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(51) INT CL:
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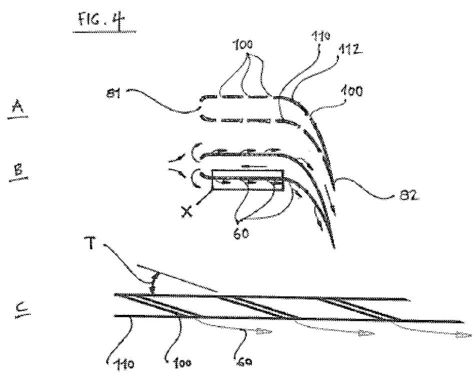
(56) Documents Cited:

GB 2405451 A	**EP 2236752 A**
EP 1262631 A	**EP 1209323 A**
EP 1061236 A	**JP 2011064207 A**
US 7862299 B1	**US 5577884 A**

(58) Field of Search:
INT CL **F01D**
Other: **EPODOC, WPI**

(54) Title of the Invention: **Gas turbine**
Abstract Title: **Gas turbine nozzle guide vane with dilution air exhaust ports**

(57) In a gas turbine, a substantial amount of dilution air is introduced into turbine nozzle guide vane 80 from which it leaves via a plurality of ports 100, 101 in the external surfaces 110, 112 which extend between the leading and trailing edges 81, 82 of the vane. The ports 100, 101 are spaced and configured so as to provide a predetermined radial distribution of gas temperature at the nozzle guide vane exit plane (P, fig.3). The ports 100, 101 may be oriented at an angle T to promote tangential flow of dilution air as indicated by arrows 60.



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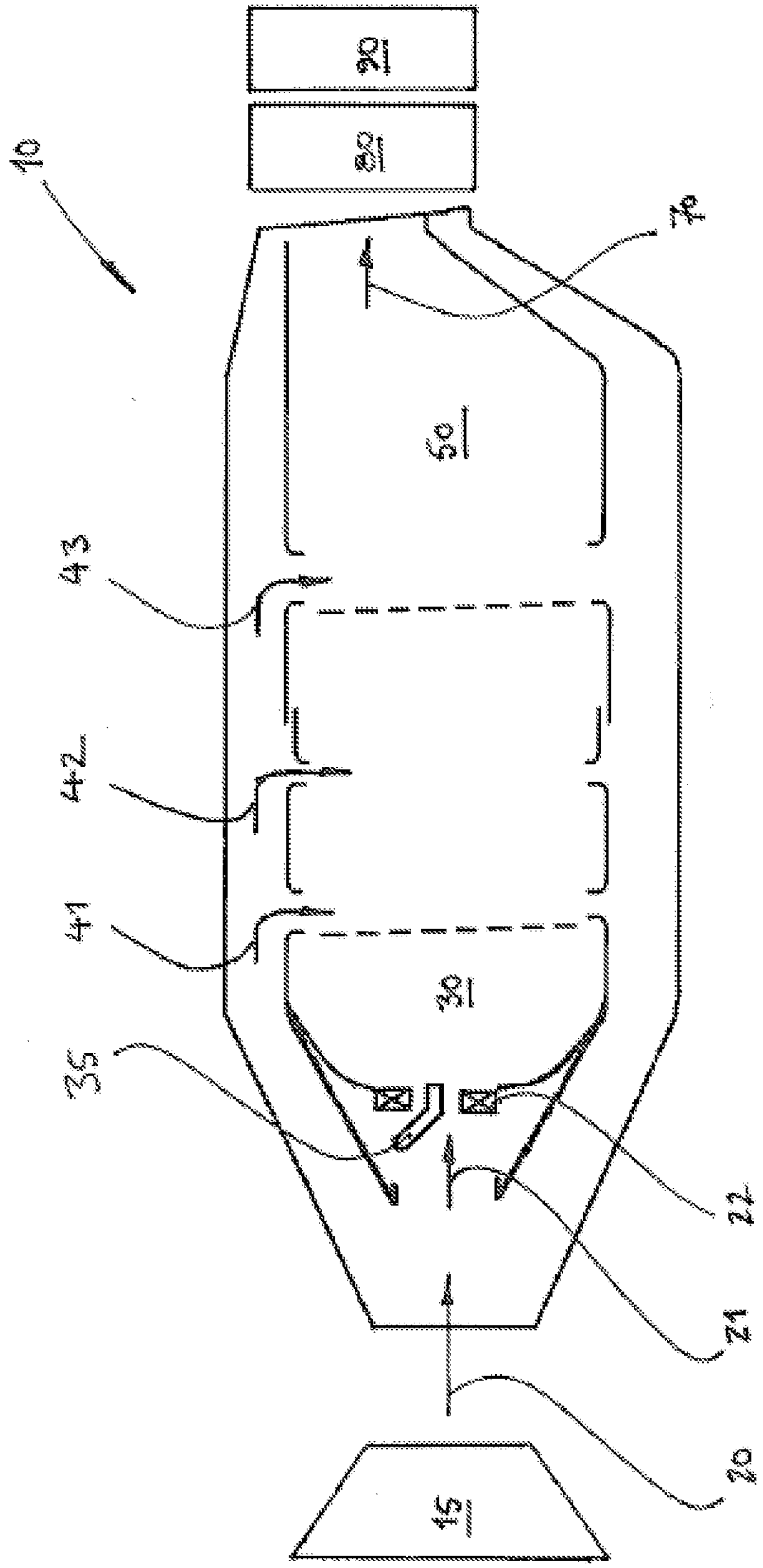


Fig. 1

FIG. 2

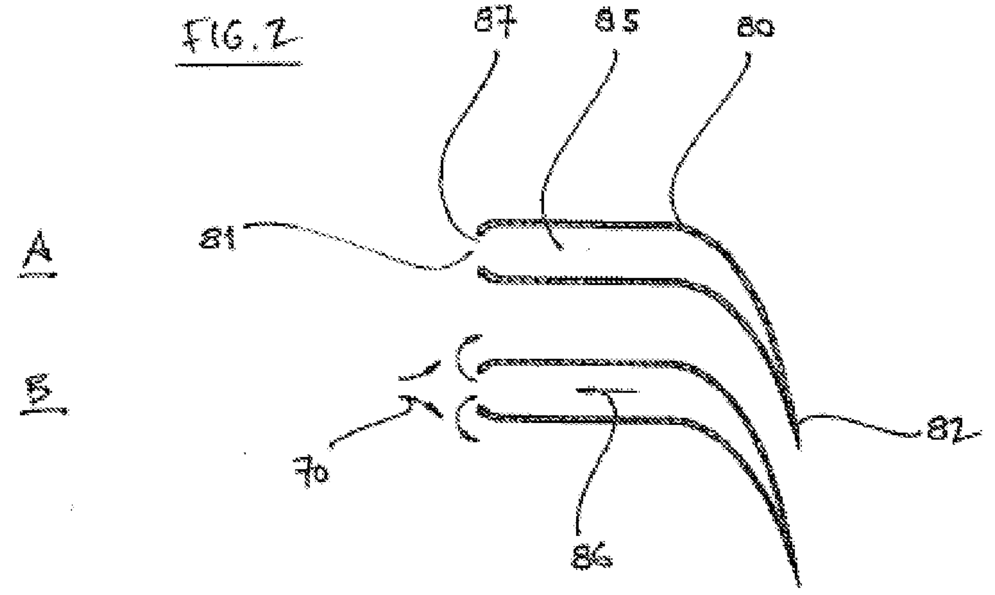
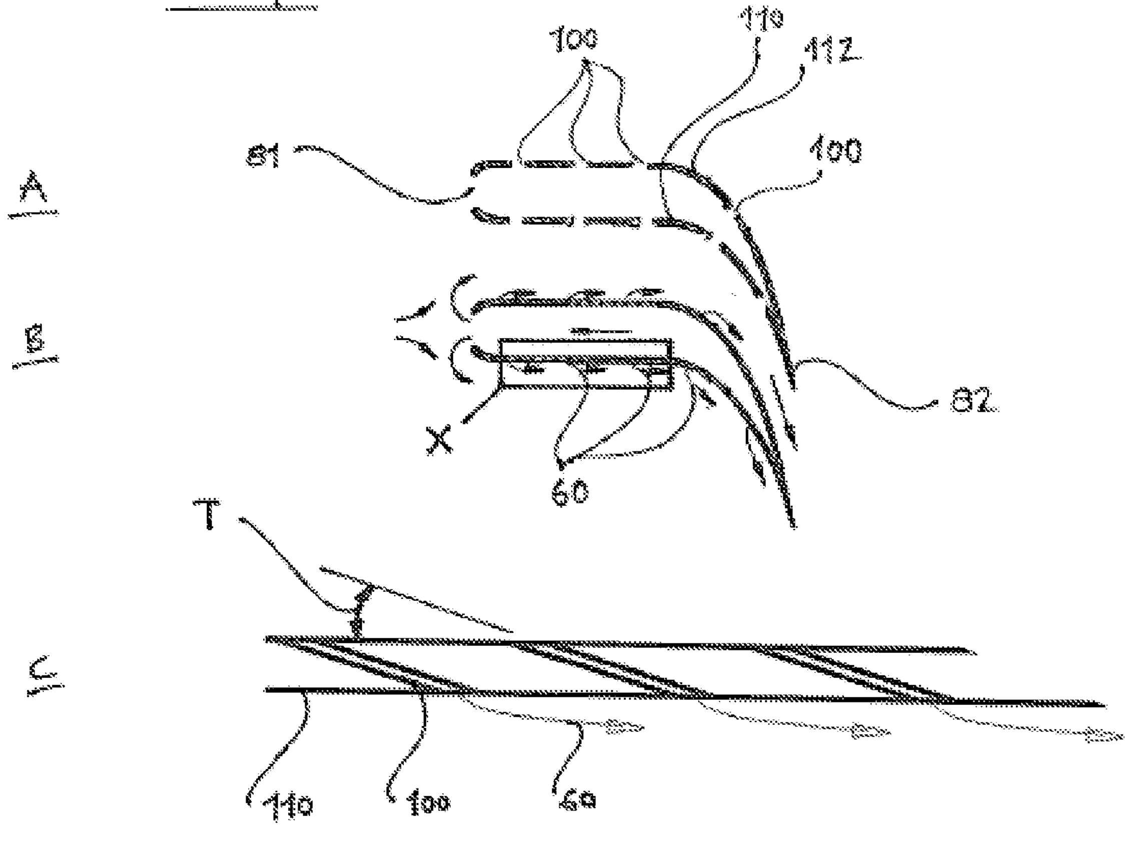


FIG. 4



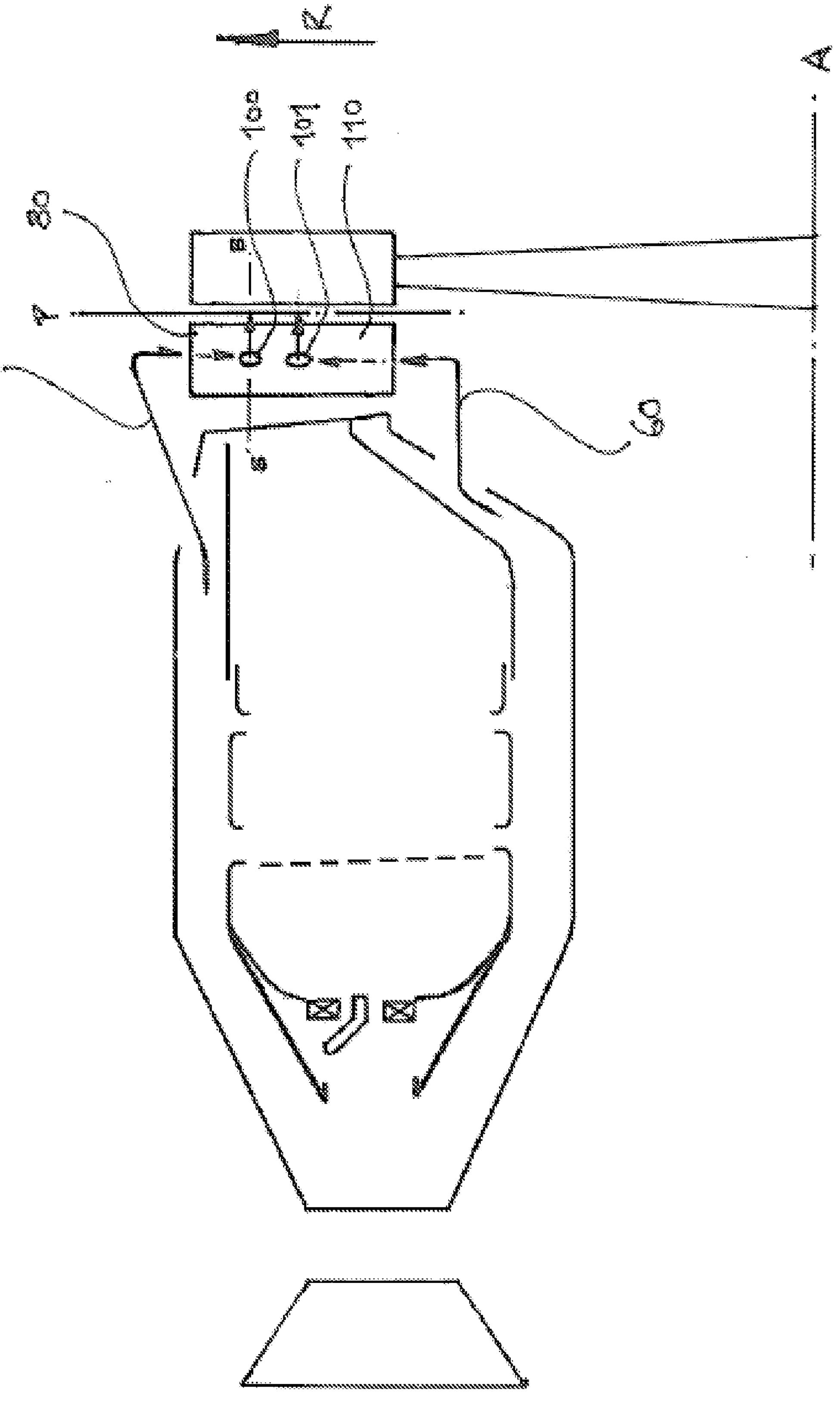


Fig. 3

TITLE: GAS TURBINE

DESCRIPTION

TECHNICAL FIELD

The present invention relates to gas turbines.

BACKGROUND ART

Figure 1 illustrates a gas turbine combustor 10 as known, e.g. from Henderson, R.E. and Blazowski, W.S., "Turbopropulsion Combustion Technology", *The Aerothermodynamics of Aircraft Gas Turbine Engines,* AFAPL-TR-78-52 (1978). As indicated by arrow 20, most of the delivery air from the compressor 15 (typically 80% in a modern gas turbine) is supplied to the combustor. A first portion 21 of this air is fed to the primary combustion zone 30 through swirlers 22 where it burns stoichiometrically with fuel introduced through nozzle 35. A second portion of the air is introduced further downstream: as primary cooling flow 41, secondary cooling flow 42 and tertiary cooling flow 43, the latter also being known as “dilution air” and the rearmost region of the combustor into which that air is introduced being known as the “dilution zone” 50. This dilution air 43 typically represents around 30% of the air 20 supplied to the combustor, although this proportion may vary between 20% and 50% depending on the particular design. As indicated at 70, the mixture of combustion products and dilution air leaving the combustion chamber passes through turbine nozzle guide vanes 80 and the turbine rotor 90, where a small amount of air from the compressor (typically 10% in a modern gas turbine) is typically introduced through the turbine nozzle guide vanes for cooling purposes.

As explained in GB774500, published in 1957, dilution air is surplus to that necessary for complete, stoichiometric combustion of the fuel and serves to cool the temperature of the mixture to a value acceptable to the turbine. As illustrated in figure 2A below, GB774500 proposes a gas turbine in which the whole or most of the dilution or cooling air is admitted to the interior 85 of hollow stator guide vanes 80 each having a slot 87 extending along its leading edge 81 for the discharge of air. As indicated by arrows 86 in figure 2B below, the dilution air discharges into the gas stream 70 issuing from the combustor and then reverses in direction to flow and mix with the combustion gases. Air may also exit through outlets (not shown) in the trailing edges of the stator guide vanes. To prevent overheating of the turbine parts, GB774500 suggests that it is usual to attempt to achieve complete mixing.

However, in modern high-performance engines, the desired average radial distribution of temperature at the combustor exit plane is far from flat: as noted in Lefebvre, A.H. *Gas Turbine Combustion*, Taylor & Francis, Philadelphia, USA. (1998), it instead has a profile that peaks above the mid-height of the turbine blade, having lower temperatures at the turbine blade root, where mechanical stresses are highest, and at the tip of the blade which is the most difficult to cool. Lefebvre indicates that such a distribution may be achieved by appropriate choice of the number and size of the air admission holes in the combustor dilution zone as well as the zone length.

DISCLOSURE OF INVENTION

According to the present invention, there is provided

a gas turbine having a compressor, a combustor and a turbine;

the turbine comprising a nozzle guide vane having leading and trailing edges linked by external surfaces;

the compressor providing a first gas flow for stoichiometric combustion of fuel in the combustor and a second gas flow for dilution of the products of said stoichiometric combustion,

wherein the second gas flow is exhausted through at least one port in at least one of said external surfaces of the nozzle guide vane.

Exhaust of the dilution air through an external surface of the nozzle guide vane, rather than through the leading and trailing edges of a nozzle guide vane as disclosed in GB774500, will cause less disturbance of the gas flow and thus lower losses. Moreover, unlike GB774500, the arrangement of the present invention requires no dedicated cooling.

The second gas flow may be exhausted through a plurality of ports in one of the external surfaces of the nozzle guide vane. The plurality of ports may be spaced in a radial direction relative to the axis of rotation of the turbine rotor. Moreover, the plurality of ports may be configured so as to provide a predetermined radial distribution of gas temperature at the nozzle guide vane exit plane. The plurality of ports may also be spaced along the external surface between the leading and trailing edges. At least one of the plurality of ports may be oriented at an angle relative to the surface to promote flow substantially tangential to the surface.

BRIEF DESCRIPTION OF DRAWINGS

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 3 is a radial cross-sectional view of a first embodiment of the invention;

Figures 4A and B are cross-sectional views of the nozzle guide vane of figure 3;

Figure 4C is a detail view of figure 4B.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

As indicated by arrows 60 in figure 3, a substantial amount of dilution air is introduced into a turbine nozzle guide vane 80 from which it leaves via ports 100, 101 in the external surfaces 110, 112 extending between the leading and trailing edges 81,82 of the nozzle guide vane 80.

Ports 100, 101 are spaced in a radial direction R relative to the axis of rotation A of the turbine rotor. Proper location of these ports will help in maintaining required temperature traverse across the turbine blade, i.e. the holes are configured so as to provide a predetermined radial distribution of gas temperature at the nozzle guide vane exit plane P.

Figure 4A is a sectional view through the nozzle guide vane 80 along line BB in figure 3. Ports 100 are spaced along the external surfaces 110, 112 between the leading and trailing edges 81, 82 and, as shown in the detail view of figure 4C, may be oriented at an angle (T) relative to the surface to promote flow substantially tangential to the surface as indicated by arrows 60. Such tangential flow of the dilution air will cause less disturbance of the gas flow than in the arrangement of GB774500. Ports (or a single slot) in the leading and trailing edges 81,82 of the nozzle guide vane are similarly shaped and sized to not disturb downstream flow.

By feeding a substantial amount of dilution air through the nozzle guide vanes it is possible to partially or indeed completely dispense with a dilution zone in the combustor. Such an arrangement, shown in figure 3, has a length (and consequently weight) that is lower than that of the conventional combustor design of figure 1. An even shorter combustor may be achieved using hydrogen fuelled micromix combustion which has a shorter flame length than conventional combustors.

It should be understood that this invention has been described by way of examples only and that a wide variety of modifications can be made without departing from the scope of the invention.

CLAIMS

1. A gas turbine having a compressor, a combustor and a turbine;
   the turbine comprising a nozzle guide vane having leading and trailing edges linked by external surfaces;
   the compressor providing a first gas flow for stoichiometric combustion of fuel in the combustor and a second gas flow for dilution of the products of said stoichiometric combustion,
   wherein the second gas flow is exhausted through at least one port in at least one of said external surfaces of the nozzle guide vanes.
2. Gas turbine according to claim 1, wherein the second gas is exhausted through a plurality of ports in one of the external surfaces of the nozzle guide vanes.
3. Gas turbine according to claim 2, wherein the ports are spaced in a radial direction relative to the axis of rotation of the turbine rotor.
4. Gas turbine according to claim 3, wherein the ports are configured so as to provide a predetermined radial distribution of gas temperature at the nozzle guide vane exit plane.
5. Gas turbine according to any preceding claim, wherein the ports are spaced along the external surface between the leading and trailing edges.
6. Gas turbine according to any preceding claim, wherein at least one of the plurality of ports is oriented at an angle relative to the surface to promote flow substantially tangential to the surface.

Application No: GB1209016.3 **Examiner:** John Twin

Claims searched: 1 to 6 **Date of search:** 11 September 2012

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-6	EP 2236752 A (Rolls-Royce) - see eg column 3, last line to column 4, line 2
X	1-6	US 7862299 B1 (Florida Turbine) - see eg fig.4
X	1-6	US 5577884 A (SNECMA) - note eg cooling holes 44
X	1-6	GB 2405451 A (Rolls-Royce)
X	1-6	JP 2011064207 A (Mitsubishi) - see eg EPODOC abstract; drawings
X	1-6	EP 1262631 A (United Technologies)
X	1-6	EP 1209323 A (Nuovo Pignone)
X	1-6	EP 1061236 A (Mitsubishi)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F01D

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
F01D	0009/04	01/01/2006