

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization International Bureau



(43) International Publication Date  
16 June 2005 (16.06.2005)

PCT

(10) International Publication Number  
**WO 2005/054633 A1**

(51) International Patent Classification<sup>7</sup>: **F01D 17/16**, 5/14

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(21) International Application Number:

PCT/EP2004/013657

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(22) International Filing Date:

30 November 2004 (30.11.2004)

(81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(25) Filing Language:

English

(84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,

(26) Publication Language:

English

[Continued on next page]

(30) Priority Data:

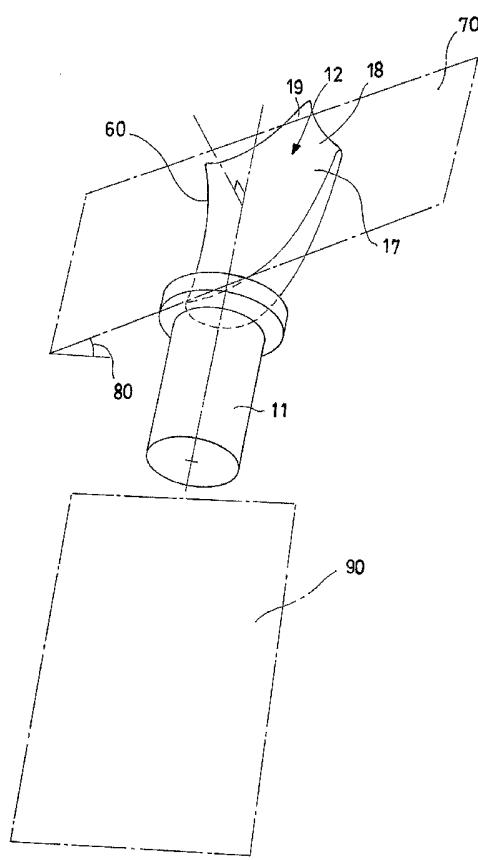
MI2003A002388 5 December 2003 (05.12.2003) IT

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(54) **Title:** VARIABLE NOZZLE FOR A GAS TURBINE



(57) **Abstract:** Variable nozzle (10) for a gas turbine fixed to a shaft (11) equipped with a pressurized upper surface (12) and a depressurized lower surface opposite to the upper surface (12), the variable nozzle comprises a series of substantially "C"-shaped sections, each having a first rounded end and a second rounded end each section of the series of sections also having the concavity facing upwards with respect to a base (90) and arranged one after another continuously, in the direction of an axis of the shaft (11) along a curved line (60), the at least second degree curved line (60) lies on a surface (70) having an axis orthogonal to the axis of the shaft (11) and also tilted with respect to the base (90) by an angle (80).

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ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Published:**

— *with international search report*

## VARIABLE NOZZLE FOR A GAS TURBINE

The present invention relates to a nozzle for a gas turbine, which can be particularly applied to the first 10 stage of a power turbine.

The present invention relates to a twin-shaft gas turbine and in particular, to a variable nozzle for a low pressure turbine.

Normally in twin-shaft turbines, the air pressurized 15 by a compressor, is mixed with a combustible fluid and injected into a burner to generate hot combusted gases.

The latter flow through the nozzles of a high pressure turbine, which diverges them and accelerates them.

Downstream of the high pressure turbine, the gases 20 then pass through a low pressure turbine, which extracts the remaining energy to feed a user.

Gas turbines for mechanical operations can have a fixed or variable nozzle, placed in the first stage of the low pressure turbine.

25 When using a variable nozzle, it is possible to ob-

tain a high operability of the turbine, at the same time maintaining the polluting emissions and efficiency of the turbine as constant as possible.

A fixed nozzle, on the other hand, is characterized 5 by a higher aerodynamic efficiency accompanied however by a lower operability of the gas turbine.

For variable nozzles, there are clearances necessary for allowing its rotation.

A variable nozzle has two surfaces touched by hot 10 combusted gases, opposite each other, of which one is pressurized and the other depressurized.

One of the disadvantages of a variable nozzle is that it has aerodynamic efficiency losses due to pressure drop losses of the flow of combusted gases through the 15 clearances, accompanied by secondary losses arising from the latter, which are mainly due to the pressure differences between the pressurized surface and the depressur- ized surface.

An objective of the present invention is to provide 20 a variable nozzle for a gas turbine, having improved performances which resemble those of a fixed nozzle, at the same time maintaining a high operability of the gas turbine with variations in its flow-rates.

Another objective of the present invention is to 25 provide a reliable variable nozzle for a gas turbine.

These objectives according to the present invention are achieved by providing a variable nozzle for a gas turbine as illustrated in claim 1.

Further characteristics of the invention are indicated in the subsequent claims.

The characteristics and advantages of a variable nozzle for a gas turbine according to the present invention will appear more evident from the following, illustrative and non-limiting description, referring to the enclosed schematic drawings, in which:

figure 1 is a raised front view of a variable nozzle according to the present invention;

figure 2 is a raised sectional front view of the nozzle of figure 1 according to a line II-II passing through an upper end of the variable nozzle;

figure 3 is a raised sectional front view of the nozzle of figure 1, according to a line III-III passing through the intermediate part of the variable nozzle;

figure 4 is a raised sectional front view of the nozzle of figure 1 according to a line IV-IV passing through the hub of the variable nozzle;

figure 5 is a perspective view of the nozzle of figure 1;

figure 6 is a view from below of the nozzle of figure 1;

figure 7 is a raised side view of the nozzle of figure 1;

figure 8 is a view from above of the nozzle of figure 1;

5 figure 9 is a raised rear view from below of the nozzle of figure 1.

With reference to the figures, these show a variable nozzle 10 for a gas turbine fixed to a shaft 11 and capable of being rotated around its axis by means of activating means not shown in the figures.

The shaped variable nozzle 10 is suitable for minimizing pressure drops and consequently increasing the efficiency of the gas turbine.

Said variable nozzle 10 has a series of sections, 15 preferably variable, substantially "C"-shaped, all facing the same direction, and preferably with the concavity facing upwards with respect to a base 90.

Each section of the series of sections represents a section of the variable nozzle 10 according to a surface 20 having an axis parallel to the axis of the shaft 11.

Each section of the series of sections has a first rounded end 20 and a second rounded end 21.

The first end 20 of each section of the series of sections is situated along the axis of the shaft 11 according to an at least second degree curved line 60.

The series of sections is positioned along the axis of the shaft 11 and respectively defines two surfaces, an upper pressurized surface 12 and an opposite lower surface 14, which is depressurized, respectively, both 5 touched by the hot combusted gases.

The pressure of the flow F of hot gas is exerted on the upper surface 12, whereas the opposite lower surface 14, is in depression.

The upper surface 12 is saddle-shaped and its saddle 10 point corresponds to the intermediate section of the variable nozzle 10.

The upper surface 12, in a parallel direction to the axis of the shaft 11, is therefore convex, whereas in an orthogonal direction to said axis, it is concave, all the 15 sections being substantially "C"-shaped.

The variable nozzle 10 has a first end portion 17, a second central portion 18, and a third hub portion 19.

The first portion 17 and the third portion respectively comprise an end section 30 and a hub section 50, 20 which have minimum aerodynamic pressure drops which consequently improve the aerodynamic efficiency of the variable nozzle 10.

Furthermore, the pressure differences which are created between the upper pressurized surface 12 and the 25 lower depressurized surface 14, always in respective cor-

respondence with said end section 30 and said hub section 50, are minimum and consequently the secondary aerodynamic losses are also minimum.

The forces which guide the flow of combusted gases 5 through the clearances are thus reduced.

The second central portion 18, on the other hand, comprises the intermediate section 40.

There are no edge effects or secondary losses in correspondence with the second central portion 18, and 10 consequently the aerodynamic efficiency in this portion of the variable nozzle 10 is greater.

For this reason, as there is a greater aerodynamic efficiency in the second central portion 18, the variable nozzle 10 is shaped so as to increase the aerodynamic 15 charge thereon.

These results are also maintained with variations in the operating conditions of the gas turbine.

All of this is obtained by shaping the variable nozzle 10, positioning each section of the series of sections 20 continuously one after another, and arranging the first end of each section of the series of sections in the direction of the axis of the shaft 11, along the at least second degree curved line 60.

Said curved line 60 lies on a surface 70 having an 25 axis orthogonal to the axis of the shaft 11 and also

tilted with respect to the base 90 by an angle 80 different from  $0^\circ$  and lower than  $90^\circ$ .

Said curved line 60 is an at least second degree line and comprises a parabolic line or a hyperbolic line 5 or a combination of these.

In a first preferred embodiment, said curved line 60 is preferably a parabolic line.

The variable nozzle 10 is therefore an arched nozzle, preferably parabolically arched.

10 In a second embodiment, said curved line 60 is preferably a hyperbolic line.

In a third embodiment, said curved line 60 is preferably a third degree line.

Said curved line 60, moreover, preferably has a 15 maximum or minimum point.

It can thus be seen that a variable nozzle for a gas turbine according to the present invention achieves the objectives specified above.

Numerous modifications and variants can be applied 20 to the variable nozzle for a gas turbine of the present invention, thus conceived, all included within the same inventive concept.

Furthermore, in practice, the materials used as also 25 the dimensions and components, can vary according to technical demands.

CLAIMS

1. A variable nozzle (10) for a gas turbine fixed to a shaft (11), said variable nozzle (10) comprising a pressurized upper surface (12) and a depressurized lower surface (14) opposite to the upper surface (12), characterized in that said variable nozzle comprises a series of substantially "C"-shaped sections, each having a first rounded end (20) and a second rounded end (21), each section of the series of sections also having the concavity 10 facing upwards with respect to a base (90) and arranged one after another continuously, in the direction of an axis of the shaft (11) along a curved line (60), characterized in that said at least second degree curved line (60) lies on a surface (70) having an axis orthogonal to 15 the axis of the shaft (11) and also tilted with respect to the base (90) by an angle (80).
2. The variable nozzle (10) according to claim 1, characterized in that said curved line (60) is a parabolic line.
- 20 3. The variable nozzle (10) according to claim 1, characterized in that said curved line (60) is a hyperbolic line.
4. The variable nozzle (10) according to claim 1, characterized in that said curved line (60) is a combination 25 of a parabolic line and a hyperbolic line.

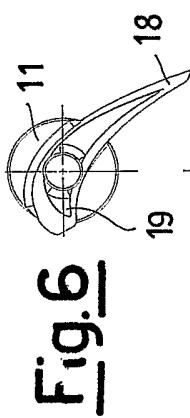
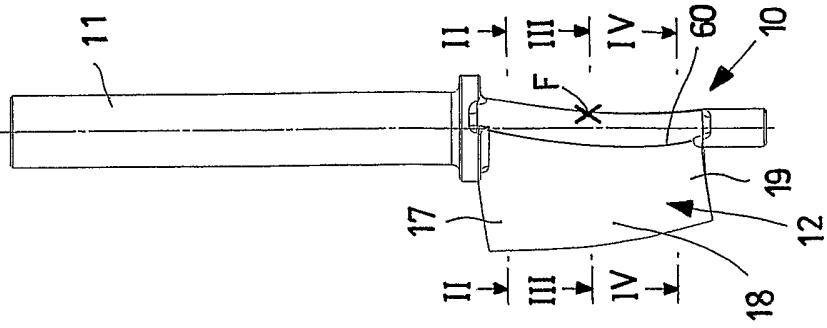
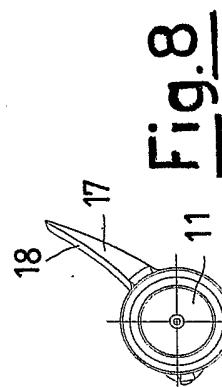
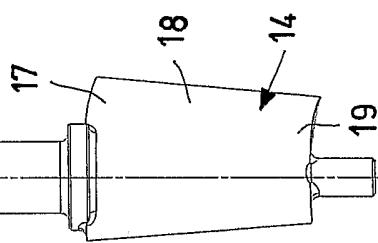
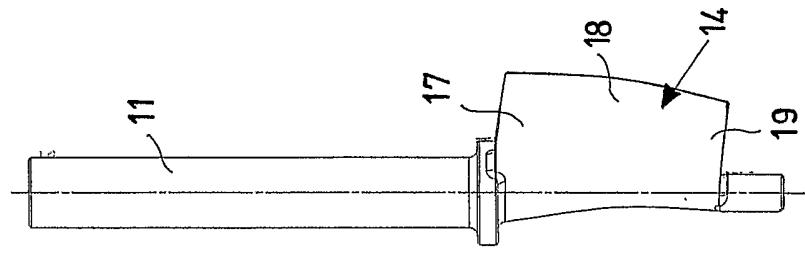
5. The variable nozzle (10) according to claim 1, characterized in that said curved line (60) is a third degree line.
6. The variable nozzle (10) according to any of the 5 previous claims, characterized in that said curved line (60) has a maximum or minimum point.
7. The variable nozzle (10) according to any of the previous claims, characterized in that the upper surface (12) is saddle-shaped.
- 10 8. A variable nozzle for a gas turbine as previously described and illustrated above and for the purposes specified above.

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Fig.1Fig.6Fig.7Fig.8Fig.9

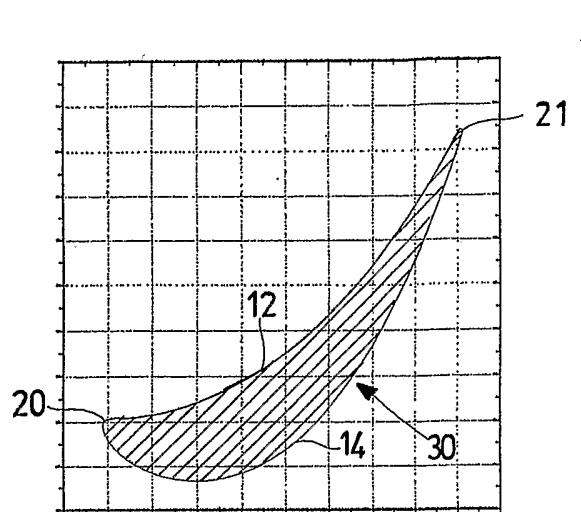


Fig.2

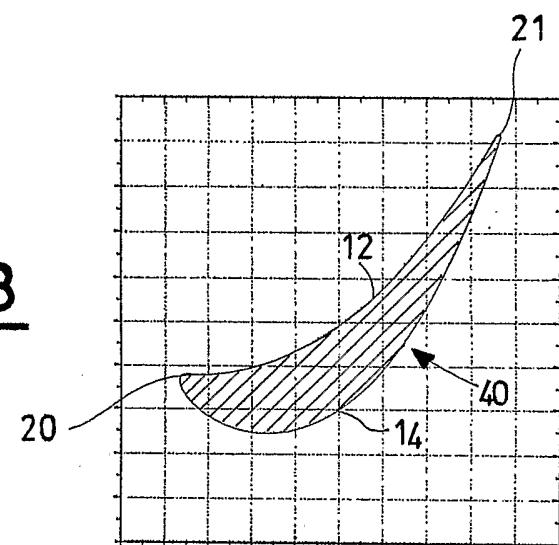


Fig.3

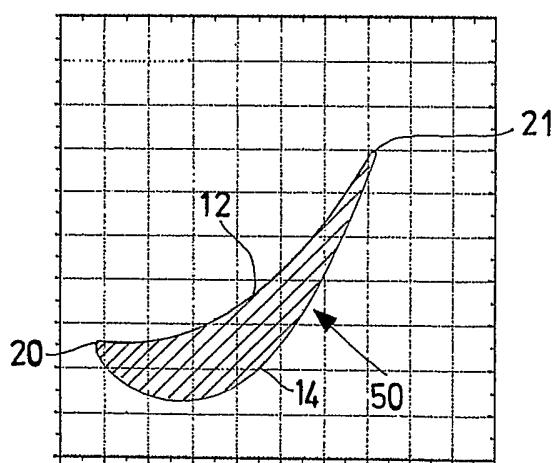
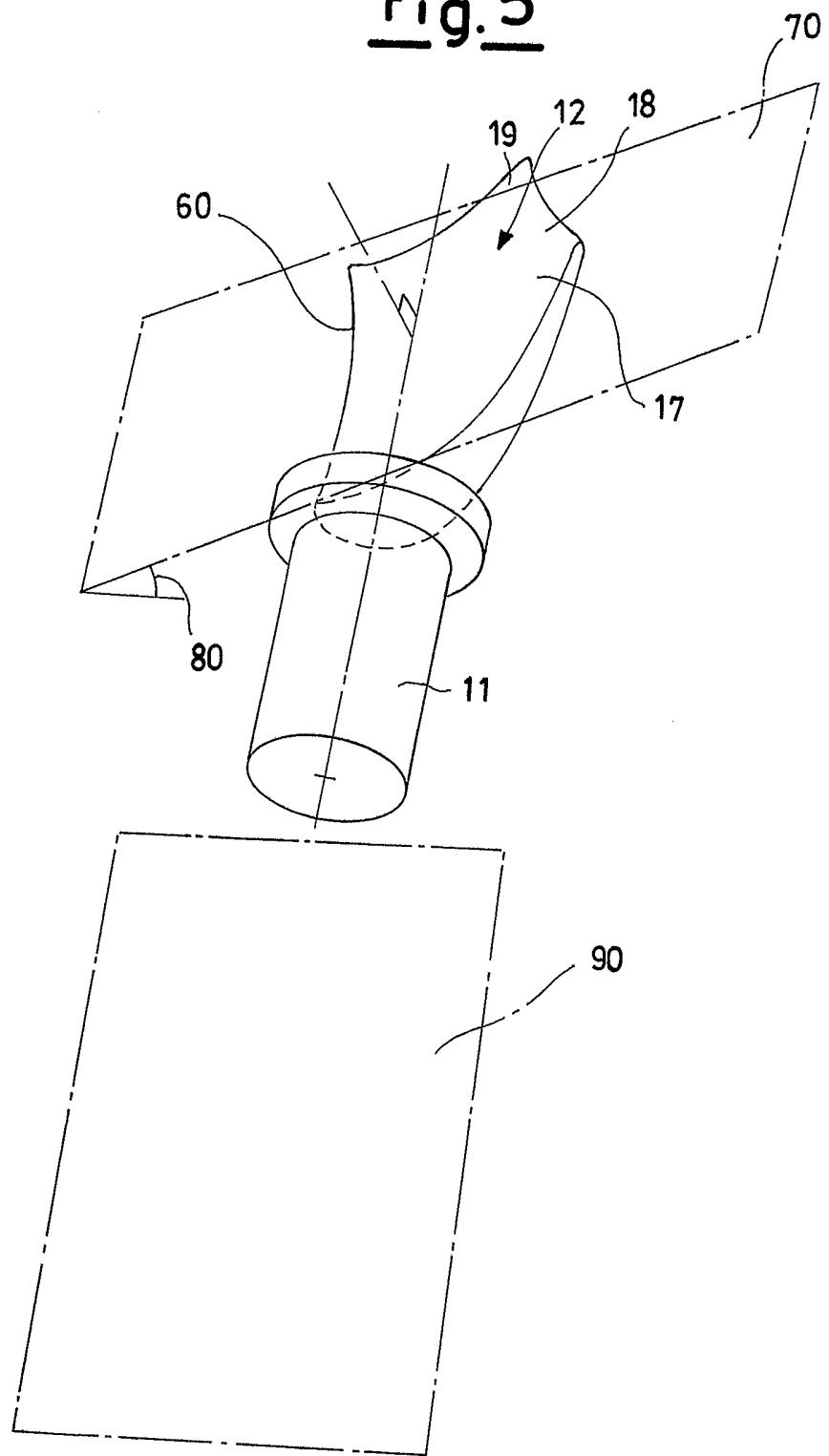


Fig.4

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Fig. 5



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP2004/013657

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 7 F01D17/16 F01D5/14

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
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|            | -----  | -/-                   |

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Patent family members are listed in annex.

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Date of the actual completion of the international search

16 March 2005

Date of mailing of the international search report

31/03/2005

Name and mailing address of the ISA

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## INTERNATIONAL SEARCH REPORT

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages            | Relevant to claim No. |
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