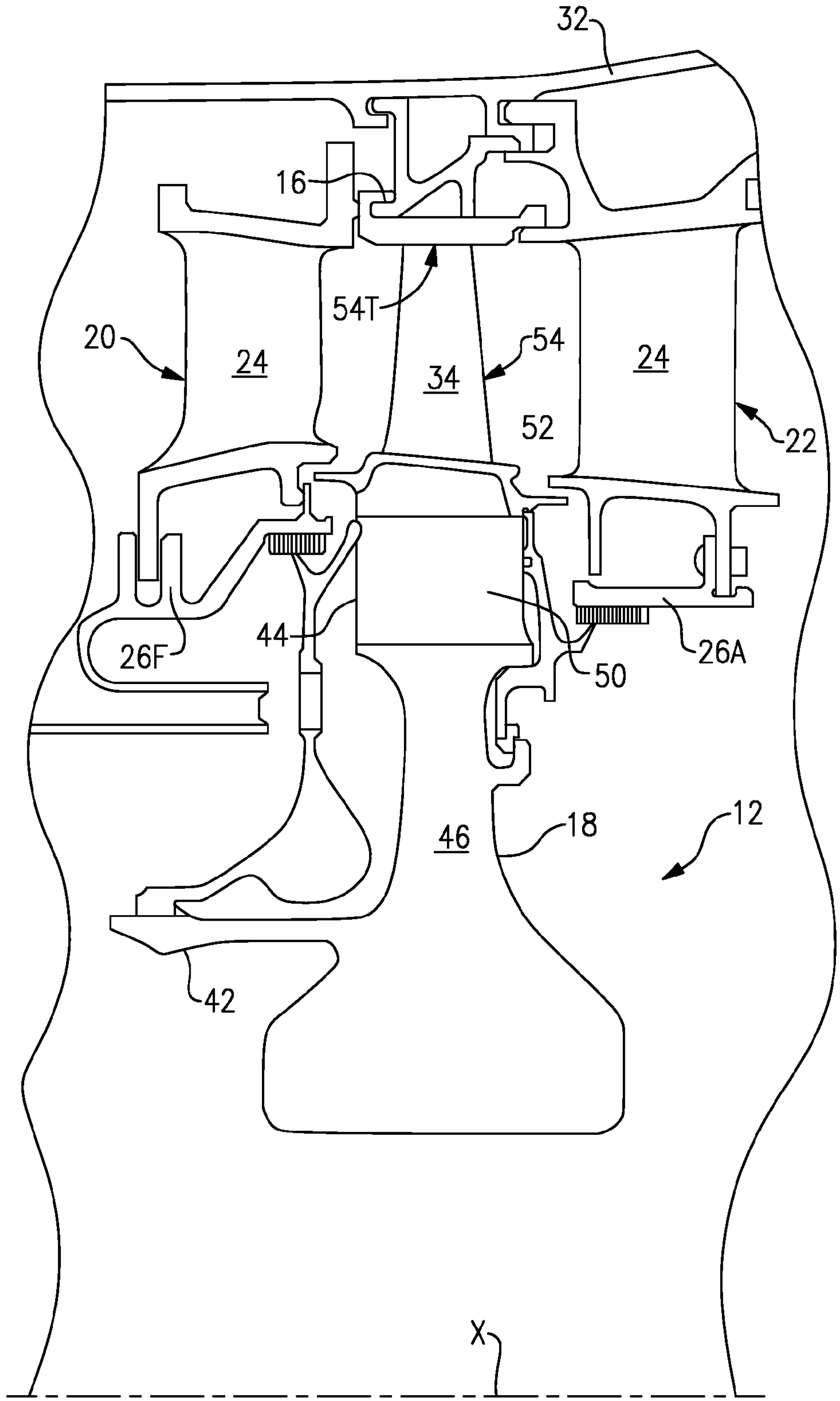


FIG.3

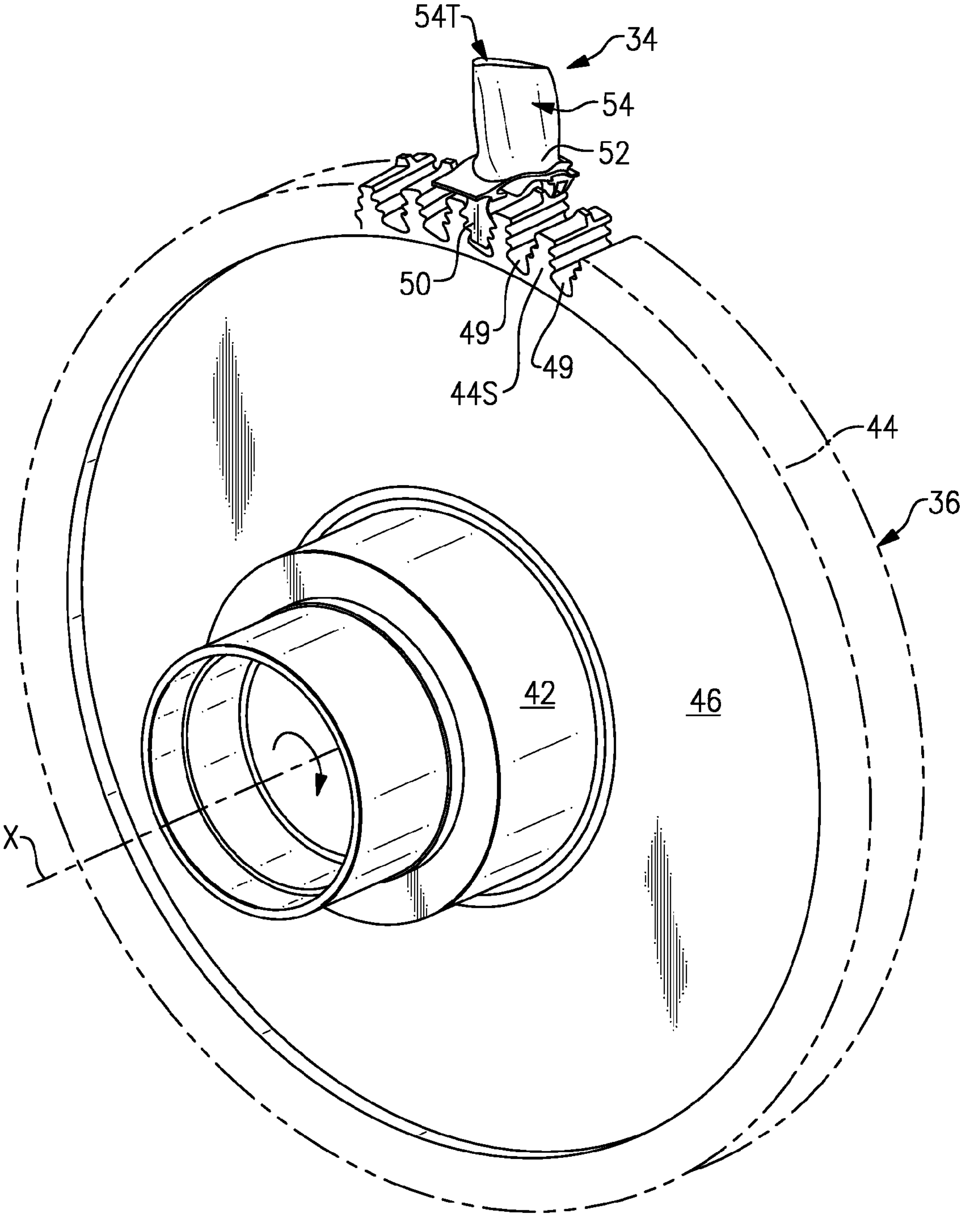
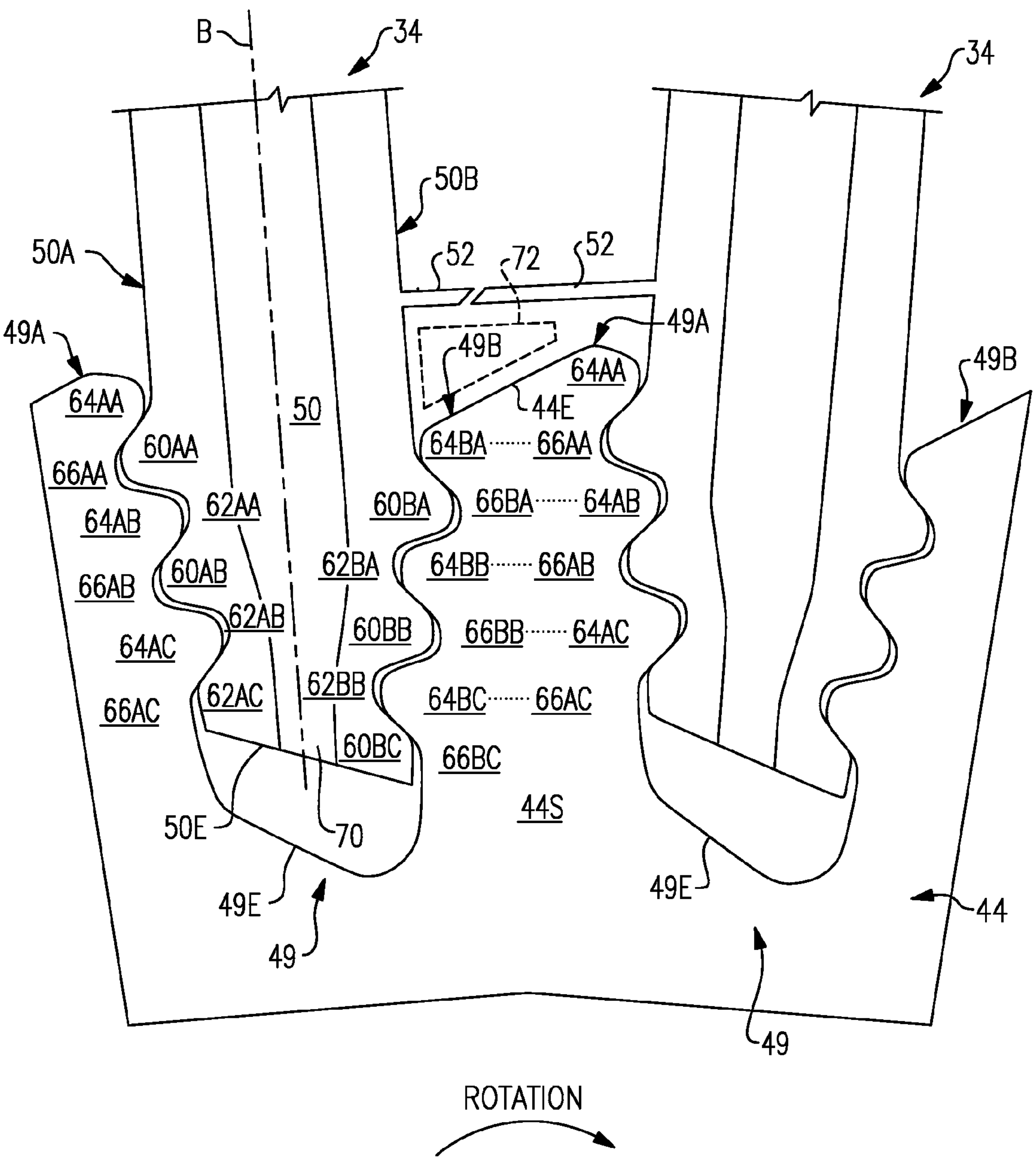


FIG.4


B
34
34
50B
52
72
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66AA
66AA
62AA
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64BB
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62AB
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66BB
64AC
64AC
62AC
62BB
64BC
66AC
66AC
60BC
66BC
44S
50E
70
49E
49E
44
49
49
ROTATION

FIG.5A

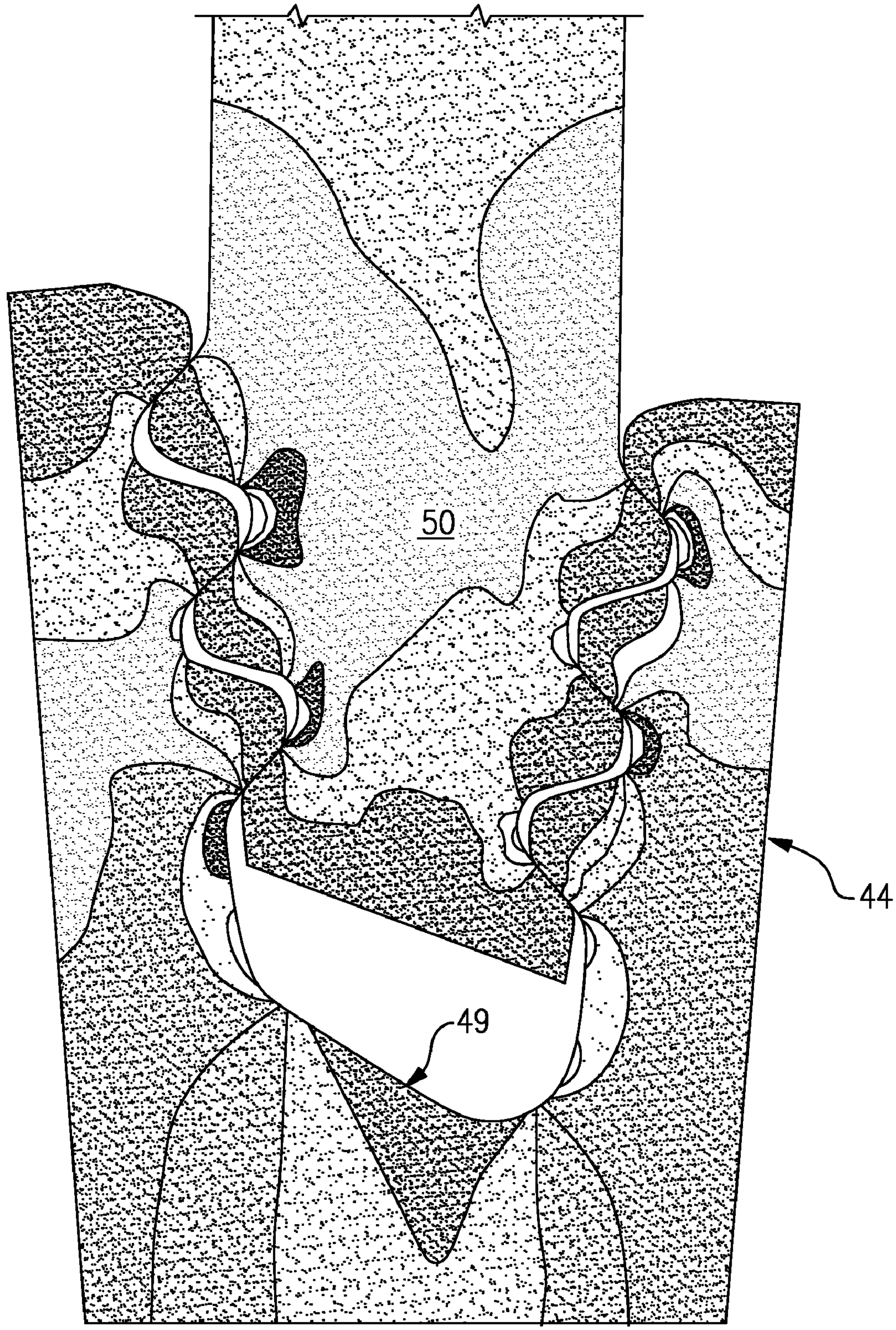

FIG.5B

ASYMMETRICAL ROTOR BLADE FIR-TREE ATTACHMENT

BACKGROUND

The present invention relates to a gas turbine engine, and more particularly to a rotor blade attachment thereof.

Gas turbine engines often include a multiple of rotor assemblies within a fan, compressor and turbine section. Each rotor assembly has a multitude of blades attached about a circumference of a rotor disk. Each of the blades is spaced a distance apart from adjacent blades to accommodate movement and expansion during operation. Each blade includes a root section that attaches to the rotor disk, a platform section, and an airfoil section that extends radially outwardly from the platform section.

Gas turbine engine rotor blades are typically attached in a rotor disk rim through a fir-tree-type root attachment section. The blades are then locked into place with bolts, peening, locking wires, pins, keys, plates, or other locks. The blades need not fit too tightly in the rotor disk due to the centrifugal forces during engine operation. Some blade movement reduces the vibrational stresses produced by high-velocity airstreams between the blades.

Referring to FIG. 1A, current rotor blade fir-tree-type root design attachments are symmetrical in shape and may vary from one lobe to four or more lobe tooth attachment designs. Although effective, this symmetry results in a reduced cross-sectional area between each blade which may limit Low Cycle Fatigue (LCF) and shear strength (P/A) (FIG. 1B) capability.

SUMMARY

A rotor blade for a gas turbine engine according to an exemplary aspect of the present invention includes: an asymmetric attachment section.

A rotor disk for a gas turbine engine according to an exemplary aspect of the present invention includes: a hub; a rim; and a web which extends between said hub and said rim, said rim defines a multiple of asymmetric slots.

A rotor blade for a gas turbine engine according to an exemplary aspect of the present invention includes: an asymmetric attachment section defines a multiple of first lobes and a multiple of first pockets on a first side and a multiple of second lobes and a multiple of second pockets on a second side, at least one of the multiple of first lobes located generally opposite a second pocket and at least one of the multiple of first pockets located generally opposite a second lobe.

BRIEF DESCRIPTION OF THE DRAWINGS

The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the disclosed non-limiting embodiment. The drawings that accompany the detailed description can be briefly described as follows:

FIG. **1**A is an expanded front sectional view of a PRIOR ART rotor disk illustrating a symmetric attachment between two blades and the rotor disk;

FIG. **1**B is an expanded front sectional view of a PRIOR ART rotor disk illustrating the stresses on the symmetric attachment between one blade and the rotor disk;

FIG. **2** is a schematic illustration of a gas turbine engine;

FIG. **3** is a general sectional diagrammatic view of a gas turbine engine HPT section of the engine of FIG. **2**;

FIG. **4** is an expanded perspective view of the blade mounted to a rotor disk;

FIG. **5**A is an expanded front sectional view of the rotor disk illustrating an asymmetric attachment between two blades and the rotor disk; and

FIG. **5**B is an expanded front sectional view of a rotor disk illustrating the stresses on the asymmetric attachment between one blade and the rotor disk.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

FIG. **2** schematically illustrates a gas turbine engine **10** which generally includes a fan section F, a compressor section C, a combustor section G, a turbine section T, an augmentor section A, and an exhaust duct assembly E. The compressor section C, combustor section G, and turbine section T are generally referred to as the core engine. An engine longitudinal axis X is centrally disposed and extends longitudinally through these sections. Although a particular engine configuration is illustrated and described in the disclosed embodiment, other engines will also benefit herefrom.

FIG. **3** schematically illustrates a High Pressure Turbine (HPT) section of the gas turbine engine **10** having a turbine disk assembly **12** within the turbine section T disposed along the engine longitudinal axis X. It should be understood that a multiple of disks may be contained within each engine section and that although the HPT section is illustrated and described in the disclosed embodiment, other sections which have other blades such as fan blades, low pressure turbine blades, high pressure turbine blades, high pressure compressor blades and low pressure compressor blades will also benefit herefrom.

The HPT section includes a blade outer air seal assembly **16** with a rotor assembly **18** disposed between a forward stationary vane assembly **20** and an aft stationary vane assembly **22**. Each vane assembly **20**, **22** includes a plurality of vanes **24** circumferentially disposed around an inner vane support **26**F, **26**A.

The rotor assembly **18** includes a plurality of blades **34** circumferentially disposed around a rotor disk **36** (FIG. **4**). The rotor disk **36** generally includes a hub **42**, a rim **44**, and a web **46** which extends therebetween. Each blade **34** generally includes an asymmetric attachment section **50**, a platform section **52** and an airfoil section **54** along a longitudinal axis X. Each of the blades **34** is received within the rim **44** of the rotor disk **36** such that the asymmetric attachment section **50** is engaged therewith. The outer edge of each airfoil section **54** is a blade tip **54**T which is adjacent the blade outer air seal assembly **16**.

Referring to FIG. **5**A, the asymmetric attachment section **50** defines a first side **50**A and a second side **50**B. In one non-limiting embodiment, the first side **50**A is the pressure side and the second side **50**B is a suction side relative the rotational direction of the rotor disk **36**. The first side **50**A includes a multiple of lobes **60**AA, **60**AB, **60**AC and a multiple of pockets **62**AA, **62**AB. The second side **50**B includes a multiple of lobes **60**BA, **60**BB, **60**BC and a multiple of pockets **62**BA, **62**BB. The multiple of lobes **60**AA, **60**AB, **60**AC and the multiple of pockets **62**AA, **62**AB on the first side **50** are offset from the respective multiple of lobes **60**BA, **60**BB, **60**BC and the multiple of pockets **62**BA, **62**BB on the second side **50**B. The pocket **62**AA is across from the lobe **60**BA; the lobe **60**AB is across from the lobe **62**BA; the pocket **62**AB is across from the lobe **60**BB; and the lobe **60**AC is across from the pocket **62**BB relative to blade axis B. The asymmetrical fir-tree type attachment thereby provides tooth attachment lobes that are radially offset relative to the opposite side of the accepting set. The asymmetrical fir-tree type attachment may be manufactured through EDM, broaching, or grinding.

The rim **44** defines an asymmetrical slot **49** to receive the asymmetric attachment section **50** of the respective blade **34**. Each asymmetrical slot **49** defines a first side **49**A and a second side **49**B. The first side **49**A includes a multiple of lobes **64**AA, **64**AB, **64**AC and a multiple of pockets **66**AA, **66**AB, **66**AC. The second side **49**B includes a multiple of lobes **64**BA, **64**BB, **64**BC and a multiple of pockets **66**BA, **66**BB, **66**BC. The pocket **66**AA is across from the lobe **64**BA; the lobe **64**AB is across from the pocket **66**BA; the pocket **66**AB is across from the lobe **64**BB; the lobe **64**AC is across from the pocket **66**BB; and the pocket **66**AC is across from the lobe **64**BC relative to blade axis B.

A rim section **44**S is defined between each of two asymmetric slots **49**. The rim section **44**S includes the lobe **64**BA across from the pocket **66**AA; the pocket **66**BA across from the lobe **64**AB; the lobe **64**BB across from the pocket **66**AB; the pocket **66**BB across from the lobe **64**AC; and the lobe **64**BC across from the pocket **66**AC.

This asymmetrical shape of the asymmetric attachment section **50** and the asymmetrical slot **49** may be formed through EDM, grinding, or broaching, which facilitates the flexibility to shape the fir-tree in a manner that can vary symmetry. The variation in symmetry increases the cross-sectional area of the rim section **44**S between each blade asymmetrical slot **49** and the asymmetric attachment section **50** by offsetting the lobes.

The asymmetrical interface reduces shear stress and increase the overall capability of the blade **34** and the rotor disk **36**. The reduced stress (FIG. **5**B) allows for reduced weight or an increase in performance by allowing the rotor system to increase in operational speed (RPM—revolutions per minute). Although the asymmetrical interface of the asymmetric attachment section **50** and the asymmetrical slot **49** may generate a slight moment, the moment is readily compensated for by slight changes to the airfoil section **54**.

An angled distal end **50**E (FIG. **5**A) of the asymmetric attachment section **50** relative to an angled distal end **49**E of the asymmetric slot **49** provides a larger inlet area for cooling flow into an airflow cooling channel **70** of the blade **34**.

A shorter neck length below the platform section **53** is also facilitated by the asymmetric attachment section **50** as underplatform section hardware **72** (illustrated schematically) such as a damper and featherseal may be located adjacent an angled outer diameter **44**E of the rims section **44**S. That is, the underplatform section hardware **72** is located within the triangular area defined by the angled outer diameter **44**E and the platform section **52**.

It should be understood that relative positional terms such as “forward,” “aft,” “upper,” “lower,” “above,” “below,” and the like are with reference to the normal operational attitude of the vehicle and should not be considered otherwise limiting.

It should be understood that like reference numerals identify corresponding or similar elements throughout the several drawings. It should also be understood that although a particular component arrangement is disclosed in the illustrated embodiment, other arrangements will benefit from the instant invention.

Although particular step sequences are shown, described, and claimed, it should be understood that steps may be performed in any order, separated or combined unless otherwise indicated and will still benefit from the present invention.

The foregoing description is exemplary rather than defined by the limitations within. Many modifications and variations of the present invention are possible in light of the above teachings. The disclosed embodiments of this invention have been disclosed, however, one of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. For that reason the following claims should be studied to determine the true scope and content of this invention.

What is claimed is:

1. A rotor blade for a gas turbine engine comprising:

an asymmetric attachment section, which locates a lobe generally opposite a pocket wherein the radially outermost lobe of the attachment section includes a surface facing away from an axis of rotation of the gas turbine engine, the surface interfacing directly with a radially directed surface of a blade.

2. The rotor blade as recited in claim **1**, wherein said asymmetric attachment section extends from a platform section and an airfoil section extends from said platform section opposite said asymmetric attachment.

3. The rotor blade as recited in claim **1**, wherein said asymmetric attachment section defines an angled distal end.

4. The rotor blade as recited in claim **3**, wherein the angled distal end is aligned with an angled distal end of an asymmetric slot that is configured to receive the asymmetric attachment section.

5. The rotor blade as recited in claim **1**, wherein said asymmetric attachment section defines a multiple of lobes and a multiple of pockets, each of said multiple of lobes located on a first side of said asymmetric attachment section generally opposite a pocket of said multiple of pockets on a second side of said asymmetric attachment section.

6. The rotor blade as recited in claim **1**, wherein said asymmetric attachment section defines a multiple of lobes and a multiple of pockets, each of said multiple of lobes located on a second side of said asymmetric attachment section generally opposite a pocket of said multiple of pockets on a first side of said asymmetric attachment section.

7. The rotor blade as recited in claim **1**, wherein said asymmetric attachment section defines a multiple of lobes and a multiple of pockets, each of said multiple of lobes located on a first side of said asymmetric attachment section generally opposite a pocket of said multiple of pockets on a second side of said asymmetric attachment section.

8. The rotor blade as recited in claim **1**, wherein the circumferentially outermost portion of the asymmetric attachment section is radially spaced from a platform section of a blade having the asymmetric attachment section.

9. A rotor disk for a gas turbine engine comprising:

a hub;

a rim; and

a web which extends between said hub and said rim, said rim defines a multiple of asymmetric slots, each of said multiple of slots comprises a lobe generally opposite a pocket, wherein each of two of said multiple of asymmetric slots defines a rim section therebetween, and wherein said rim section defines an angled outer diameter.

10. The rotor disk as recited in claim **9**, wherein each of said multiple of asymmetric slots defines an angled distal end.

11. The rotor disk as recited in claim **9**, wherein each of said multiple of asymmetric slots defines a multiple of lobes and a multiple of pockets, each of said multiple of lobes located on a first side of each of said multiple of asymmetric slots generally opposite a pocket of said multiple of pockets on a second side of each of said multiple of asymmetric slots.

12. The rotor disk as recited in claim **9**, wherein each of said multiple of asymmetric slots defines a multiple of lobes and a multiple of pockets, each of said multiple of lobes located on a second side of each of said multiple of asymmetric slots generally opposite a pocket of said multiple of pockets on a first side of each of said multiple of asymmetric slots.

13. The rotor disk as recited in claim **9**, wherein each of said multiple of asymmetric slots defines a multiple of lobes and a multiple of pockets, each of said multiple of lobes located on a first side of each of said multiple of asymmetric slots generally opposite a pocket of said multiple of pockets on a second side of each of said multiple of asymmetric slots, each of said multiple of lobes located on said second side of each of said multiple of asymmetric slots generally opposite a pocket of said multiple of pockets on said first side of each of said multiple of asymmetric slots.

14. A rotor blade for a gas turbine engine comprising:

an asymmetric attachment section defines a multiple of first lobes and a multiple of first pockets on a first side and a multiple of second lobes and a multiple of second pockets on a second side, at least one of said multiple of first lobes located generally opposite a second pocket and at least one of said multiple of first pockets located generally opposite a second lobe; and

a radially outermost lobe of the asymmetric attachment section includes a surface facing radially away from a rotational axis of the gas turbine engine.

15. The rotor blade as recited in claim **14**, wherein said asymmetric attachment section extends from a platform section and an airfoil section extends from said platform section opposite said symmetric attachment.

16. The rotor blade as recited in claim **14**, wherein the surface facing away from the rotational axis is radially closer to the rotational axis than an outermost diameter of said rim.

* * * * *