United States Patent [19]

Hess et al.

[11] 3,887,298

[45] June 3, 1975

[54] **APPARATUS FOR SEALING TURBINE BLADE DAMPER CAVITIES**

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[73] Assignee: **United Aircraft Corporation**, East Hartford, Conn.

[22] Filed: **May 30, 1974**

[21] Appl. No.: **474,756**

[52] **U.S. Cl.** **416/220**; 416/95; 416/193; 416/221; 416/500

[51] **Int. Cl.** **F01d 5/26**

[58] **Field of Search** 416/193, 500, 220, 219, 416/221, 215, 218, 95

[56] **References Cited**

UNITED STATES PATENTS

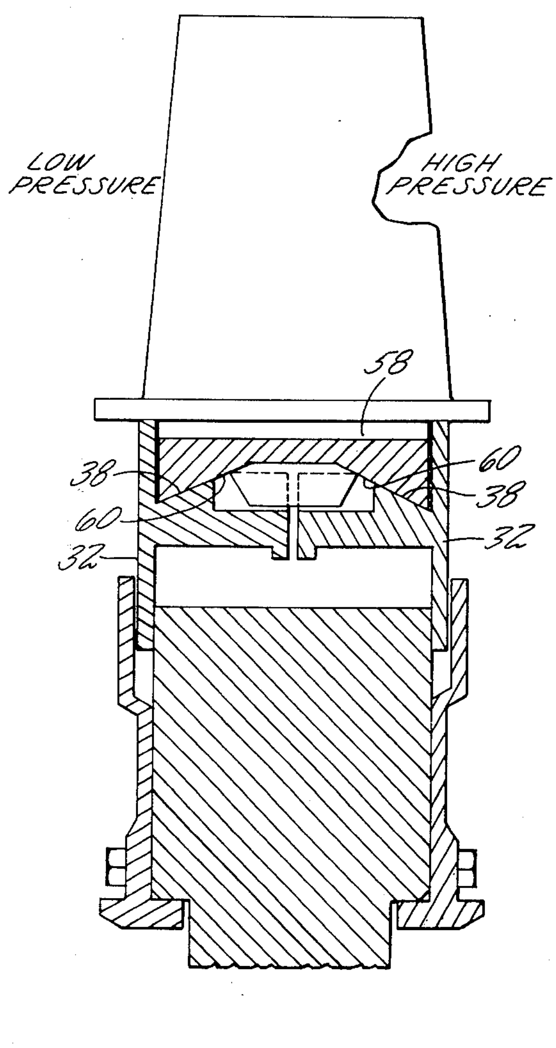
2,985,426	5/1961	Hunter et al.	416/193 UX
2,998,959	9/1961	Haworth et al.	416/221
3,112,915	12/1963	Morris	416/244 A
3,181,835	5/1965	Davis	416/219 X
3,610,778	10/1971	Suter	416/500 X
3,751,183	8/1973	Nichols et al.	416/220

Primary Examiner—Everette A. Powell, Jr.
Attorney, Agent, or Firm—Robert C. Walker

[57] **ABSTRACT**

Apparatus to prevent leakage of working medium through the turbine blade damper cavities of a gas turbine engine is disclosed. A radial seal plate, having an inclined surface which projects into a damper cavity, extends between the neck extensions of two adjacent blades in the region between the turbine disk and the platforms of the blades; the seal plate closes off one end of the damper cavity. Inside the cavity is a vibration damper having two axially extending ridges separated circumferentially by a distance exceeding the gap between the platforms defining the cavity. The damper has a sloped surface adjacent to the inclined surface on the seal plate. During rotation of the engine centrifugal force causes the inclined surface of the seal plate to slide along the sloped surface of the damper until the seal plate is firmly seated against the disk and the neck extensions of the two adjacent blades. Simultaneously, the gap between the blade platforms is sealed by the damper which is held in place against the undersurfaces of the blade platforms.

7 Claims, 5 Drawing Figures



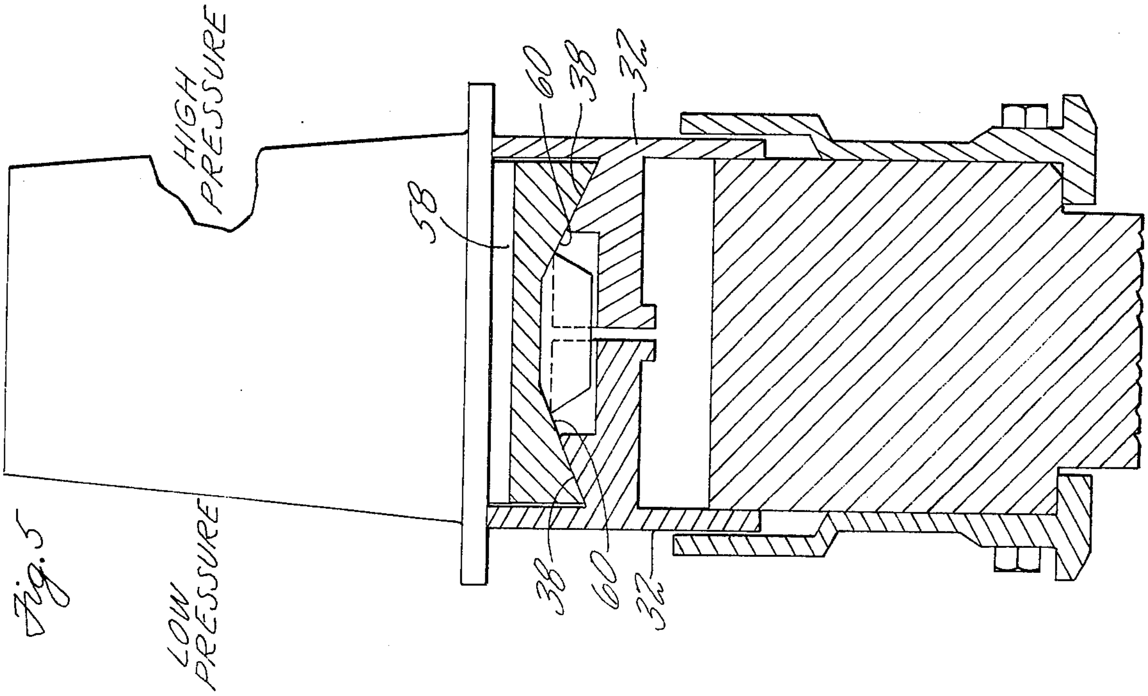

HIGH PRESSURE
LOW PRESSURE
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Fig. 5

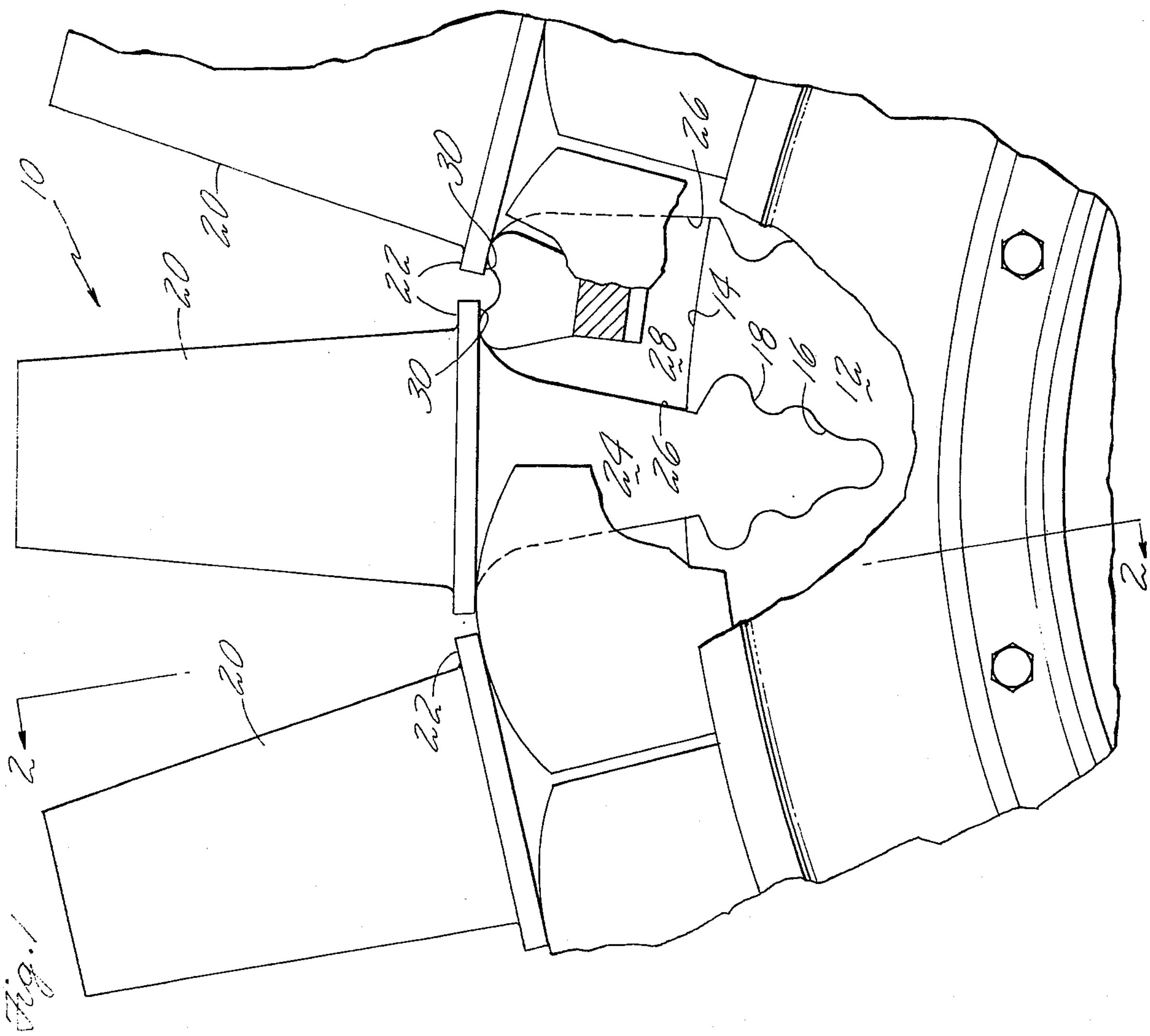
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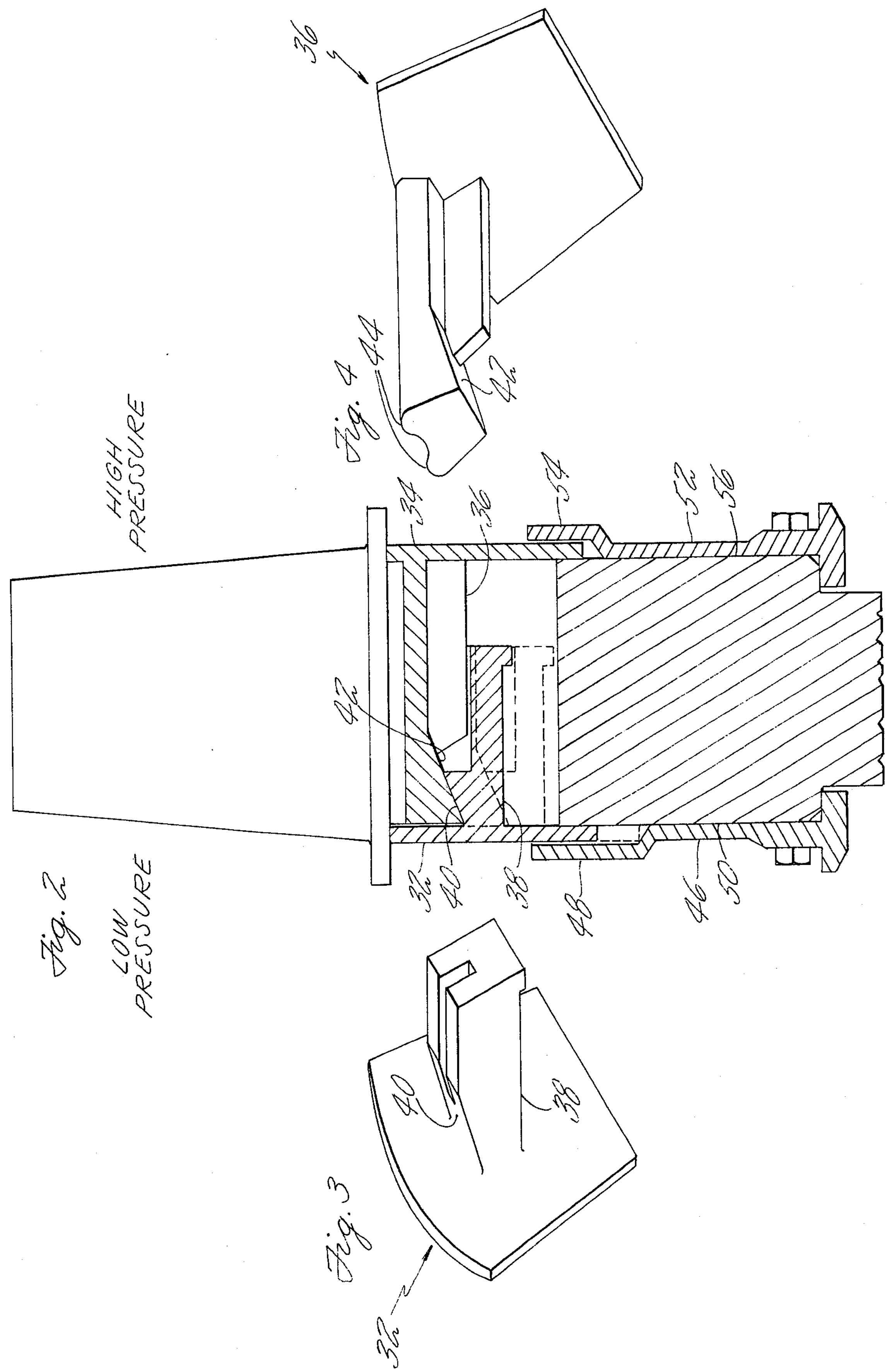
Fig. 1

PATENTED JUN 3 1975 3,887,298

SHEET 2



APPARATUS FOR SEALING TURBINE BLADE DAMPER CAVITIES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to gas turbine engines and more particularly to the axial sealing of turbine wheels.

2. Description of the Prior Art

Gas turbine wheel assemblies commonly comprise a plurality of turbine blades each of which is joined to a disk through the engagement of the fir tree blade root in a corresponding disk slot and extends radially outward from the periphery of the disk. Each blade has a platform section which is spaced radially from the blade root by a neck extension. The cylinder formed by the platforms when all blades are in place defines the inner diameter wall of the working medium flow path. The platforms of two adjacent blades, in conjunction with the disk rim and the neck extensions of the two adjacent blades forms an axially oriented cavity which contains a vibration damper.

During rotation of the turbine wheel, centrifugal force urges the damper to bear upon the undersurfaces of the two adjacent blade platforms. Vibration occurring in any turbine blade is coupled into the adjacent blades through the vibration dampers. Each damper forms a mechanical bridge between the blade platforms of adjacent blades thereby tending to equalize the frequency of blade vibration throughout the wheel assembly. In addition vibratory energy is diminished by the friction between dampers and the blade platforms.

In modern gas turbine engines it is essential that the damper cavity be sealed to prevent leakage of the working medium from the main flow path and to prevent the flow of working medium, which is comprised of hot gases, against the rim of the disk.

A typical wheel construction including vibration damper cavities is shown in U.S. Pat. No. 3,666,376 to Damlis. Each damper cavity contains a vibration damper; a fully annular sideplate seals each side of the turbine disk.

An increase in either the temperature in the turbine or the diameter of the wheel assembly causes a corresponding increase in thermal distortion of the sideplates. This distortion results in substantial leakage between the sideplate and the disk. Increasing the mass of the sideplate is one way to reduce distortion, however, the size and weight of the disk required to restrain the sideplate centrifugal loads correspondingly increase.

Alternate apparatus for sealing the cavity between the blade platforms and the disk rim are shown in U.S. Pat. No. 3,610,778 to Suter and U.S. Pat. No. 3,119,595 to Wilson et al. In Wilson the open end of a baffle member formed to a cup shaped configuration surrounds the disk rim between two adjacent blade roots. The base of the cup contacts the undersides of two adjacent blade platforms and absorbs vibrational energy imparted to it by the blade platforms. The sides of the cup contact the neck extensions of the two adjacent blades thereby substantially filling the axial cavity.

Suter also discloses a vibration damper which simultaneously fills the axial cavity while damping blade vibration. Although the dampers described in Wilson and Suter substantially fill the axial cavity, apparatus for sealing the axial interface between the damper and the blade root is not provided. Similarly, in the constructions of Suter and Wilson the interface between the turbine blade roots and the disk remains unsealed thereby permitting the escape of working medium from the main flow path.

The addition of conventional annular sideplates to the wheel assemblies of Suter and Wilson for the purpose of covering the described interfaces results in a wheel assembly that is subject to the same limitations described with respect to the Damlis construction. As the size of gas turbine engines continues to increase, the larger wheel diameters are making it increasingly impractical to hold wide sideplates in surface contact with the disk and methods are necessary to appropriately secure the seal members to the turbine wheel at the blade roots.

SUMMARY OF THE INVENTION

A primary object of the present invention is to prevent leakage of working medium in the axial direction across a turbine wheel assembly and to prevent the flow of hot gases against the disk rim. An additional object of the present invention is to provide damping of tangential vibrations in the blades of a turbine.

According to the present invention a sideplate affixed to a turbine disk covers the roots of the turbine blades to prevent leakage of working medium from the main flow path through the interface between the roots and the disk, and a seal plate which is responsive to centrifugal force closes off one side of the cavity formed between two adjacent turbine blades to prevent the leakage of working medium through the cavity; a vibration damper located in the cavity has a pair of sealing surfaces, each surface in contact with the underside of the platform of one of the two adjacent blades, to prevent the flow of working medium against the rim of the disk and impart friction forces to the blades to dissipate blade vibration. In accordance with a specific embodiment of the invention a support section extends from each seal plate into the damper cavity and has an inclined surface extending from the seal plate in a direction away from the engine centerline and each vibration damper has a corresponding sloped surface; during rotation of the engine the inclined surface of the seal plate and the sloped surface of the vibration damper are engaged by centrifugal forces which drive the seal plate in a direction parallel to the sloped surface of the vibration damper until the seal plate abuts the disk and the neck extensions of the two adjacent blades.

Primary features of the present invention are the individual seal plates which cover the vibration damper cavities and the annular sideplates having a short radial width which is sufficient to cover the interface between the turbine blade root and the disk. In one embodiment each seal plate has an inclined surface which, under centrifugal loading conditions, cooperates with a correspondingly sloped surface on the vibration damper to drive the seal plate against the surface of the turbine disk and the neck extensions of two adjacent blades. A pair of sealing surfaces on each blade vibration damper form a radial seal in the gap between against blade platforms, each sealing surface contacting the underside of the platform of one of the adjacent blades. An end plate extension on the vibration damper is driven against the surface of the turbine disk and the neck extensions of the two adjacent blades.

A principal advantage of the present invention is a reduction in a quantity of working medium leaking across the wheel assembly. Also the wheel construction in accordance with the present invention results in a significantly reduced mass at the outer diameter of the sideplates. Relative movement between the damper and the seal plate along the slope surface of the damper is encouraged by vibrations of the damper which interrupt the friction forces at the interface between the damper and the seal plate.

The foregoing and other objects, features and advantages of the present invention will become more apparent in the light of the following detailed description of the preferred embodiments thereof as illustrated in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a partially broken away rear elevation view of a portion of a turbine wheel assembly showing apparatus for axially sealing the vibration damper cavity and the interface between the blade root and the disk;

FIG. **2** is a section view taken along the line **2—2** as shown in FIG. **1**;

FIG. **3** is a perspective view of the seal plate which is shown in cross section in FIG. **2**;

FIG. **4** is a perspective view of the vibration damper which is shown in cross section in FIG. **2**; and

FIG. **5** is a section view corresponding to FIG. **2** showing alternate apparatus for axially sealing the vibration damper cavity.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** shows a turbine wheel assembly **10** including a disk **12** having a rim **14** and a plurality of fir tree type connecting slots **16** each of which engages a correspondingly shaped root **18** of a blade **20.** Each blade has a platform section **22** spaced apart from the root by a neck extention **24.** The neck extensions of two adjacent blades form the sidewalls **26** of an axially oriented damper cavity **28.** The rim forms the inner wall of the cavity and the undersides **30** of the platforms of the two adjacent blades form the outer wall of the cavity. As shown in FIG. **2,** the end walls of the damper cavity are formed by a seal plate **32** on the low pressure side of the wheel assembly and by an end plate extension **34** of a vibration damper **36** on the high pressure side of the wheel assembly. As shown in FIG. **3** the seal plate **32** includes a support section **38** having an inclined surface **40** extending from the seal plate in a direction away from the axis of rotation of the wheel assembly. The vibration damper has a sloped surface **42** which is essentially parallel to the inclined surface of the seal plate and a pair of platform sealing surfaces **44** as shown in FIG. **4.** A low pressure sideplate **46** having a long offset **48** which extends around its circumference is bolted to a low pressure face **50** of the disk and traps the seal plate between the low pressure sideplate and the disk. Similarly, a high pressure sideplate **52** having a short offset **54** which extends around its circumference is bolted to a high pressure face **56** of the disk and traps the end plate of the vibration damper between the high pressure sideplate and the disk as is shown in FIG. **2.**

To assemble the turbine wheel, the root of each blade is inserted into a fir tree shaped slot in the disk and a seal plate is positioned against the disk between two adjacent blades with the support section **38** extending into the damper cavity **28.** With all the blades and seal plates in position the low pressure sideplate **46** is affixed to the disk trapping the seal plates on the wheel assembly between the long offset **48** on the sideplate and the low pressure face of the disk. The seal plates are adjusted to a lowered position as represented by the dotted line in FIG. **2,** and a vibration damper **36** is inserted into each damper cavity. A high pressure sideplate **52** is affixed to the disk trapping the end plate extensions **34** of the vibration dampers between the short offset **54** on the sideplate and the high pressure face of the disk. Both the seal plate and the vibration damper are free to move axially and radially within limits permitted by the turbine blades, the disk and the sideplates as shown in FIG. **2.**

During operation of the gas turbine engine, centrifugal loads force the individual components radially away from the axis of rotation. Each turbine blade is restrained by the disk slot and each vibration damper is restrained by the blade platforms. The sloped surface **42** of each vibration damper engages and restrains the seal plate as the plate tends to move radially.

Each turbine blade has sufficient clearance between the blade root and the disk slot to allow limited tangential or circumferential movement of the blade when vibrationally excited. During a period of vibrational excitation, the movement of the blade is resisted by the dampers, which under the influence of centrifugal force, bear against the underside of the platform of the excited blade as well as the undersides of the next adjacent blade platforms. Frictional forces at the points of contact between the dampers and the blade platforms are energy dissipative and reduce the detrimental effects of blade vibration. The seal plate bears upon the vibration damper and effectively increases the mass of the damper with a corresponding increase in the damping effects. The sealing surfaces **44** on the vibration damper bear against the undersides of the two adjacent turbine blades to effect a radial seal between the platforms of two adjacent blades and to prevent the circulation working medium, which is comprised of hot gases from the main flow path, against the rim of the disk.

The centrifugal force due to each seal plate during rotation is transferred to the corresponding vibration damper across the slope surface **42.** The force has a component which tends to draw the seal plate and the vibration damper together until the seal plate and the end plate extension **34** on the vibration damper abut the low and high pressure faces respectively of the disk. When the sloped surface of the vibration damper and inclined surface of the seal plate are in contact friction forces resist their relative movement. However, as the damper vibrates the contact is interrupted thereby reducing the frictional resistance and permitting the seal plate and damper to reposition by sliding.

The high and low pressure sideplates, acting in a conventional manner, seal the interfaces between the turbine blade roots and the disk.

The alternative embodiment shown in FIG. **5** incorporates seal plates on both the high and low pressure sides of the wheel assembly. An independent vibration damper **58** having a pair of sloped surfaces **60** is located within the damper cavity. A pair of the seal plates **32** engage the damper, the inclined surface **38** of each seal plate engaging the correspondingly sloped surface on the damper.

The seal plates on the high and low pressure sides of the disk are drawn toward the vibration damper **58** by the axial components of centrifugally generated forces. The embodiment of FIG. **5** is particularly attractive where the movement of the damper within the cavity due to vibration is excessive and where such movement would detrimentally increase the amount of working medium leaking between the end plate extension of the vibration damper and the high pressure face of the disk.

Although the contact between the seal plate and the vibration damper has been described with respect to engaged surfaces a construction where the contact is at a point meeting an inclined surface is equally effective. For example, an embodiment of the invention may include a protrusion extending from the inclined surface **40** of the seal plate shown in FIG. **3**, the protrusion bearing upon the sloped surface of the vibration damper.

The sideplates of the present invention have a greatly reduced radial width. Conventional sideplates require sufficient mass at their outer diameter to resist thermal distortion as the sideplates are subjected to unequally distributed temperatures. The seal plates which cover only a local area are not subjected to the severe temperature gradients and may, therefore, be fabricated from material having a lesser thickness while experiencing less thermal distortion.

The axial forces generated by the seal plate during rotation are sufficient to hold the seal plate and the end plate extension of the vibration damper in surface contact with the turbine disk and the turbine blade roots, precluding a requirement for additional attaching members.

Although the invention has been described with respect to an axially oriented damper cavity the concepts disclosed equally apply where the cavity is oriented diagonal to the axis of the turbine wheel.

It should be understood by those skilled in the art that the foregoing and other changes and omissions in the form and detail thereof can be made therein without departing from the spirit and the scope of the invention.

Having thus described a typical embodiment of our invention, that which we claim as new and desire to secure by Letters Patent of the United States is:

1. In a gas turbine having an axis of rotation, a wheel assembly comprising:

- a turbine disk having a circumferentially extending rim with root connecting means spaced along the rim and first and second faces which are substantially perpendicular to the axis of rotation;
- a plurality of turbine blades extending radially from the disk, each blade having a root which engages the root connecting means and a platform spaced apart radially from the root by a neck extension;
- a plurality of seal plates, each of which abuts the first face of the disk at the rim and the neck extensions of two adjacent turbine blades and has a support section extending between the neck extensions of the adjacent blades;
- a plurality of vibration dampers each of which is located between the neck extensions of two adjacent blades in a position radially outward from the support of the seal plate, and has a sloped surface facing, and in contact with, the support section of the seal plate which is urged against the first face of the disk by axial components of centrifugal loads during rotation of the wheel assembly;
- a first sideplate which is in surface contact with the first face of the disk and covers the root portions of a plurality of turbine blades; and
- a second sideplate which is in surface contact with the second face of the disk and covers the root portions of a plurality of turbine blades.

2. The invention according to claim **1** wherein the support section has an inclined surface substantially parallel to, and in contact with, the sloped surface of the vibration damper.

3. The invention according to claim **1** wherein the vibration damper further has an end plate extension which abuts the second face of the disk at the rim and the neck extensions of the two adjacent blades, and a pair of sealing surfaces, each of which is in contact with the undersurface of the platform of one of the adjacent blades, whereby the end plate extension of the vibration damper is urged against the second face of the disk by axial components of centrifugal loads during rotation of the wheel assembly and whereby the sealing surfaces of the vibration damper are held in contact with the platforms by radial components of centrifugal loads.

4. The invention according to claim **1** wherein the first sideplate has a circumferential offset at its periphery which engages and retains the seal plates between the offset and the first face of the disk.

5. The invention according to claim **1** wherein the second sideplate has a circumferential offset at its periphery which engages and retains the vibration dampers between the offset and the second face of the disk.

6. In a gas turbine engine having an axis of rotation, a wheel assembly of the type wherein a plurality of blades is attached to a turbine disk and extend radially from the disk, the disk having a face which is substantially perpendicular to the axis of rotation and a circumferentially extending rim with root connecting means spaced about the rim, and each blade having a root which engages the root connecting means of the disk and a blade platform joined to the root by a neck extension, and wherein a plurality of seal plates is held in contact with the disk face and the neck extensions of two adjacent blades to prevent the leakage of working medium in the axial direction across the wheel assembly, the improvement which comprises:

- means responsive to centrifugal force to urge each seal plate against the face of the disk and to damp vibration in the blades.

7. The invention according to claim **6** wherein the means responsive to centrifugal force comprises:

- a support which is integral with the seal plate, extends axially between the neck extensions of two adjacent blades, and has a surface which extends from the seal plate and is inclined in a direction away from the axis of rotation; and
- a vibration damper which is axially restrained by the disk and has a sloped surface substantially parallel to, and in contact with, the inclined surface of the seal plate.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,887,298

DATED : June 3, 1975

INVENTOR(S) : John R. Hess and Joseph R. Kozlin

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 38, before the word "It" insert --Although the invention has been shown and described with respect to the preferred embodiments thereof,--

Signed and Sealed this

seventh **Day of** *October 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks