United States Patent

[11] 3,574,481

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[54] **VARIABLE AREA COOLED AIRFOIL CONSTRUCTION FOR GAS TURBINES**
3 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **416/90,** 416/97
[51] **Int. Cl.** **F01d 5/18**
[50] **Field of Search** ..... 253/39.1 (B), 39.15 (B); 416/95—97, 90

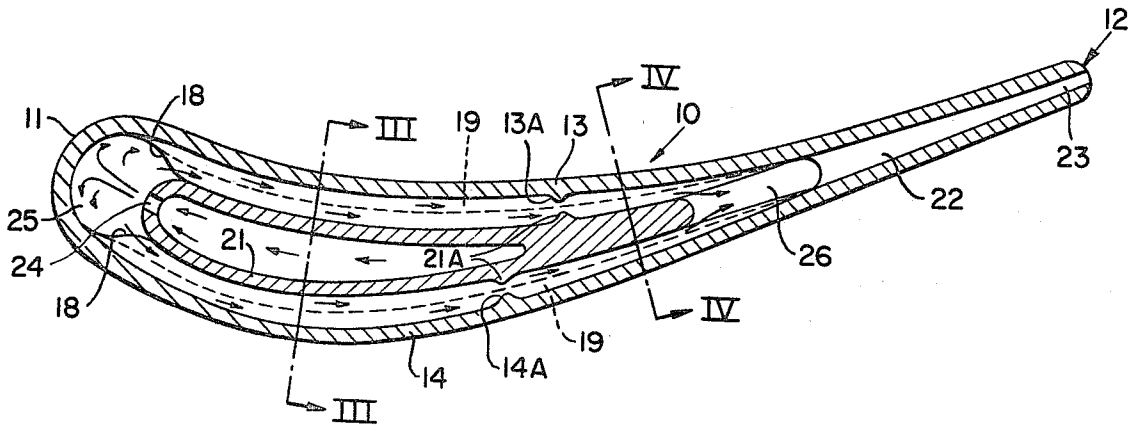
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ABSTRACT: A cooled airfoil for gas turbines having a hollow airfoil-shaped body with an impingement tube disposed therein in spaced relation to the sidewalls. Such tube receives a cooling medium and is formed with openings disposed to direct the cooling medium against the inner surface of the leading edge wall. The inner surfaces of the body sidewalls have heat dissipating fins substantially engaging the impingement tube to provide passages extending chordwise of the airfoil to conduct the cooling medium to the rear where it is vented through openings in the airfoil trailing edge. The passage forming fins may be variably spaced and of variable height to vary the cooling medium flow area at predetermined variable height to vary the cooling medium flow area at predetermined regions of the airfoil sidewalls, and other fins of predetermined variable height may be provided in the passages to effect differential cooling effects as required by the temperatures to which different portions of the airfoil are exposed.



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SHEET 1 OF 2

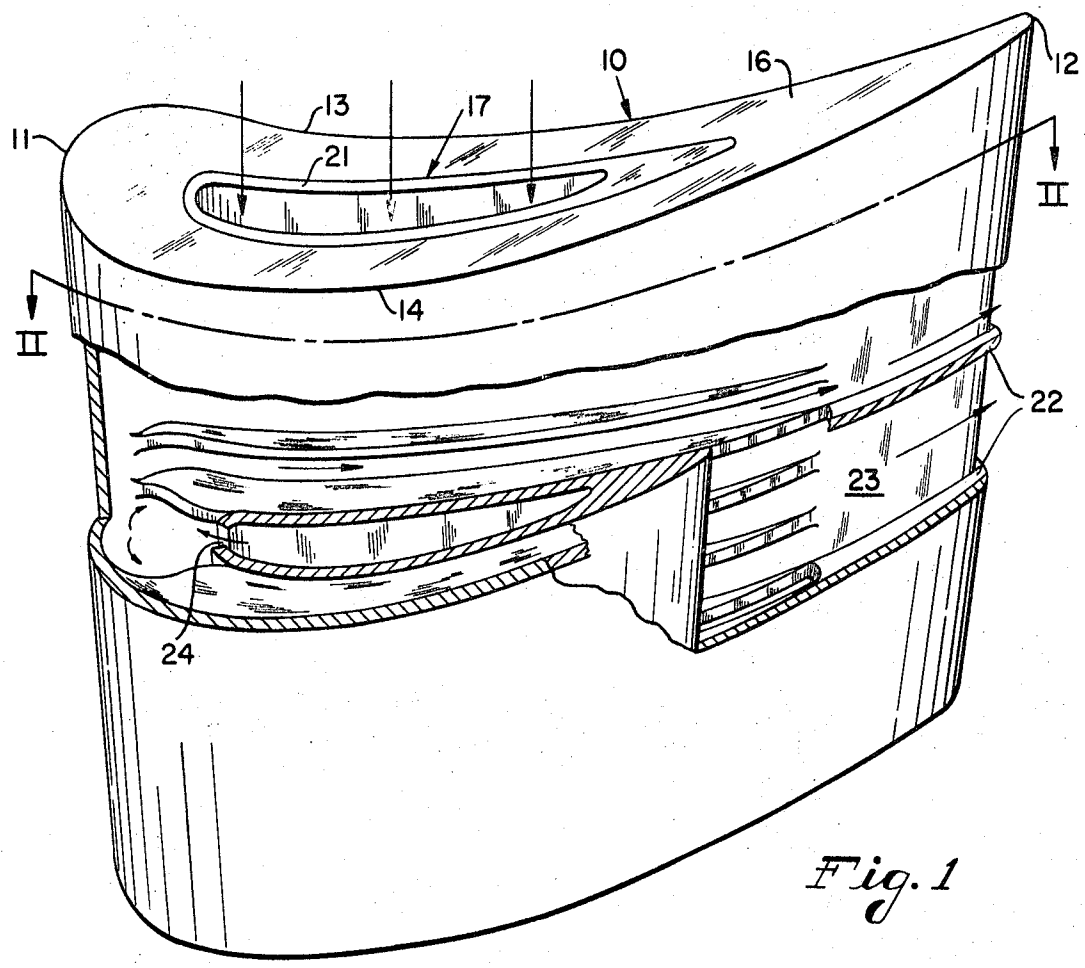


Fig. 1

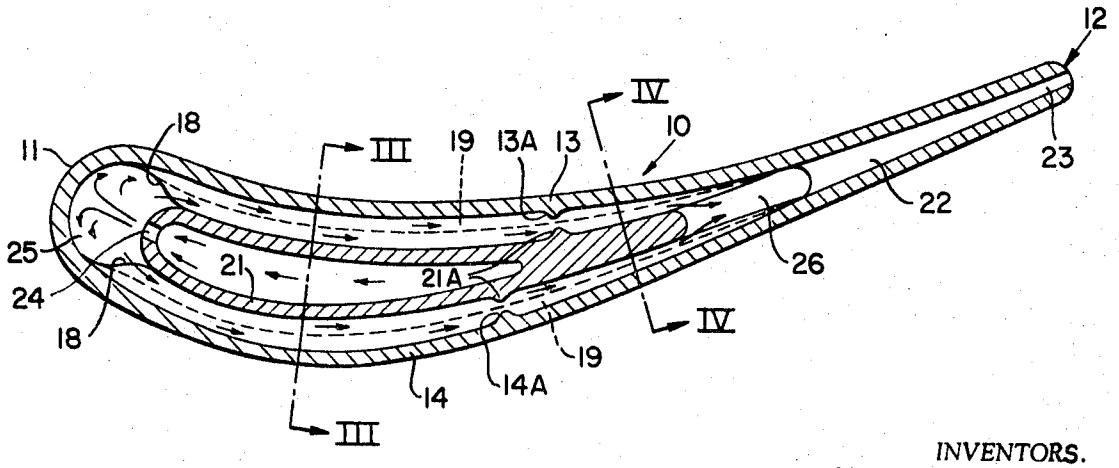


Fig. 2

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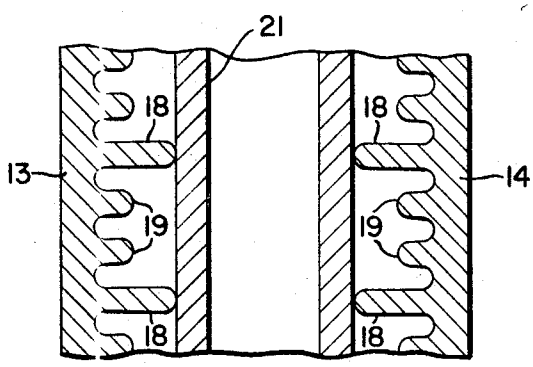


Fig. 3

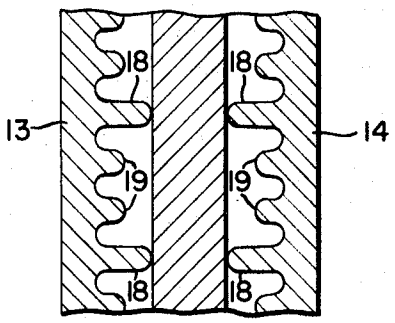


Fig. 4

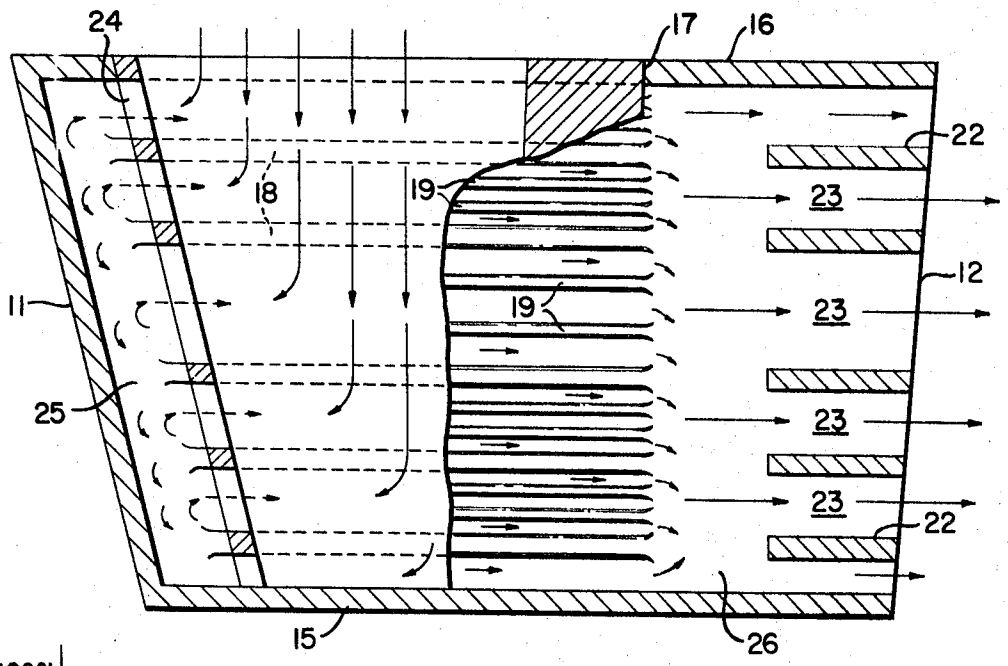


Fig. 5

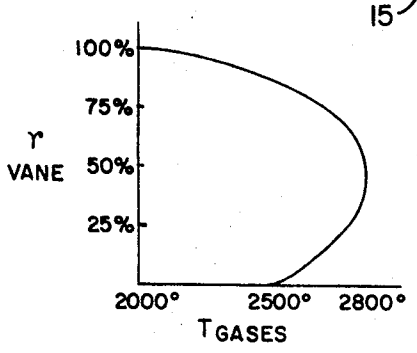


Fig. 6

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VARIABLE AREA COOLED AIRFOIL CONSTRUCTION FOR GAS TURBINES

SUMMARY

This invention relates generally to gas turbines. It is more particularly directed to the construction of blades or vanes for use in gas turbines designed for operation at higher than conventional temperatures, the airfoils being adapted to receive a cooling medium and to use it more efficiently than blades or vanes heretofore proposed.

In a gas turbine, compressed air is supplied to and mixed with fuel in a combustor where it is then burned to generate hot gases which are directed against and expanded in turbine wheels to effect engine operation. As is well-known in the art, engine operating power and efficiency are dependent, in part, on gas temperature and are improved with increases therein. One of the limiting factors in turbine engine design is the ability of materials comprising engine components to withstand such high temperatures. An object of this invention is to provide a vane or blade construction which will increase the life of engines constructed of presently available materials. This end is secured by forming a vane or blade with a unique cooling system which will remove heat from portions of the structure exposed to the highest temperatures to provide more uniform and compatible metal temperatures.

This invention utilizes a cooling scheme in which a gas turbine vane or blade construction is provided wherein a hollow airfoil-shaped body has leading and trailing edges connected by curved sides, the interior of the body receiving a similarly shaped impingement tube to which a cooling medium under pressure is supplied, the tube having outlet means for impinging a stream of the cooling medium against the inner surface of the leading edge wall at the location exposed to the hot gases to effectively cool said wall.

It is an object of this invention to provide the curved sidewalls of the body mentioned in the preceding paragraph with fins on the inner surfaces thereof, the fins projecting inwardly to substantially contact the aforesaid impingement tube providing cooling medium passages in the space between the outer surface of the impingement tube and the inner surface of the blade or vane body sidewalls. These passages extend in a chordwise or front-to-rear direction, whereby the cooling medium, after impinging on the inner surface of the leading edge, will flow through the aforementioned passages which are connected with outlet openings or slots formed in the trailing edge of the vane.

The primary object of the invention is the variable area feature in which the inner surfaces of the sidewalls of the body of the airfoil are provided with additional fins between those forming the passages, the additional fins being of variable height and number selected to control the amount of heat removed from the sidewalls and maintain the metal temperature distribution as desired.

Other objects and advantages of the invention will be apparent from the following description of the embodiment of the invention selected for illustration in the accompanying drawings.

THE DRAWINGS

FIG. 1 is a perspective view of a cooled gas turbine inlet nozzle vane formed in accordance with the present invention, parts of the vane being broken away to show internal construction;

FIG. 2 is a horizontal sectional view taken on a plane indicated by the line II–II of FIG. 1;

FIGS. 3 and 4 are vertical sectional views taken through the vane on planes indicated by the lines III–III and IV–IV, respectively, of FIG. 2;

FIG. 5 is a typical schematic representing a passage arrangement and cooling medium flow therethrough; and

FIG. 6 is a graph showing a typical temperature profile of the gases flowing past a nozzle vane in a gas turbine engine.

DESCRIPTION

Reference to FIG. 1 of the drawings shows that the vane selected for illustration comprises an airfoil-shaped body **10** having a rounded leading edge **11**, a narrow trailing edge **12** and curved sides **13** and **14**. The vane illustrated in intended to be a stationary vane employed in the inlet nozzle of a gas turbine engine, substantially duplicate vanes being arranged in circularly spaced order to form the inlet to the gas turbine. Similar construction may be employed in the blades of turbine wheels if desired; however, the description herein relates primarily to inlet nozzle vanes. Such vanes may be formed in groups around a hub or they may be formed separately and secured to inner and outer rings in the formation of the turbine inlet.

The vane shown is hollow, as illustrated in FIG. 2, the leading leading edge and the sidewalls being variable but substantially equal to in thickness to provide the vane with an internal chamber. The trailing edge may have one of more openings formed therein, such opening or openings being of slotlike form and extending along the trailing edge. One end (in this instance, the bottom) of the vane may be closed by a wall **15** and the other end may have a wall **16** in which is formed an opening **17** having an outline corresponding substantially to the cross-sectional or airfoil shape of body **10**.

Internally, as shown in FIGS. **2**, **3** and **4**, the sidewalls of the body are provided with integrally formed fins **18** and **19**, these fins being spaced between the walls **15** and **16** of the vane and extending chordwise or from the front to back thereof. For the purposes of this description, the length of the fins means the measurement from front to rear of the vane; the thickness means the vertical dimension, as viewed in FIG. **3**, at right angles to the length; and the height of the fins means the distance they project from the wall of the vane inwardly thereof.

Certain fins, i.e., those identified by reference numeral **18**, are higher than the remainder and have their inner or extreme edges substantially registering with the longitudinal edges of the opening **17** in the top wall **16**. This opening and the spaces provided between the inner or extreme edges of the fins **18** receive in an insert or impingement tube **21** which is of irregular tubular form and corresponds substantially in cross-sectional configuration to the body **10**. This insert substantially engages the inner or extreme edges of fins **18** to form passages which extend from the forward end of the chamber to the rear portion of such chamber. The forward edge of the insert is spaced from the inner surface of the leading edge wall, and the rear edge of the insert is also spaced from the forward edge of one or more partitions **22** disposed between the sidewalls of the body **10** adjacent the trailing edge thereof. The spacing of the sidewalls of the body at the trailing edge forms one or more slots **23** establishing communication between the chamber in the body **10** and the main gas passage in the turbine. The purpose of these openings will be made apparent hereinafter. FIGS. **2**, **3** and **4** show that the fins **19** are of lesser height than the fins **18** and are disposed between the latter. They also extend chordwise or from front to rear of the body and may vary in thickness and height if found necessary.

FIGS. **1** and **2** show that the impingement tube insert **21** has one or more openings **24** in the forward edge to direct fluid under pressure supplied to the impingement tube insert toward the inner surface of the leading edge wall of the body. This fluid may be air or other cooling medium supplied from a suitable source to the insert. Such cooling medium impinges against the inner surface of the leading edge wall, thereby cooling said wall. The opening **24** may be in the form of a slot and is oriented to direct the cooling medium toward the portion of the leading edge wall exposed to the hottest gases used to effect the operation of the gas turbine. After impinging on the leading edge wall, the cooling medium divides and flows into the inlet ends of the cooling passages provided between the fins **18**, the sidewalls **13** and **14**, and the insert **21**.

The coolant flows in a chordwise direction, cooling the sidewalls of the body. To prevent overcooling some portions and undercooling other portions of the sidewalls, the spacing between adjoining fins may be varied. Fins height and thickness may also be varied, as shown by a comparison of FIGS. **2**, **3** and **4**, and if desired or found necessary, flow restriction rib means such as illustrated at **13A**, **14A** or **21A** may be formed on the sidewalls or insert walls, respectively. In this manner the flow of cooling medium may be varied as required. As shown in FIG. **2**, the fins on the inner wall of the body start near the leading edge of the body and fair into the sidewalls near the rear edge of the insert **21**. This construction provides manifolds **25** and **26** at the front and rear of the impingement tube insert. It should be noted that these manifolds are not a requisite of this invention, i.e., the fins need not fair into the sidewalls of the body.

FIG. **5** illustrates schematically the distribution of the cooling medium to the cooling passage and trailing edge discharge slots. This FIG. also illustrates that the spacing between the fins **18** may be a predetermined variable to define the cooling medium flow area as desired adjacent to selected portions of the sidewalls of the body. As illustrated by FIGS. **2**, **3** and **4**, the height of the pins **19** may be varied in relation to one another, as sell well as along the length of predetermined fins, to control the cooling effect. In this manner, the cooling requirements are met.

FIG. **6** shows graphically a typical temperature profile of the driving gases as they flow past a nozzle vane in one form of engine examined. This graph discloses that the highest temperatures are concentrated at a region between 40 and 70 percent of the radial length of the vane. The fins and flow varying ribs are therefore designed and arranged to effect the necessary cooling to maintain these portions of the vane at a temperature which is substantially equal to that of the other portions.

It should be obvious that both ends of the body **10** could be provided with openings **17** and both ends of the impingement tube insert **21** could be open if it is desired to supply the cooling medium from both ends of the said insert. It should be obvious also that the bottom end of the body could have an opening **17** and the insert **21** could be closed at this end. In addition, it should be obvious that either one or both manifolds **25** and **26** could be eliminated by extending the fins through said manifold in a manner such that the cooling passages communicate with the aforementioned discharge slots. Many other variations in construction and relation of parts could be employed without departing from the spirit of the invention.

We claim:

1. A cooled airfoil for gas turbines, comprising:

a. impervious body means forming an airfoil with a rounded leading edge, a relatively narrow trailing edge and curved sides connecting said edges, the body walls being of predetermined substantially uniform thickness and providing said airfoil with an internal chamber, the body having at least one outlet opening in the trailing edge;

b. tubular insert means of similar airfoil shape disposed in the internal chamber of said body for receiving a cooling medium under pressure, said tubular means having a slot in the forward wall adjacent the leading edge of the body means for directing a stream of cooling medium against the inner surface of the leading edge wall;

c. a first set of fins elements projecting from the inner surfaces of the body sidewalls into engagement with the outer surfaces of said tubular insert means, the fins of said first set extending transversely of the sidewalls and being spaced longitudinally of said body to form cooling fluid conducting passages extending chordwise of the airfoil to establish communication between the slot in the tubular means and the outlet opening in the trailing edge of the body means; and

d. a second set of fin elements projecting from the inner surfaces of the body sidewalls in the spaces between the fins of the first set, the fins of the second set terminating in spaced relation from the tubular means and being of variable height to form heat exchange surfaces of predetermined variable area disposed to provide a selected temperature distribution over the sidewalls of said body.

2. A cooled airfoil for gas turbines according to claim **1** in which the fin elements of both sets fair into the sidewalls adjacent the leading and trailing edges of the tubular insert means to form substantially continuous manifolds for the cooling medium at the inlet and outlet ends of said chordwise extending passages.

3. A cooled airfoil for gas turbines according to claim **2** in which flow-restricting means are provided on the opposed surfaces of the body and tubular insert walls to control the flow of cooling medium through the chordwise passages to increase heat exchange efficiency.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,574,481 Dated Apr. 13, 1971

Inventor(s) James A. Pyne, Jr. et al.

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

On the cover sheet insert -- [73] Assignee The Garret Corporation --.

Signed and sealed this 2nd day of May 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patent