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Paz

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(54) **GAS TURBINE BLADE WITH PLATFORM UNDERCUT**

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(51) **Int. Cl.**[7] **F01D 5/14**

(52) **U.S. Cl.** .... **416/193 A**

(58) **Field of Search** .... 416/193 A, 223 R, 416/234, 235, 236 R, 248

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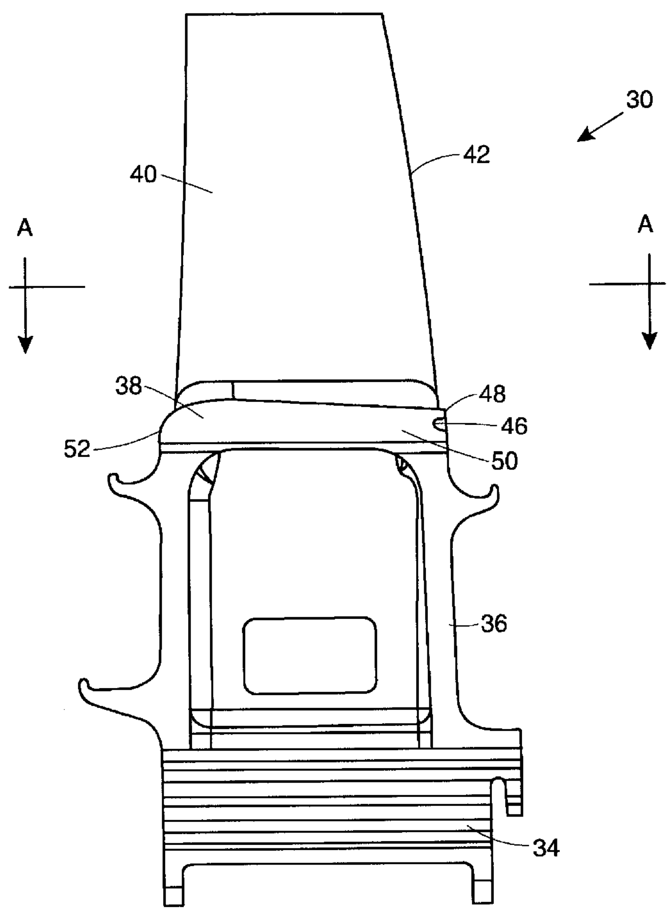
(57) **ABSTRACT**

A gas turbine moving blade includes a platform which is undercut with a groove. The groove extends from the concave side to the trailing edge side of the platform, where the groove exits the platform. The groove has a depth which will enter a stress line causing a change to the load path direction away from the trailing edge. The location and depth of the groove reduces both high thermal stress and mechanical stress arising at a connection portion of a blade trailing edge and the platform of the gas turbine air cooled moving blade during transient engine operation as well as steady state, full speed, full load conditions.

8 Claims, 8 Drawing Sheets



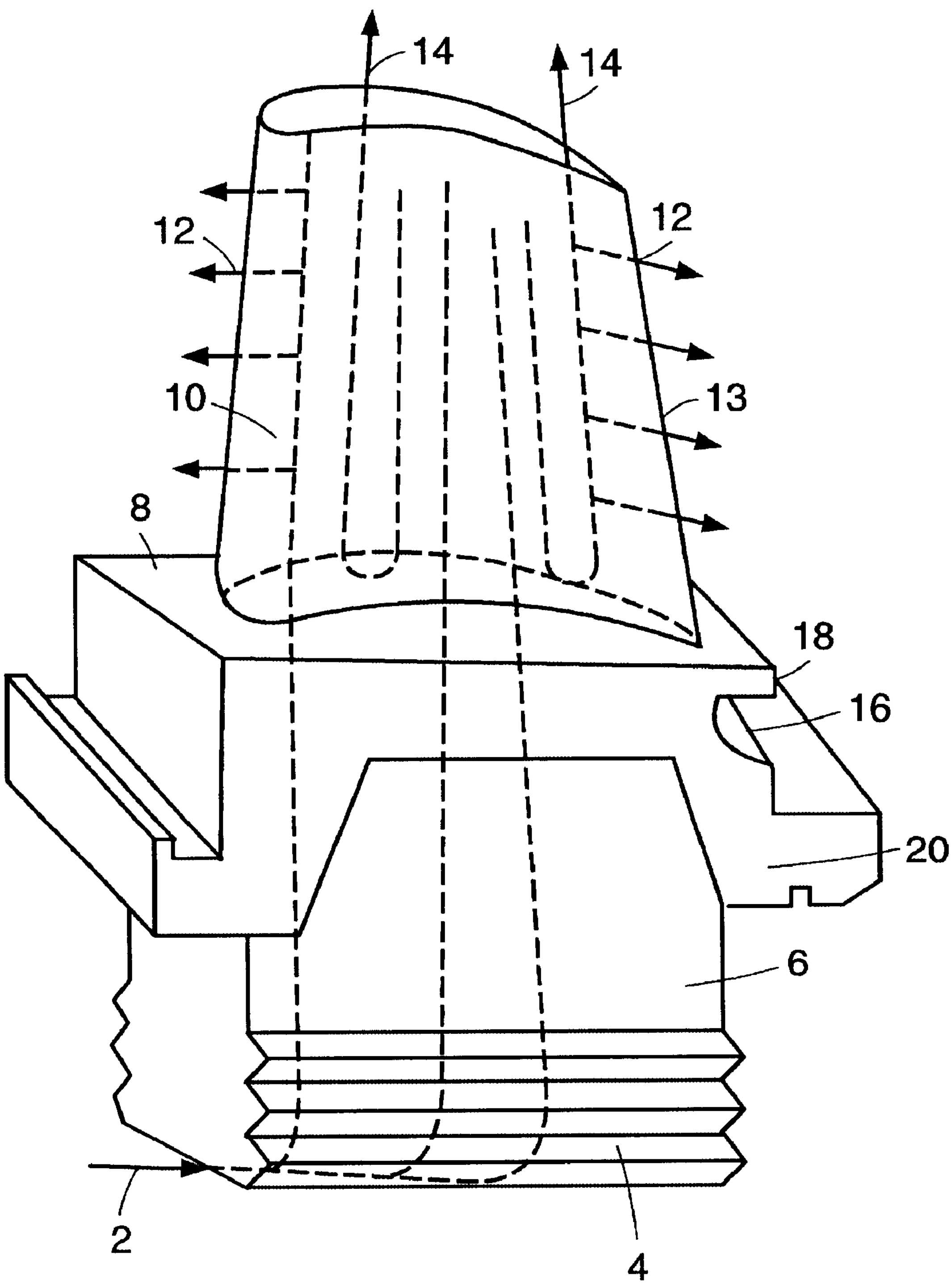


FIG. 1
PRIOR ART

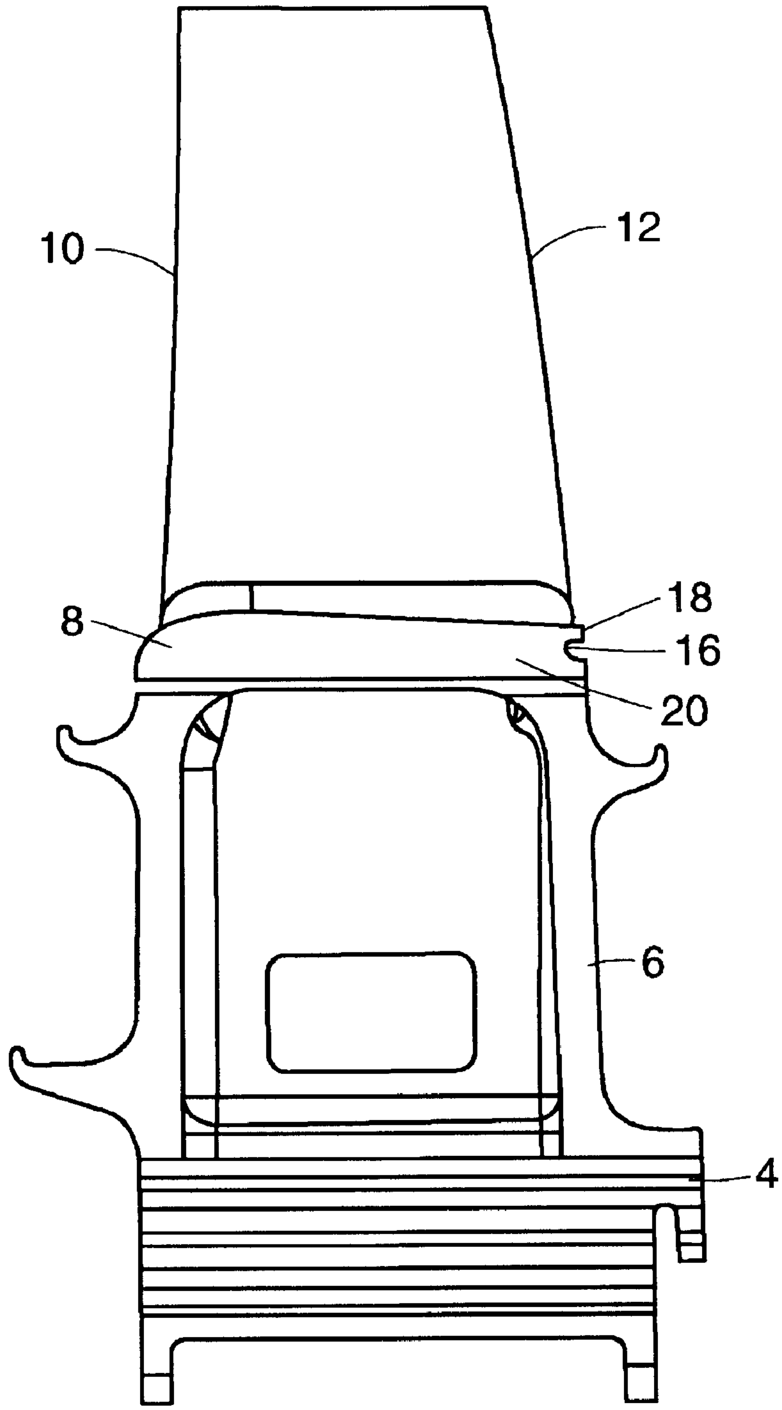


FIG. 2
PRIOR ART

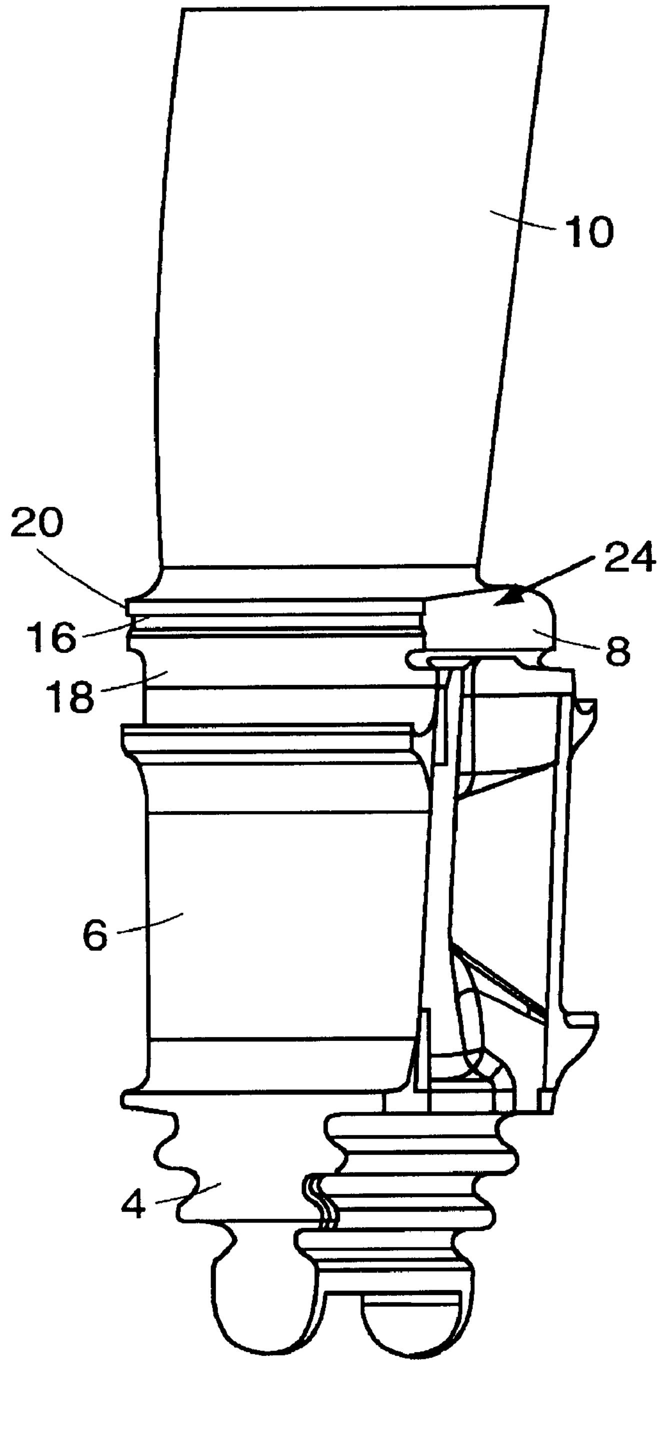


FIG. 3
PRIOR ART

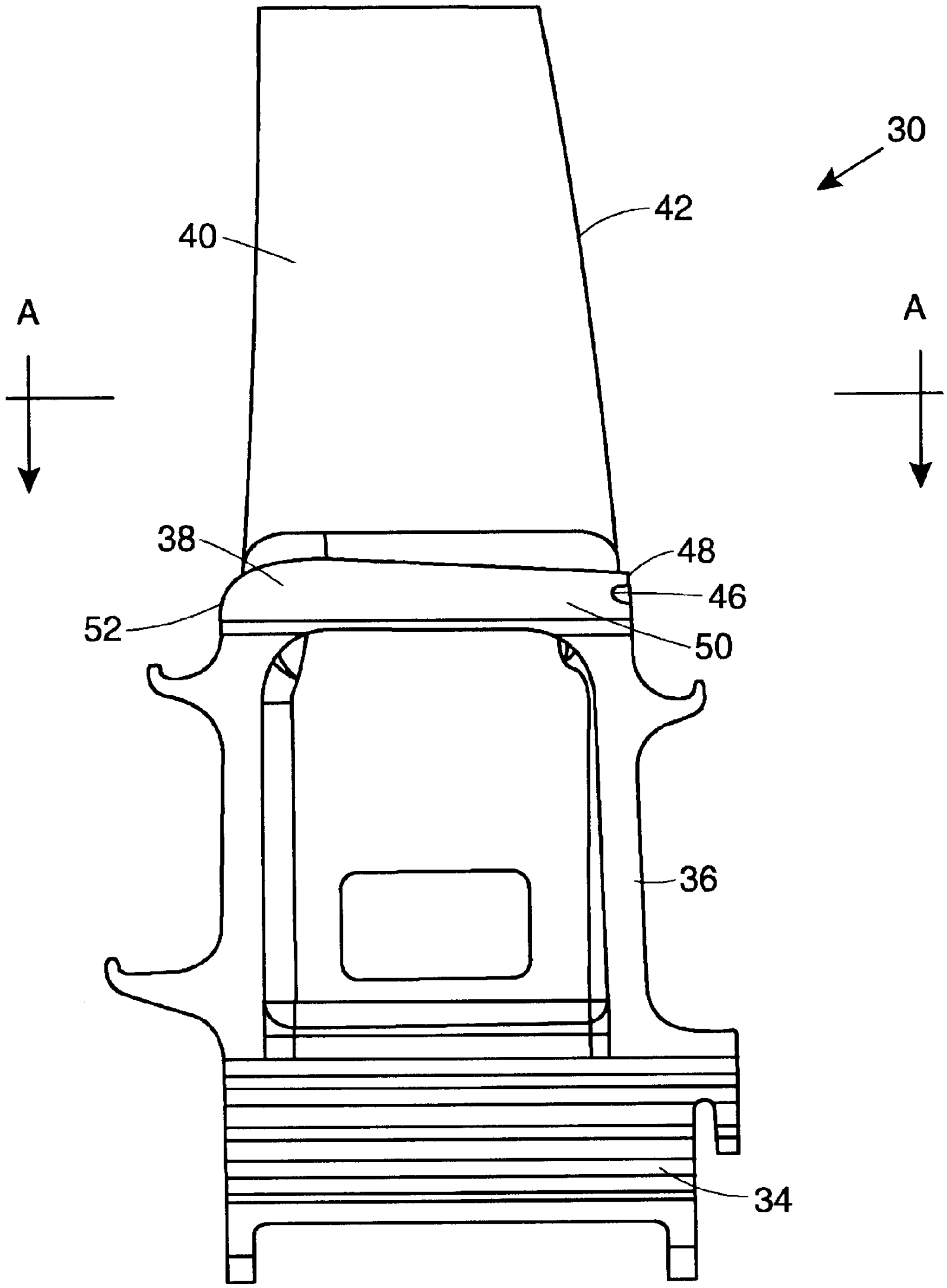


FIG. 4

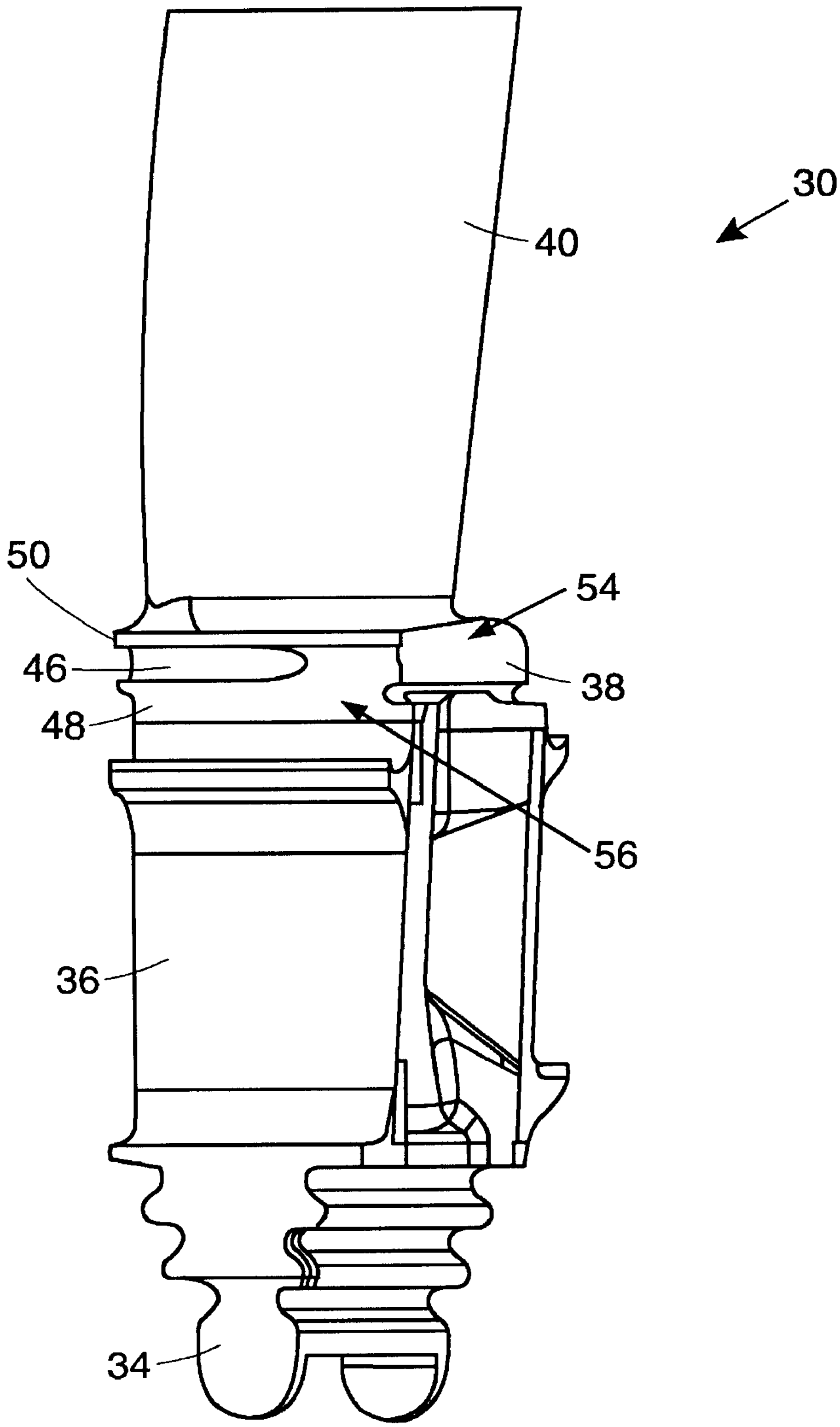


FIG. 5

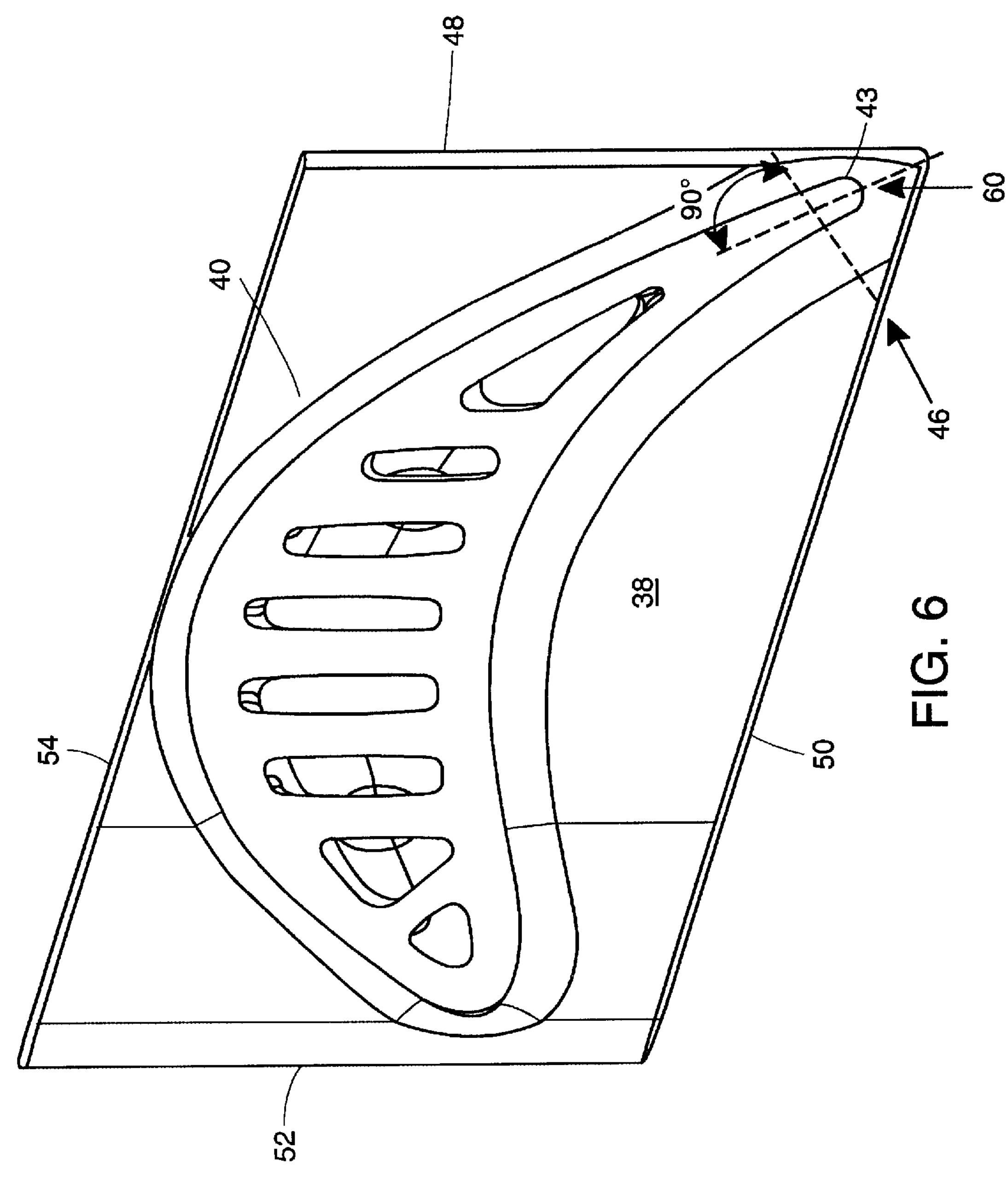


FIG. 6

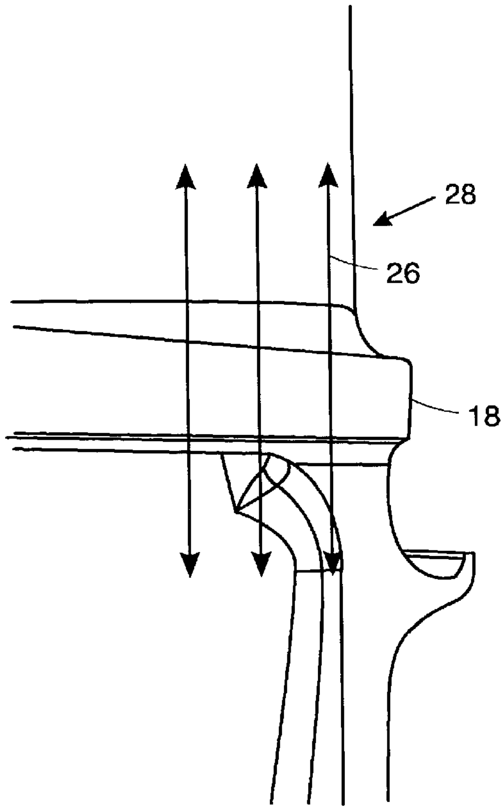


FIG. 7
PRIOR ART

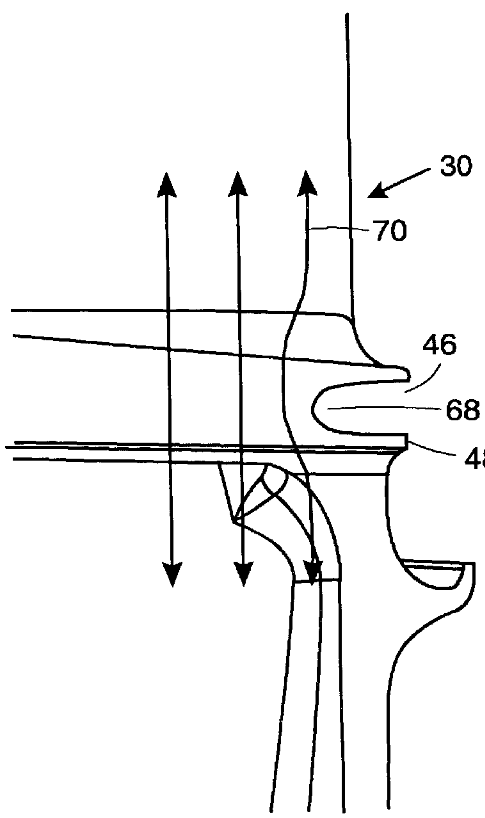


FIG. 8

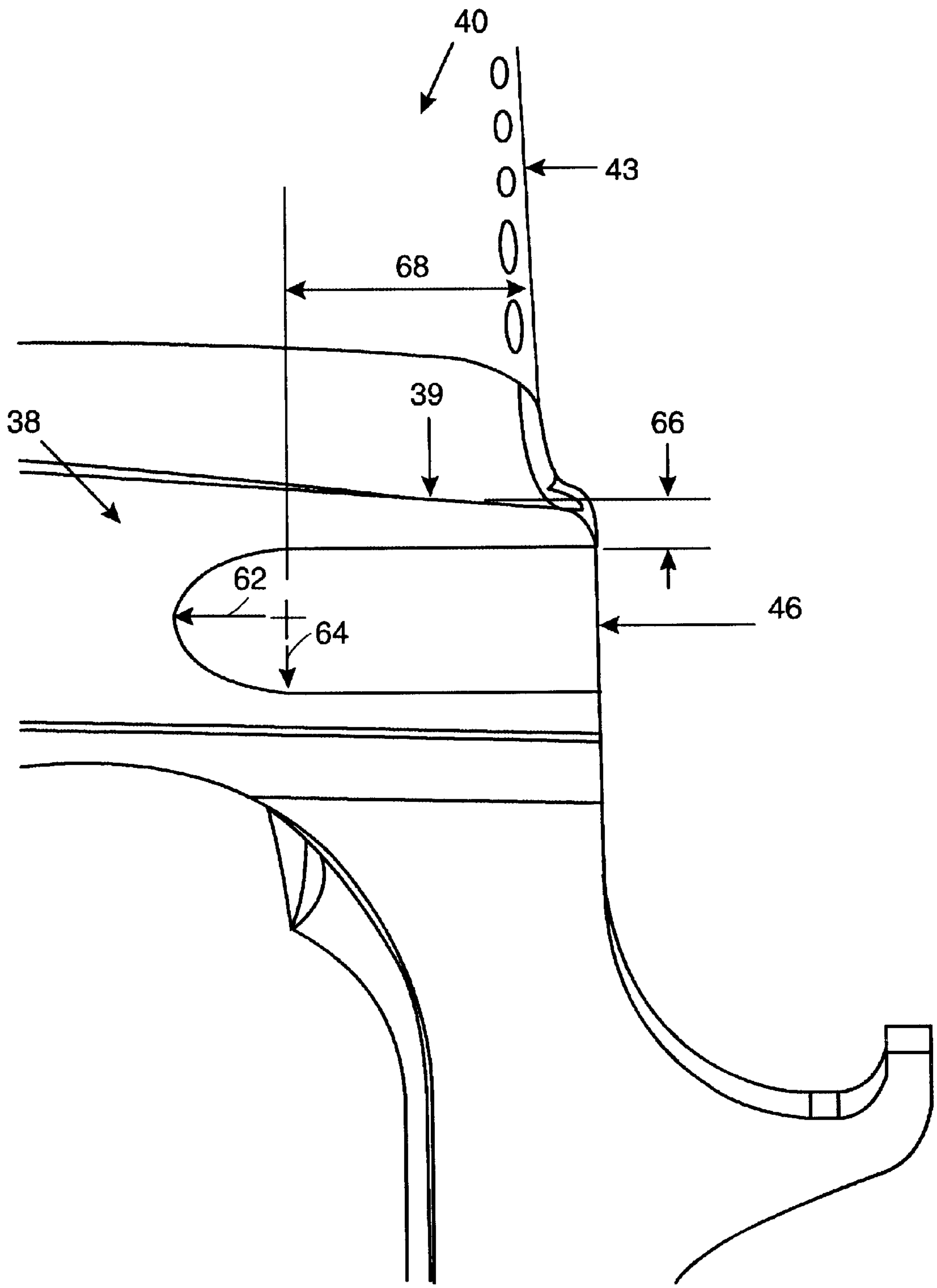


FIG. 9

GAS TURBINE BLADE WITH PLATFORM UNDERCUT

BACKGROUND OF THE INVENTION

The present invention relates to a gas turbine moving blade, and, more particularly, to a gas turbine blade having a platform undercut with improved thermal stress relief.

Gas turbine blades, also referred to as buckets, are exposed to high temperature combustion gases, and, consequently, are subject to high thermal stresses. Methods are known in the art for cooling the blades and reducing the thermal stresses. FIGS. **1–3** show one example of a prior art air-cooled moving blade. High pressure air **2**, discharged from a compressor, is introduced into an interior of an air-cooled blade from a blade root bottom portion **4**. The high pressure air, after cooling a shank portion **6**, a platform **8** and a blade profile portion (or airfoil) **10**, flows out of fine holes **12** provided at a blade face, or out of fine holes **14** provided at a blade tip portion. Also, fine holes **12** are provided at a blade trailing edge portion **13** of the blade, through which the high pressure air flows to cool the trailing edge of the blade. Thus, the high pressure air cools the metal temperature of the moving blade.

Highly cooled gas turbine buckets experience high temperature mismatches at the interface of the hot airfoil and the relatively cooler shank portion of the bucket platform. These high temperature differences produce thermal deformations at the bucket platform, which are incompatible with those of the airfoil. In the prior art, the airfoil is attached to a bucket platform that is of greater stiffness than the airfoil. When the airfoil is forced to follow the displacement of the shank and platform, high thermal stresses occur on the airfoil, particularly in the thin trailing edge region. These high thermal stresses are present during transient engine operation as well as steady state, full speed, full load conditions, and can lead to crack initiation and propagation. These cracks potentially can ultimately lead to catastrophic failure of the component.

U.S. Pat. No. 5,947,687 discloses a gas turbine moving blade (FIGS. **1–3**) having a groove **16** on the trailing side **18** of the platform of a turbine blade, designed to suppress a high thermal stress at the attachment point of the airfoil trailing edge and platform that occurs during transient operating conditions, i.e., starting and stopping of the turbine. However, the groove has a depth which does not enter a stress line of the platform caused by the load on the airfoil. Since the groove does not enter a stress line, it does not affect the load path through the trailing edge of the airfoil, and the groove is, therefore, not highly stressed. Also, this groove extends along the entire length of the platform, from the concave side **20** of the blade to the convex side **24**, along a circumference of the turbine, parallel to a plane of rotation of the turbine. In this configuration, the groove affects blade natural frequencies, thereby potentially inducing additional mechanical vibratory stress on the blade.

BRIEF SUMMARY OF THE INVENTION

It is therefore seen to be desirable to reduce the likelihood of initiating cracks in the root trailing edge region of the airfoil by reducing the thermal and mechanical stresses that occur due to the mismatch between the airfoil and the shank.

The present invention provides a gas turbine moving blade in which a groove is introduced in the bucket platform, at an angle with respect to a mean camber line of the airfoil, such that the groove begins on the concave side of the platform and exits the platform on the trailing edge side of the bucket shank cover plate. In alternative embodiments, the cross-section of the groove may be circular, elliptical, or square with simple or compound radii, rectangular, or polygonal, in which the groove is defined by two or more planes. This groove has a depth which will enter a stress line of the platform caused by a load encountered by the blade, and will change the load path direction away from the trailing edge.

The location and depth of the groove of the present invention results in a reduced mechanical as well as thermal stress condition in the airfoil root trailing edge and a higher stressed condition in the groove. An increase in the fatigue capability of this region of the component is possible because the groove is located in a region of cooler metal temperatures having greater material fatigue strength. This groove, additionally, provides a decrease in the mechanical stress in the trailing edge by cutting into the load path of the airfoil, thus having an overall greater benefit in the fatigue life of the region.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a prior art turbine blade.

FIG. **2** is a front side view showing an example of a prior artturbine blade.

FIG. **3** is right side view of the example of a prior art turbine blade illustrated in FIG. **2**.

FIG. **4** is a front side view showing a preferred embodiment of a turbine blade according to the present invention.

FIG. **5** is a right side view of the turbine blade illustrated in FIG. **4**.

FIG. **6** is a cross sectional view, taken along line A—A of FIG. **4**, of the turbine blade of the present invention.

FIG. **7** is a front side view showing the stress line in a prior art turbine blade.

FIG. **8** is a front side view showing the stress line in a preferred embodiment of a turbine blade according to the present invention.

FIG. **9** is an elevation view of another preferred embodiment of the turbine blade of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In a preferred embodiment of the present invention, as seen in FIGS. **4–5**, a turbine blade **30** has a blade root portion **34**, a shank portion **36**, a blade platform **38**, and a blade profile portion (or airfoil) **40**. The platform has a trailing edge side **48**, a concave side **50**, a leading edge side **52**, and a convex side **54**, where the sides are labeled according to their position relative to the blade profile portion **40**. A groove **46** is provided in the platform **38**, such that the groove **46** extends from the concave side **50** to the trailing edge side **48** of the platform **38**, where the groove exits the platform.

As seen in FIG. **6**, the preferred orientation of groove **46** is at an angle of about 90 degrees from the mean camber line **60** at the trailing edge **43** of the airfoil **40**. A prior art turbine blade **28** shown in FIG. **7** has a stress line **26** encountered by blade **28**, or blade load, that includes stress distribution along the airfoil root trailing edge **18**. As seen in FIG. **8**, groove **46** has a depth **68** that will enter a stress line **70** (shown after alteration by groove **46**) of turbine blade **30** caused by a load encountered by blade **30**, or blade load. Thus, groove **46** causes a change to the load path direction away from the trailing edge **48**. Consequently, the groove location and depth results in a reduced mechanical as well as thermal stress condition in the airfoil root trailing edge **48** and a higher stressed condition in the groove **46**. An increase in the fatigue capability of this region of the component is possible because the groove **46** is located in a region of cooler metal temperatures having greater material fatigue strength. This groove **46** additionally provides a decrease in the mechanical stress in the trailing edge **48** by cutting into the load path of the airfoil, thus having an overall greater benefit in the fatigue life of the region. Also, the groove **46** is angled, such that the groove **46** begins on the concave side **50** of the platform and exits on the trailing edge side **48** of the bucket shank cover plate **56**. This groove orientation has a significantly smaller effect on blade natural frequencies than a groove that completely extends from the concave side to the convex side of the blade, thereby further reducing the potential for increased mechanical vibratory stress in the airfoil.

In alternative embodiments, the groove **46** may possess any of a number of shapes, such that the cross-section of the groove may be, but is not limited to, circular, elliptical, square, rectangular, or polygonal, in which the groove is defined by two or more planes. In a preferred embodiment of the present invention, the shape of the groove has an elliptical cross-section. In a most-preferred embodiment, as seen in FIG. **9**, the elliptical groove **46** has a semi-major dimension **62** of 0.237" and a semi-minor dimension **64** of 0.160", based on an airfoil **40** height of 5.60". This embodiment has a preferred radial distance **66** from the groove **46** to the top **39** of the blade platform **38** of 0.085", and the depth **68** is 1.050". The depth **68** of the groove **46** is application specific, and controls the distribution of load between the groove and the airfoil trailing edge **48**. Increasing the depth **68** decreases trailing edge stress and increases groove stress, and vice versa.

While the preferred form of the present invention has been described, variations thereof will occur to those skilled in the art within the scope of the present inventive concepts that are delineated by the following claims.

What is claimed is:

1. A gas turbine blade comprising:

a blade platform having a blade trailing edge side, a blade convex side, a blade concave side, and a blade leading edge side;

a blade profile portion connected to said blade platform; and

a groove formed in said blade trailing edge side of said blade platform, wherein said groove begins on said blade concave side and exits on said blade trailing edge side.

2. The groove as claimed in claim **1**, said groove being at an angle with respect to a mean camber line of a trailing edge of said blade profile portion.

3. The groove as claimed in claim **2**, said angle being 90 degrees.

4. The groove as claimed in claim **1**, said groove having a depth that will enter into a line of stress created by a blade load.

5. The gas turbine blade as claimed in claim **1**, said groove having a substantially elliptical cross-section.

6. The gas turbine blade as claimed in claim **1**, said groove having a substantially round cross-section.

7. A gas turbine blade comprising:

a blade platform having a blade trailing edge side, a blade convex side, a blade concave side, and a blade leading edge side;

a blade profile portion connected to the blade platform; and

a groove formed in the blade platform, the groove having an elliptical cross-section and extending from the blade concave side to the blade trailing edge side at an angle of 90° with respect to a mean camber line of a trailing edge of the blade profile portion.

8. The gas turbine blade as claimed in claim **7**, wherein the groove has a depth that will enter into a line of stress created by a blade load.

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