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Schaller et al.

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[54] **CERAMIC INSULATOR FOR A GAS TURBINE BLADE STRUCTURE**

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[52] **U.S. Cl.** ..... **415/214,** 415/217, 415/219 R

[51] **Int. Cl.** **F01d 9/02**

[58] **Field of Search** ..... 415/200, 214, 216, 217, 415/219 R, 218

[56] **References Cited**

UNITED STATES PATENTS

2,341,664	2/1944	Schutte	415/214
2,497,041	2/1950	Bodger	415/214
2,855,179	10/1958	Brown	415/214
2,937,805	5/1960	Warnken	415/214
3,118,593	1/1964	Robinson et al.	415/214
3,635,577	1/1972	Dee	415/214

FOREIGN PATENTS OR APPLICATIONS

723,505	2/1955	Great Britain	415/214

OTHER PUBLICATIONS

Publication; "Ceramics"-Key to the Hot Turbine Gas Turbine International, Jan.-Feb. 1973, pages 30-36.

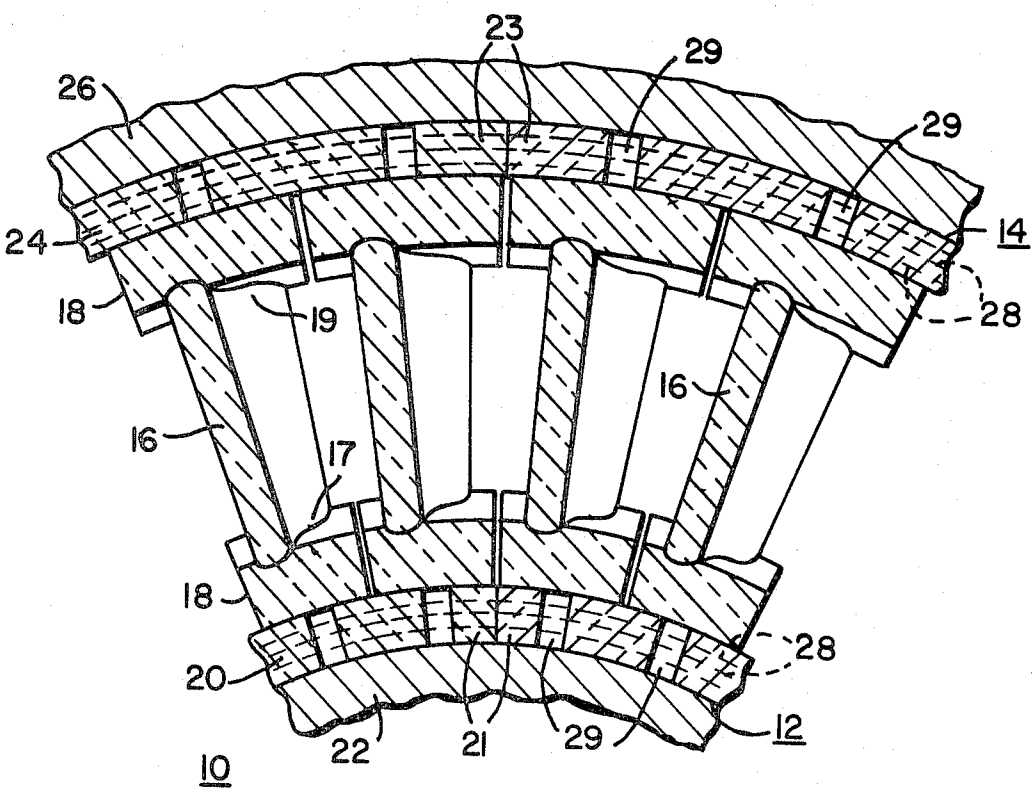
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[57] **ABSTRACT**

A stationary ceramic three-piece blade structure for gas turbines has an annularly shaped ceramic insulator disposed on its outer periphery. An annularly shaped ceramic insulator is disposed on the inner side of the inner periphery of the blade structure. The ceramic insulators maintain required heat patterns within the three-piece ceramic blade members. The ceramic insulators also prevent heat and thermal gradients from damaging the three piece stationary blade structure and the metal members which surround and support the stationary blade structure in the turbine.

2 Claims, 4 Drawing Figures



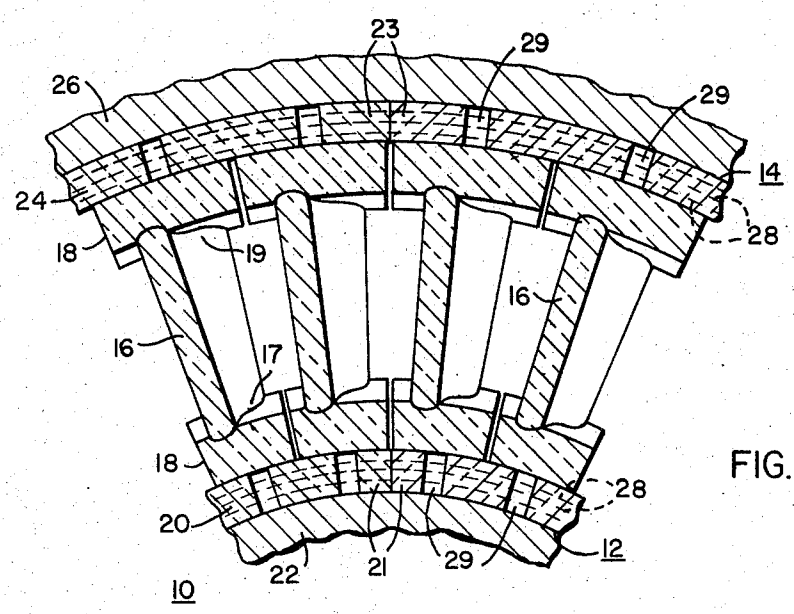

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FIG.1

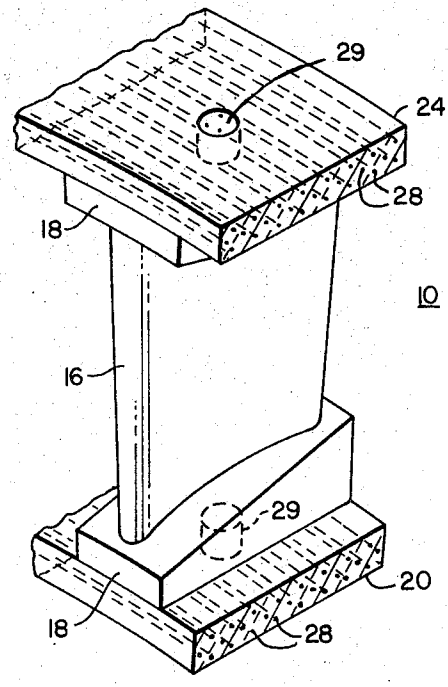

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FIG.2

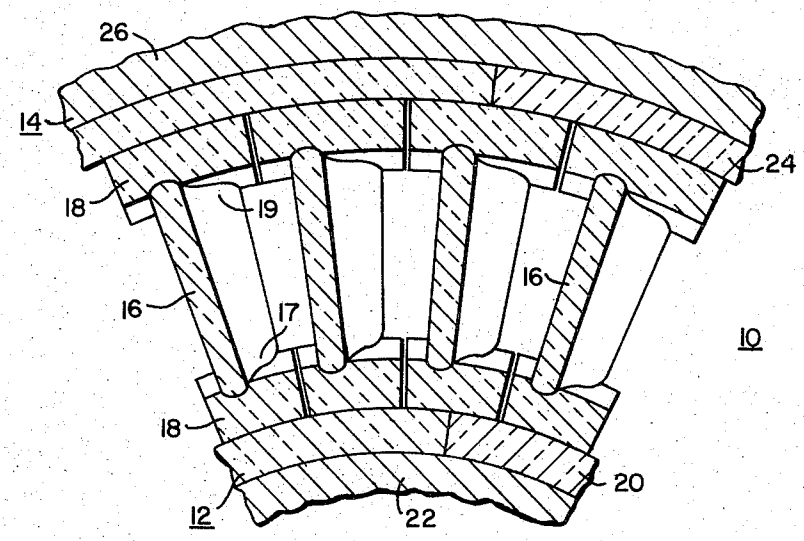


FIG.3

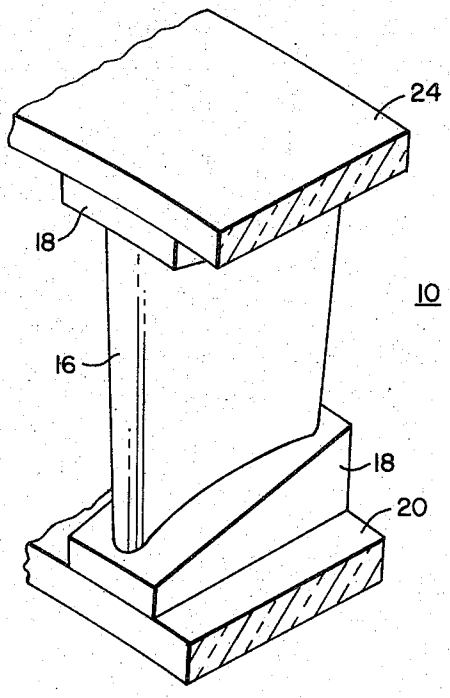


FIG.4

CERAMIC INSULATOR FOR A GAS TURBINE BLADE STRUCTURE

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

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to gas turbines, and more particularly to ceramic insulators disposed about a plurality of radially directed stationary ceramic three-piece blade structures in a gas turbine for reducing any damaging properties of heat that may effect the blade structures, and their metal support members.

2. Description of the Prior Art

The efficiency of gas turbines can be increased markedly over present turbomachines, by increasing the hot motive fluid working temperature. To operate at high temperatures; however, components within and surrounding the hot motive fluid flow path, must be able to withstand very high temperatures. These temperatures are in the vicinity of 2,500°F. Turbine designers have created turbine blades using ceramic materials which can withstand this high temperature. Supporting end caps of ceramic material are also necessary to withstand the high temperatures and to maintain the ceramic blades in place. However, these ceramic end caps do not provide enough insulation to prevent the high temperatures of the motive fluid from effecting the surrounding metal components, and some means is also needed to prevent large thermal gradients from damaging the end caps themselves. Cooling air, at temperatures of 650°F, for cooling the supporting metal structure, is used to reduce the damaging effects of the heat emanating from the hot motive fluid flow path. This means a temperature drop of 1,850°F between the inside hot face of the supporting ceramic end caps and the adjacent metal structure in which the end caps are supported. Severe thermal distortions will take place in the end caps, due to the high linear and non-linear thermal gradients within the end caps. The supporting elements will also be affected by the high temperatures and non-linear thermal gradients. The high temperatures and thermal distortions will cause the metal components near the hot motive fluid path to have a short life.

Accordingly, it is one object of the present invention to provide a novel and improved insulating structure around the ceramic blades in a gas turbine.

It is another object of the invention to provide a novel and improved structure for maintaining metal components near the hot motive fluid path at lower temperatures and in a non-distorted state.

Accordingly, it is one object of the present invention to provide a novel and improved insulating structure around the ceramic blades in a gas turbine.

It is another object of the invention to provide a novel and improved structure for maintaining metal components of gas turbine at lower temperatures and in a non-distorted state.

SUMMARY OF THE INVENTION

In accordance with this invention, the turbine is provided with an annular row of ceramic blades, each blade having ceramic inner and ceramic outer supporting end caps, and a metal shroud structure supporting the end cap members. The shroud structure consists of an annular series of arcuate segments which are on the outermost portion of the radially outward end caps and an annular series of arcuate segments which are on the innermost portion of the radially inward end caps. The shroud members are arranged in end-to-end abutment with each other. An insulating member is disposed on the blade side of each inner and outer shroud and adjacent the shrouds. The insulating member which is made from a ceramic insulating material may be comprised of a generally uniform ceramic material, or it may have a directionally oriented fibrous ceramic material interwoven within the ceramic body insulator member. The ceramic insulator is actually a portion of the shroud. The ceramic material insulator portion of the shroud member has low thermal conductivity compared to the thermal conductivity of the ceramic blades and the supporting ceramic end caps.

The temperature drop across the ceramic insulator is large, and therefore it will extend the life of the ceramic end caps and blades by minimizing non-linear thermal gradients within the blades and caps and it will extend the life of the supporting metal shrouds and turbine components disposed about the ceramic insulator in the gas turbine by reducing the heat flow to those components.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference may be had to the following drawings for a better understanding of the nature and the objects of the invention, in which:

FIG. 1 is a radial sectional view of a portion of an inner and an outer shroud comprising fibrous ceramic insulators, with a plurality of ceramic blades and supporting end caps therebetween, constructed according to the principles of this invention; and,

FIG. 2 is a view in perspective, of a portion of a bladed structure showing the fibrous ceramic insulators.

FIG. 3 is a radial sectional view similar to FIG. 1 showing the invention using solid ceramic insulators.

FIG. 4 is a view similar to FIG. 2 showing the invention using solid ceramic insulators.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings in detail, and particularly to FIG. 1, there is shown a portion of a turbine diaphragm structure **10**, comprising an annularly disposed inner shroud member **12**, an annularly disposed outer shroud member **14**, and a plurality of radially extending stationary ceramic blades **16**, each blade having a radially inner end **17** and a radially outer end **19**, supported and disposed therebetween. Although the entire diaphragm structure **10** is not shown, it will be understood that the shroud members, **12** and **14**, are of circular cross section, and the blades **16** are arranged in an annular circumferential array between the inner and outer shroud members.

The ceramic blades **16** each have a ceramic supporting end cap **18** at both their radially inner end **17** and their radially outer end **19**. A ceramic insulator **20** is annularly disposed radially inwardly of the inner ceramic end caps **18**, between the inner end cap **18** and a metal portion **22** of the inner shroud member **12**. The overall inner ceramic insulator **20** may comprise a plurality of arcuate segments **21** in end to end abutment with each other, while still maintaining their circumferential disposition. The arrangement of the outer shroud member **14** may be the same as that for the inner shroud member **12**. A ceramic insulator **24** is annularly

disposed radially outwardly of the outer ceramic end caps **18.** The overall outer ceramic insulator **24** may also comprise a plurality of arcuate segments **23** in end to end abutment with each other, while still maintaining their circumferential disposition. The outer ceramic insulator **24** is disposed between the outer end caps **18** and a metal portion **26** of the outer shroud **14.**

One embodiment of the ceramic insulators, **20** and **24,** comprises a ceramic fiber **28,** interwoven within the ceramic insulator members, **20** and **24,** as shown in FIGS. **1** and **2.** The ceramic fiber **28** may be comprised of zirconium oxide, fused quartz or fused silica. The ceramic fiber **28** reinforces the ceramic insulators **20** and **24,** and/or the ceramic fiber **28** may give a directional preference to certain properties of the ceramic material. For example, the ceramic fiber **28** may have a specific weave to give the insulator members, **20** and **24,** a low thermal conductivity in the radial direction thereby causing a reduction in the heat loss from the hot motive fluid flow path, and also causing a reduction in the thermal gradients across the end caps **18** that support the ceramic blades **16.** Additionally, a ceramic fiber **28** interwoven within the ceramic insulators, **20** and **24,** would allow the insulators, **20** and **24,** to be more compatible to thermal distortions than would a solid insulator, and therefore, would be less susceptible to thermal bending stresses.

As also shown more clearly in FIG. **2,** a hole **29** is disposed within the insulators, **20** and **24,** radially inwardly of and radially outwardly of each of the end caps **18,** as part of an arrangement for providing a compressive force upon the ceramic blade **16** and the ceramic end caps **18.** Holes **29** that are disposed in the ceramic insulator members, **20** and **24,** that have a fibrous ceramic material **28** interwoven therein, are not as critical from a point of view of stress concentrations as are solid ceramic insulator members, **20** and **24,** without any ceramic fiber **28** woven therein, as shown in FIGS. **3** and **4.**

The diaphragm structure **10,** shown in FIGS. **3** and **4,** is similar to the diaphragm structure **10** shown in FIGS. **1** and **2,** except that the FIGS. **3** and **4** show insulators, **20** and **24,** that do not include any fibrous ceramic **28** therein; that is, they are generally a solid uniform ceramic. The embodiment shown in FIGS. **3** and **4** also do not have holes in the insulators, **20** and **24.** The solid non-fibrous ceramic insulators **20** and **24** may be comprised of lithium aluminum silicate. The non-fibrous insulators, **20** and **24,** are characterized by low thermal stresses, high wear resistance and load bearing capabilities.

The purpose of the fibrous or solid non-fibrous ceramic insulator members, **20** and **24,** is however, to provide a large temperature drop between each ceramic end cap **18** and the metal portions, **22** and **26,** of the inner and outer shroud members, **12** and **14.** A large temperature drop is required because the stationary ceramic blades **16** and the ceramic end caps **18** may be constructed from silicon carbide, SiC, or silicon nitride, Si_3N_4, both of which have a thermal conductivity (K) of about 10 to 65 BTU/hr.-ft.-F°, for a temperature range from 2,500°F down to ambient temperature. Temperatures of about 2,500°F will be necessary in the stationary inlet vanes of gas turbines if they are to achieve a high efficiency and power output. Without an insulator on the radially inner and radially outer side of each radially inner and radially outer end cap, **18** respectively, the ceramic end caps **18** would be subject to a gas temperature of about 2,500°F on their side nearest the hot motive fluid flow path, and to a temperature of about 650°F caused by cooling air impinging upon their side radially furthermost from the hot motive fluid flow path. A temperature drop of 1,850°F across the ceramic end caps **18** would result in severe thermal distortions and large steady state and transient thermal stresses within the ceramic end caps **18.** Also large bending stresses would occur in the ceramic end caps **18** if the temperature gradient across them were non-linear, which is the situation for both the transient and the steady state turbine operation. The metal shroud members, **22** and **26,** adjacent the ceramic end caps **18** would be subject to high temperatures, thermal distortions and bending stresses were it not for the disposition of ceramic insulators, **20** and **24,** therebetween, having low thermal conductivity. The ceramic insulators, **20** and **24,** prevent high thermal gradients from extending across the end caps **18,** and the ceramic insulators, **20** and **24,** prevent damaging temperatures within the metal portions, **22** and **26,** of the surrounding shroud members **12** and **14.**

Since numerous changes may be made in the above-described construction, and different embodiments may be made without departing from the spirit and scope thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

We claim:

1. A hot elastic fluid stator blade construction for a gas turbine, comprising a plurality of radially directed stationary ceramic blades disposed across an annularly shaped hot fluid flow path, each of said stationary ceramic blades being supported on their radially inner ends by a ceramic inner end cap, each of said stationary ceramic blades being supported on their radially outer ends by a ceramic outer end cap, said ceramic outer end caps defining a portion of the radially outer surface of said annularly shaped hot fluid flow path, said inner ceramic end caps defining a portion of the radially inner surface of said annularly shaped hot fluid flow path, and an arcuately shaped ceramic insulator disposed on the radially outer side of said outer ceramic end caps, and an arcuately shaped ceramic insulator disposed on the radially inner side of the inner ceramic end caps, said ceramic insulators preventing damage to said end caps from thermal distortion caused by uneven temperature distribution therein, said ceramic insulators having a woven fibrous ceramic material disposed therein.

2. A hot elastic fluid stator blade construction as recited in claim **1,** wherein said woven fibrous ceramic material has a directed orientation within said ceramic insulators to reduce thermal conductivity through the ceramic insulators in the radial direction, and to add structural strength to the ceramic insulators.

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