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Frei et al.

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[54] **COOLED GUIDE BLADE FOR A GAS TURBINE**

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[52] **U.S. Cl.** **415/116,** 416/97, 415/178

[51] **Int. Cl.** **F04d 31/00,** F01d 5/08, F04d 29/58

[58] **Field of Search** 416/97, 95, 96; 415/115, 415/116, 117

[56] **References Cited**

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[57] **ABSTRACT**

The body of the blade is provided with a first coolant flow path at the front of the blade and a second tortuous coolant flow path behind the first flow path. Both flow paths terminate at the trailing edge of the blade. The first path is subjected to a low pressure drop and with a narrow cross-section allows the collant to flow through at high velocity to obtain a rapid heat transfer. The second path is also subjected to a low pressure drop, but with a larger cross-section in the middle part of the blade body and restrictors at the trailing edge, also allows discharge at high velocity.

8 Claims, 4 Drawing Figures

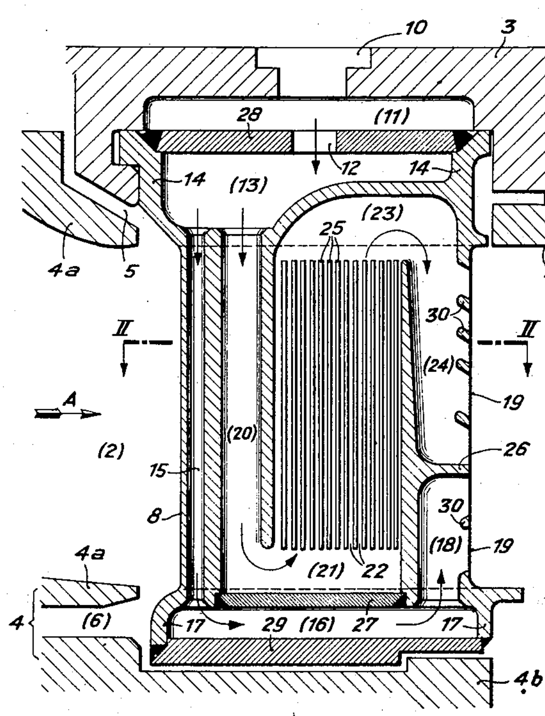


Fig. 1

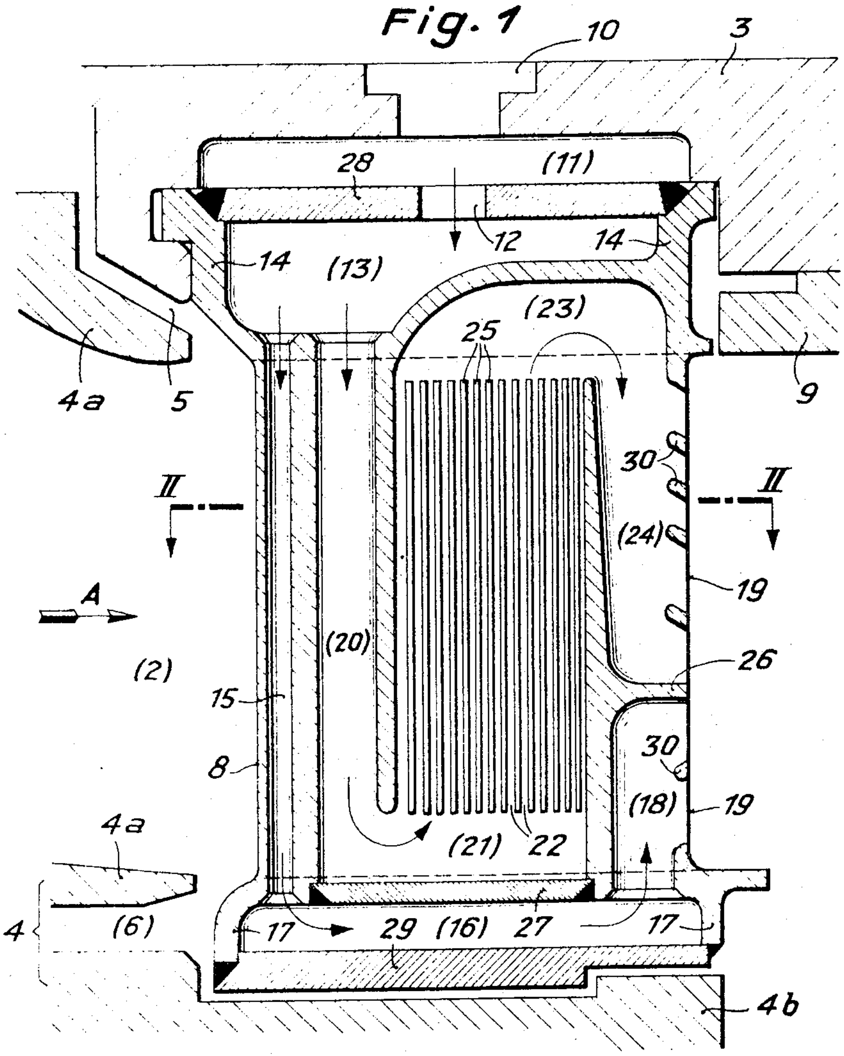


Fig. 2

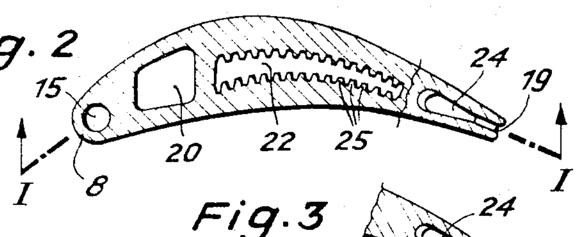


Fig. 3

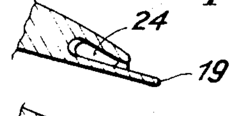
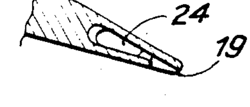


Fig. 4



COOLED GUIDE BLADE FOR A GAS TURBINE

This invention relates to a cooled guide blade for a gas turbine.

Generally, in order to achieve cooling of the gas blades, both guide blades and rotor blades, in an operating turbine, two contradictory conditions must be basically satisfied. First, good cooling requires high coefficients of heat transmission which, in turn, involve high flow velocities and relatively high pressure losses. Second, the amount of cooling air required by each blade should be as small as possible because the cooling air branched off, for example, from a compressor represents a loss in a certain sense and results in a deterioration of the efficiency of the entire process. Moreover, in practice it frequently occurs that the pressure gradient available between the cooling air entry into the blade and the cooling air exit from the blade is relatively low. Thus, the required velocities cannot be obtained or, if obtained because a high consumption of cooling air can be tolerated, is done only with difficulty.

In order to overcome these basic problems, it has been known to provide constructions in which the cooling air is passed once through the blade through a plurality of ducts radially of the machine from the interior to the exterior. The required velocities can be easily obtained with this system but require relatively large quantities of air. Moreover, the cooling capacity of the air in this system is only very incompletely utilized.

In other systems, one or more streams of cooling air are blown into the blade, generally through the blade root. The flows have then been branched and/or are repeatedly reversed before emerging from the blade through air exits which may be disposed in the blade front or tip and/or the blade root or in the trailing edge. If the flow ducts in these constructions are relatively narrow to achieve the necessary velocities, this will necessarily result in high pressure losses. This applies particularly to constructions in which the cooling air in the zone of the blade front or in the middle of the blade is fed into the blade root and is guided to the trailing edge after repeated reversals. In constructions in which the cooling air streams in the blade are branched through a perforated bulkhead, any defined distribution of branch flows can hardly be achieved, for example, because of uneven bulkhead perforations. Thus, in some circumstances, either specific parts receive only insufficient cooling or unnecessarily large quantities of cooling air are required.

Accordingly, it is an object of the invention to achieve optimum cooling of guide blades with a relatively low consumption of cooling air and a relatively low available pressure gradient.

It is another object of the invention to obtain high coefficients of heat transfer and intensive cooling actions in a guide blade of a gas turbine.

It is another object of the invention to provide a simple technique for cooling gas turbine blades.

It is another object of the invention to provide a guide blade for a gas turbine of relatively precise construction which can be easily and effectively cooled.

Briefly, the invention provides a guide blade for a gas turbine comprising a blade body having a blade front and a trailing edge with two separate flow paths in which a coolant flow is reversed at least once for cooling different portions of the blade. To this end, a first means defines a first flow path in the body immediately downstream of and parallel to the blade front. This first flow path includes at least two parallel portions to reverse the flow of coolant at least once and terminates in a first exit in or near to the trailing edge of the blade. In addition, a second means defines a second flow path in the body which includes at least two parallel portions to reverse a second flow of coolant at least once and also terminates in a second exit in or near to the trailing edge of the blade. Both flow paths emanate from a common pressure chamber in the blade body which is adapted to receive a supply of coolant, such as air while only the first flow path passes through a second pressure chamber on the opposite side of the body.

The respective pressure chambers can be defined in part by blade coverings or boundary jackets which extend outwardly from the blade front.

By contrast to previous constructions, the direct stream flowing in the longitudinal direction of the blade front not only cools the blade front because of its high velocity but is also utilized to absorb a substantial part of the heat on the trailing edge without the pressure losses becoming excessively high. This latter effect is due to the practically loss-free pressure chamber which is disposed between the blade front and air exit. It is also advantageous to proportion the blade height of the two air exits, given an at least approximately constant exit cross-section, so that the ratio of the relative proportions of blade height for the two air exits vary at least approximately relative to each other as the mount of air in the two flow paths.

By completely separating the two flow paths, a defined distribution of the cooling air flow rate over the two part flows is obtainable. This dispenses with the need to make unnecessarily large quantities of cooling air available to compensate for a fluctuating distribution over both flows. In constructional terms, defined distribution over the part flows may be achieved in known manner by the use of suitable restrictors in the air exits. Such restrictors may be varied to a certain extent and may be individually adjusted on the basis of tests in order to vary the distribution over a small range and, for example, to compensate for manufacturing inaccuracies.

The second flow path may be advantageously constructed to extend parallel to the first flow path with at least two reversals through 180° and to be practically free of pressure losses as far as the second reversal. The portions of the body which define this second flow path may also be provided with boundary walls on which fins are provided at least over a portion of the walls to project into the flow path. The purpose of this is to increase the cooled surface in the low-pressure loss zone of low flow velocity and thus to improve cooling thereat.

It is generally known that because of their higher mechanical strength, more particularly of the higher high-temperature strength, their materials and simpler method of production, or in the absence of the need for finish-machining, cast blades are preferred over forged and welded blades. The novel blade is therefore advantageously constructed so that the blade together with the blade coverings or boundary jackets of the pressure chambers is a precision casting. This casting can then be provided with a separating plate, as an insert, which is mounted in the casting in gas-tight manner, for example by welding, to separate the two flow paths from each other as well as with two cover plates which enclose the pressure chambers against the ambient zone.

If a plurality of individual blades are combined in known manner into a blade segment, the construction enables the entire blade segments, that is the blades of the segment and the jacket boundaries of the common external and internal pressure chambers to be integrally cast while a separate separating plate is provided for each blade and cover plates are provided which are common to the entire segment.

These and other objects and advantages of the invention will become more apparent from the following detailed description and appended claims taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates a longitudinal sectional view taken along line I—I of FIG. 2 of a guide blade according to the invention;

FIG. 2 illustrates a sectional view taken on line II—II of FIG. 1; and

FIGS. 3 and 4 each illustrates in the same manner as in FIG. 2 a detail of the trailing edge of a blade according to FIG. 1 but of different construction.

Referring to FIG. 1, the guide blade to which hot gases flow from the left (arrow A) as viewed, through a flow duct 2 from one or more combustion chambers (not shown) is retained in a guide blade support 3 within a gas turbine (not shown). The hot gas duct 2 is defined in the upstream direction by different parts of a hot gas casing 4 in which flow paths 5, 6 are provided for cooling the blade from the outside. These flow paths are adapted to conduct a coolant such as cooling air from an air receiver (not shown) which surrounds the guide blade support 3 along the inner and outer boundaries of the duct 2. The cooling air flow paths 5, 6 also cool the parts 4*a* of the hot gas casing 4 of high-temperature resistant materials and separate these parts 4*a* from another part 4*b* of the casing 4 which is not directly subjected to the hot gases or from the guide blade support 3. Both of these latter parts 4*b*, 3 are constructed of ferritic material having a lower high-temperature strength. Downstream of the illustrated guide blade, the guide blade support 3 is also protected against hot gases by a filler ring segment 9 which is also constructed of high-temperature resistant material. The cooling air for the blade first passes from the air receiver (not shown) through an aperture 10 in the blade support 3 into an intermediate chamber 11. The air then flows through an aperture 12 into a pressure chamber 13 which is disposed in an outer blade covering or boundary jacket 14.

As shown, the blade body has a blade front 8 facing the duct 2 and a trailing edge 19 disposed downstream of the blade front 8. In addition, two flow paths are defined by various means within the blade body. These flow paths serve to pass cooling air through the blade and extend from the pressure chamber 13. The first flow path leads into a second pressure chamber 16 through a relatively narrow duct 15 disposed immediately downstream of the blade front 8. The second pressure chamber 16 is shown disposed in an inner blade covering or boundary jacket 17. Air which passes through the first path leaves the pressure chamber 16, through which the air flows practically without pressure loss, and passes through an air exit 18 which extends over part of the blade height in the zone of the trailing edge 19. This air exit 18 may be disposed in the trailing edge itself as shown in FIG. 2 or may be disposed on the suction side (FIG. 3) or on the delivery side (FIG. 4) of the blade.

The second flow path extends parallel to the first flow path and includes a relatively wide duct 20 in the blade body which is connected via a reversal chamber 21 in which the flow passes through a first reversal of 180° to a duct 22 which is also relatively wide and is disposed in the middle part of the blade. The duct 22 communicates via a reversal chamber 23, of optimum construction for the flow because of the pressure loss, in which the flow passes through a further reversal of 180° to an air exit 24 which is also disposed in the zone of the trailing edge 19. This exit 24 is separated by a bulkhead 26 from the air exit 18 for the first flow path and fills the height of the blade 1 which is not covered by the exit 18. The air exit 24 may, of course, also be disposed in the trailing edge 19 itself or on the suction side or on the delivery side of the blade. In addition, the duct 22 is provided with fins 25 over the height of the opposed boundary walls to increase the heat dissipating surfaces.

The relatively low available pressure gradient between the pressure chamber 13 and the first duct 2 in the zone of the trailing edge 19 of the blade in the first flow path allows a relatively high velocity to be obtained in the arrow duct 15. This, therefore, allows a large coefficient of heat transfer and intensive cooling of the blade front 8 to be achieved. In a practical embodiment, approximately half the pressure gradient is utilized in this way. After flowing through the pressure chamber 16 practically without loss, the remaining positive pressure relative to the duct 2 results in high velocities in the air exit 18 and therefore in good cooling of part of the blade height in the zone of the trailing edge 19.

In the second flow path, the air enters the reversal chamber 23 with relatively low velocities and practically without pressure losses, that is, with the exception of the two reversals through 180°. The entire available pressure gradient is thus utilized to achieve the most uniform possible discharge at high velocities and corresponding good cooling of the trailing edge 19 over the remaining blade height in the zone of the air exit 24.

The flow resistances, which may be altered to a certain extent by modification of the fins 30 which act as restrictors and guide surfaces in the air exits 18 and 24, may be experimentally matched to each other in both flow paths so that the available amount of cooling air is distributed over both paths in a ratio which is at least approximately constant. This ratio will then also define the relative height of the bulkhead 26 by means of which the entire blade height is subdivided over the two air exits 18 and 24 approximately in the ratio of the part quantities, if the exit cross-section is approximately constant over the entire height.

By contrast to known constructions, subdivision of the amount of cooling air in an at least approximately constant ratio ensures reliable cooling of all blade parts in all cases with the lowest consumption of cooling air. Subdivision over two flow paths and loss-free flow over certain sections on these two paths provides high velocities in the other parts of the flow path even if the available pressure gradients are low. Accordingly, high coefficients of heat transfer and intensive cooling actions are obtained in these ranges. In terms of manufacture, the blade together with the coverings 14 and 17 can be made as a precision casting of a high-temperature resistant cast alloy. After completion of the casting, a separating plate **27** is welded therein seal-tight manner to separate the reversing chamber **21** from the delivery chamber **16.** Cover plates **28** and **29** which are also subsequently welded in position in seal-tight manner are provided to separate the delivery chambers **13, 16** from the ambient zone.

Where the guide blades are constructed as blade segments in a guide blade ring with the blade segments comprising a plurality of blades, such can also be produced as a casting by the precision casting method. In this case, the separating plates **27** are then co-ordinated to the individual blades but the cover plates **28** and **29** are common to the entire segment.

What is claimed is:

1. A cooled guide blade for a gas turbine comprising

a blade body having a blade front and a trailing edge;

a first pressure chamber in said body for receiving a supply of coolant;

means defining a first flow path in said body immediately downstream of and parallel to said blade front, said flow path being in communication with said pressure chamber and including at least two parallel portions to reverse a flow of coolant therethrough at least once;

a second pressure chamber in said body in communication with said flow path between said parallel portions on an opposite side of said blade body from said first pressure chamber;

a first exit in said trailing edge communicating with said flow path for passage of a first coolant flow therethrough, said exit extending along a part of the length of said trailing edge;

means defining a second flow path independent of said first flow path in said body extending from said first chamber, said second flow path having at least two parallel portions to reverse a second flow of coolant therethrough at least once; and

a second exit at said trailing edge communicating with said second flow path for passage of the second coolant flow therethrough.

2. A cooled guide blade as set forth in claim **1** which further comprises an outer cover plate over said first pressure chamber and an inner cover plate over said second pressure chamber.

3. A cooled guide blade as set forth in claim **1** wherein said second flow path is parallel to said first flow path and wherein said second flow path includes at least three parallel portions and a pair of reversal portions interconnecting said parallel portions in series to deflect the second flow of coolant through consecutive parallel portions by 180°.

4. A cooled guide blade as set forth in claim **3** wherein the last of said parallel portions of said second flow path includes means for creating a pressure loss in the flow of coolant passing therethrough.

5. A cooled guide blade as set forth in claim **1** wherein said means defining said second flow path includes boundary walls and fins on at least a portion of said walls projecting into said second flow path.

6. A cooled guide blade as set forth in claim **1** wherein said exits each have a constant cross-sectional exit opening and wherein said exits are of a length relative to each other in a ratio proportional to the amount of coolant flowing through each exit.

7. A cooled guide blade as set forth in claim **1** wherein said body further includes a first covering adjacent said blade front disposed to define a portion of said first pressure chamber and a second covering adjacent said blade front disposed to define a portion of said second pressure chamber.

8. A cooled guide blade as set forth in claim **7** wherein said body and said coverings form an integral one-piece precision casting and which further comprises a separating plate disposed in said body in seal-tight manner between said flow paths, an outer cover plate disposed in said body in seal-tight manner over said first chamber and an inner cover plate disposed in said body in seal-tight manner over said second chamber and opposite to said separating plate relative to said second chamber.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,807,892 Dated April 30, 1974

Inventor(s) Oskar Frei et al

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

In the title page of the patent insert the following:

-- Switzerland
699/72 filed January 18, 1972 to which the right of priority is claimed.--

Column 2, line 30, "mount" should be --amount--.

Signed and sealed this 1st day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

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