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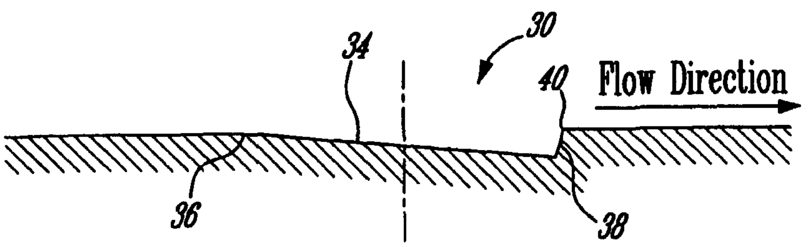
(54) Title: ASPHERICAL DIMPLES FOR HEAT TRANSFER SURFACES AND METHOD



(57) Abstract: A dimple (30) for use on a heat transfer surface (20) exposed to a flowing gas, for use for example in a gas turbine engine (10), the dimple (30) having an aspherical shape. The dimple (30) may also be shaped as a segment of a torus, a double wedge, and have a flat bottom surface. The ratio of the dimple maximum depth to maximum diameter is less than 0.2 and may be equal to 0.1.

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ASPHERICAL DIMPLES FOR HEAT TRANSFER SURFACES AND METHOD

TECHNICAL FIELD

The invention relates generally to shaped dimples for use in heat transfer surfaces such as, for example, those employed in cooling gas turbine engines.

BACKGROUND OF THE ART

In heat transfer technologies, dimples are small depressions provided on a heat transfer surface to create or amplify localised turbulences in the boundary layer of a gas flowing over the surface. Many dimples are generally provided on a same surface. One purpose of this turbulence is to increase the heat transfer between the gas and the surface on which the dimples are provided. This is often used, for example, in internal airfoil cooling or combustor cooling in gas turbine engines. Dimples can also be used for other purposes, however the purpose affects dimple placement, arrangement, etc.

Fig. 3 illustrates a typical heat transfer dimple as found in the prior art. This dimple is semi-spherical, namely that its bottom surface is shaped as a segment of a sphere. It comprises a bottom surface having a radius of curvature r. The ratio between the maximum depth (δ) and the maximum diameter (D) is generally 0.2 or more.

As there is a constant need for more efficient and reliable gas turbine engines, there is consequently a constant need for new features and methods that allow reaching these goals, such as improvements in the field of heat transfer.

SUMMARY OF THE INVENTION

In one aspect, the present invention provides a gas turbine engine component comprising a turbine portion exposed, in use, to a hot fluid flow; at least one cooling passage disposed within the turbine portion, the passage having a surface; and a plurality of aspherically-shaped dimple provided on the surface.

In another aspect, the present invention provides an airfoil for use in a gas turbine engine, the airfoil having at least one internal cooling passage therein adapted to direct a cooling fluid flow therethrough, the airfoil comprising a plurality of aspherical dimples disposed on at least one internal surface of the passage.

In another aspect, the present invention provides a heat transfer dimple for use on a surface exposed, in use, to a flowing gas, the dimple having an aspherical shape.

In another aspect, the present invention provides a shaped surface for use in a gas turbine engine to create turbulences in a gas when the gas flows thereon, the surface comprising a plurality of aspherical dimples.

In another aspect, the present invention provides a method of promoting heat transfer, the method comprising: providing a plurality of aspherical dimples on a surface; and directing a gas over the surface, the gas having a temperature being different than that of the surface.

In another aspect, the present invention provides a method of inducing turbulence in a gas flowing inside a gas turbine engine, the method comprising: providing a plurality of aspherical dimples on a surface; and directing the gas over the surface.

Further details of these and other aspects of the present invention will be apparent from the detailed description and figures included below.

DESCRIPTION OF THE DRAWINGS

Reference is now made to the accompanying figures depicting aspects of the present invention, in which:

Fig. 1 shows a generic gas turbine engine to illustrate an example of a general environment in which the invention can be used.

Fig. 2 is a schematic top plan view of a generic heat transfer surface on which dimples are provided.

Fig. 3 is a cross-sectional view of a spherical dimple, as found in the prior art.

Figs. 4a, 4b and 4c are schematic views of an aspherical dimple in accordance with one preferred embodiment of the present invention.

Figs. 5a, 5b and 5c are schematic views of an aspherical dimple in accordance with another preferred embodiment of the present invention.

Figs. 6a, 6b and 6c are schematic views of an aspherical dimple in accordance with yet another preferred embodiment of the present invention.

DETAILED DESCRIPTION

Fig. 1 illustrates an example of a gas turbine engine 10 of a type preferably provided for use in subsonic flight, generally comprising in serial flow communication a fan 12 through which ambient air is propelled, a multistage compressor 14 for pressurizing the air, a combustor 16 in which the compressed air is mixed with fuel and ignited for generating an annular stream of hot combustion gases, and a turbine section 18 for extracting energy from the combustion gases. This figure illustrates an example of the environment in which the present invention can be used.

Fig. 2 schematically illustrates a generic surface 20 in which a plurality of dimples 30 are provided. Such surface 20 can be present in various components of the gas turbine engine 10, for instance in the internal cooling paths of airfoils or in some areas of the combustor 16. Although the illustrated surface 20 appears to be flat, dimples 30 can be provided on surfaces 20 of about any shape and configuration.

Dimples 30 are small and usually shallow depressions. They are usually made directly within the material of the surface 20 in which they are located. Traditionally, the dimples 30 were shaped as segments of sphere. Fig. 3 shows an example of a spherical dimple 30'.

During operation of the gas turbine engine 10, the gas flowing on the surface 20 has a boundary layer whose flow will be disrupted by the presence of the dimples 30. As a result, turbulences appear in the gas flow but without causing significant pressure losses. These turbulences increase the swirling of the gas molecules above the surface 20, thereby increasing the heat transfer efficiency between the gas and the surface 20.

It was found by the inventors that aspherically-shaped dimples 30 can be used to improve the efficiency of the turbulences compared to spherically-shaped dimples 30' (Fig. 3). These non-spherical dimples 30 can have many possible embodiments, some of which are shown in Figs. 4a through 6c. Each of these preferred embodiments have some specificities that may attract the attention of the engineers in the design of their components.

Figs. 4a, 4b and 4c schematically illustrate a cross section of an aspherical dimple 30 in accordance with one preferred embodiment. Fig. 4a illustrates a "disproportional" dimple in which the shape has been exaggerated for illustration proposes only. The real preferred aspect is shown in Fig. 4b. Fig. 4c shows an upper view of the dimple 30, as shown in Fig. 4b. The dimple 30 preferably comprises acircular rim 32. The bottom surface 34 of the dimple is preferably flat and inclined. The inclination preferably begins at the leading side 36 with reference to the gas flow, although any desired orientation may be used. The bottom surface 34 intersects a corresponding inclined wall 38 at the trailing side 40 of the dimple 30. Preferably, the ratio of the maximum depth (δ) versus the maximum diameter (D) of the dimple is less than 0.2, and more preferably being about 0.1.

Figs. 5a, 4b and 4c schematically illustrate a cross section of an aspherical dimple 30 in accordance with another embodiment. Fig. 5a illustrates a "disproportional" dimple 30 for illustration purposes. The real preferred aspect is shown in Fig. 5b. Fig. 5c shows an upper view of the dimple 30, as shown in Fig. 5b. The dimple 30 preferably comprises a circular rim 32 and a central circular raised portion 42 with a flat upper surface 44 which is at the same level than the main surface 20. The raised portion 42 has a diameter D' that is preferably about a quarter of the diameter D of the dimple 30. The bottom surface 34 of the dimple 30 is substantially shaped as a segment of torus (or donut). Preferably, the ratio of the maximum depth (δ) versus the maximum diameter (D) of the dimple is less than 0.2, and more preferably being about 0.1.

Figs. 6a, 4b and 4c schematically illustrate a cross section of an aspherical dimple 30 in accordance with another embodiment. Fig. 6a illustrates a "disproportional" dimple 30 for illustration purposes. The real preferred aspect is shown in Fig. 6b. Fig. 6c shows an upper view of the dimple 30, as shown in Fig. 6b. The dimple 30 is preferably shaped as a double wedge with a substantially flat bottom surface 34. The double wedge forms an arrow-like shape which is preferably pointed towards the upstream side of the gas flow, although any desired orientation may be used. The bottom surface 34 of the dimple 30 is substantially flat and inclined, starting from the leading side 36 with reference to the gas flow and up to the trailing side 40. Preferably, the ratio of the maximum depth (δ) versus the maximum diameter (D) of an imaginary circle 50, in which the arrow is positioned, is less than 0.2, and more preferably being about 0.1. This dimple itself otherwise has an a circular rim.

As can be appreciated, the aspherical dimples 30 will allow engineers designing devices in which it is possible to enhance heat transfer or induce more effective turbulences when exposed to a gas flowing on a surface having several of these dimples 30.

The above description is meant to be exemplary only, and one skilled in the art will recognize that changes may be made to the embodiments described without department from the scope of the invention disclosed. For example, other aspherical shapes can be used, and the ones disclosed herein are exemplary only. The orientations of the exemplary dimples relative to the direction of flow thereover may be any desired, and need not be as described. The ratio between the maximum depth and the maximum diameter of the dimples can be equal or more than 0.2, although a lesser value is believed to be more advantageous where pressure losses caused by the dimple are important, as they are in the filed of gas turbine cooling. Also, aspherical dimples need not be employed exclusively, not one type of aspherical dimples employed, but rather a plurality of types and sizes may be employed, and can be used in conjunction with spherical dimples 30', if desired. Although the present invention has been described with respect to its application to gas turbine engines, the skilled reader will appreciate that the invention has board application to many different types of heat transfer environments and applications. Still other modifications which fall within the scope of the present invention will be apparent to those skilled in the art, in light of a review of this disclosure, and such modifications are intended to fall within the appended claims.

WHAT IS CLAIMED IS:

1. A gas turbine engine component comprising:

a turbine portion exposed, in use, to a hot fluid flow;

at least one cooling passage disposed within the turbine portion, the passage having a surface; and

a plurality of aspherically-shaped dimple provided on the surface.

2. The gas turbine engine component of claim 1, wherein at least some of the dimples have a generally circular rim, said rim being an interface between the dimples and the surface.

3. The gas turbine engine component of claim 1, wherein at least some of the dimples have a generally a circular rim, said rim being an interface between the dimples and the surface.

4. The gas turbine engine component of claim 1, wherein at least some of the dimples have a ratio between a maximum depth and a maximum diameter of less than 0.2.

5. The gas turbine engine component of claim 4, wherein the ratio is substantially equal to 0.1.

6. The gas turbine engine component of claim 1, wherein at least some of the dimples have a substantially flat bottom surface.

7. The gas turbine engine component of claim 1, wherein at least some of the dimples have a bottom surface substantially shaped as a segment of torus.

8. The gas turbine engine component of claim 1, wherein at least some of the dimples have a bottom surface shaped as a double wedge with a substantially flat bottom surface.

9. An airfoil for use in a gas turbine engine, the airfoil having at least one internal cooling passage therein adapted to direct a cooling fluid flow therethrough, the airfoil comprising:

a plurality of aspherical dimples disposed on at least one internal surface of the passage.

10. The airfoil of claim 9, wherein at least some of the dimples have a generally circular rim, said rim being an interface between the dimples and the surface.

11. The airfoil of claim 9, wherein at least some of the dimples have a generally acircular rim, said rim being an interface between the dimples and the surface.

12. The airfoil of claim 9, wherein at least some of the dimples have a ratio between a maximum depth and a maximum diameter of less than 0.2.

13. The airfoil of claim 12, wherein the ratio is substantially equal to 0.1.

14. The airfoil of claim 9, wherein at least some of the dimples have a substantially flat bottom surface.

15. The airfoil of claim 9, wherein at least some of the dimples have a bottom surface substantially shaped as a segment of torus.

16. The airfoil of claim 9, wherein at least some of the dimples have a bottom surface shaped as a double wedge with a substantially flat bottom surface.

17. A heat transfer dimple for use on a surface exposed, in use, to a flowing gas, the dimple having an aspherical shape.

18. The heat transfer dimple of claim 17, wherein the dimple has a generally circular rim, said rim being an interface between the dimple and the surface.

19. The heat transfer dimple of claim 17, wherein the dimple has a generally acircular rim, said rim being an interface between the dimple and the surface.

20. The heat transfer dimple of claim 17, wherein the dimple has a ratio between a maximum depth and a maximum diameter of less than 0.2.

21. The heat transfer dimple of claim 20, wherein the ratio is substantially equal to 0.1.

22. The heat transfer dimple of claim 17, wherein the dimple has a substantially flat bottom surface.

23. The heat transfer dimple of claim 17, wherein the dimple has a bottom surface substantially shaped as a segment of torus.

24. The heat transfer dimple of claim 17, wherein the dimple has a bottom surface shaped as a double wedge with a substantially flat bottom surface.

25. A shaped surface for use in a gas turbine engine to create turbulences in a gas when the gas flows thereon, the surface comprising a plurality of aspherical dimples.

26. The surface of claim 25, wherein at least some of the dimples have a generally circular rim, said rim being an interface between the dimples and the surface.

27. The surface of claim 25, wherein at least some of the dimples have a generally acircular rim, said rim being an interface between the dimples and the surface.

28. The surface of claim 25, wherein at least some of the dimples have a ratio between a maximum depth and a maximum diameter of less than 0.2.

29. The surface of claim 28, wherein the ratio is substantially equal to 0.1.

30. The surface of claim 25, wherein at least some of the dimples have a substantially flat bottom surface.

31. The surface of claim 25, wherein at least some of the dimples have a bottom surface substantially shaped as a segment of torus.

32. The surface of claim 25, wherein at least some of the dimples have a bottom surface shaped as a double wedge with a substantially flat bottom surface.

33. A method of promoting heat transfer, the method comprising:

providing a plurality of aspherical dimples on a surface; and

directing a gas over the surface, the gas having a temperature being different than that of the surface.

34. The method of claim 33, wherein the dimples induce increased turbulence in the flow and thereby promote heat transfer.

35. A method of inducing turbulence in a gas flowing inside a gas turbine engine, the method comprising:

providing a plurality of aspherical dimples on a surface; and

directing the gas over the surface.

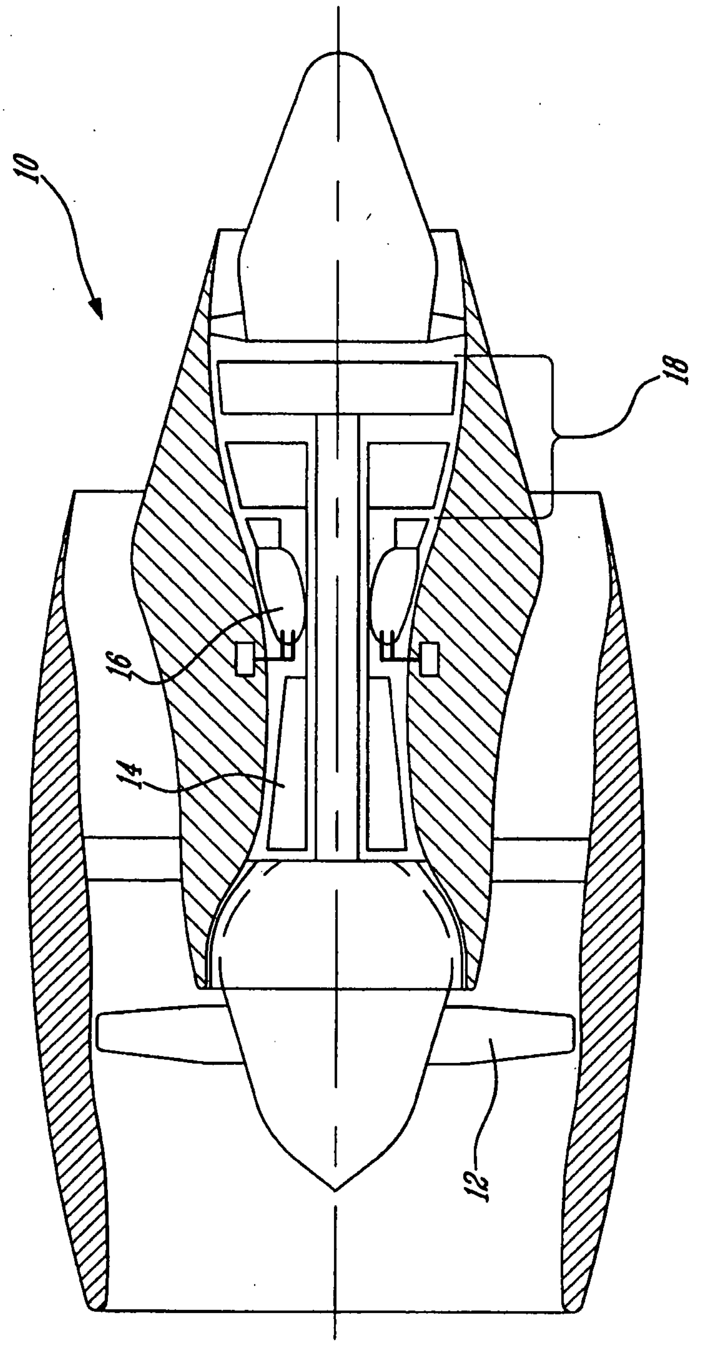

FIG. 1

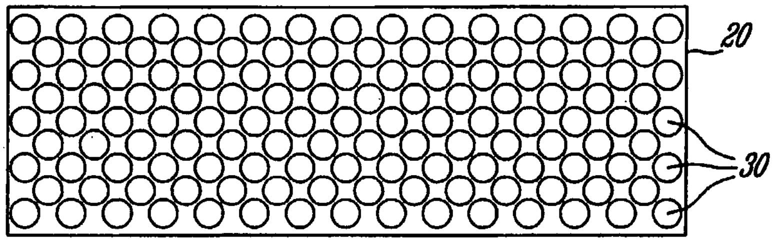

FIG. 2

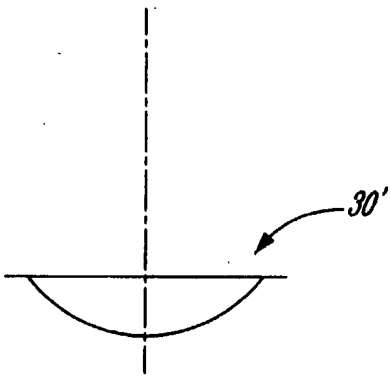

FIG. 3 (PRIOR ART)

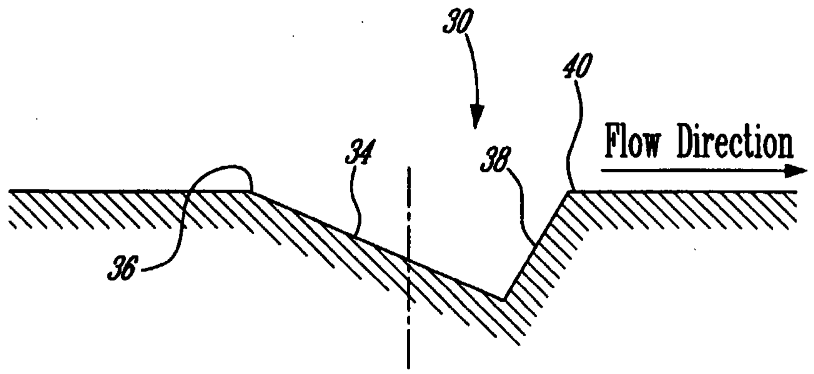

FIG. 4A

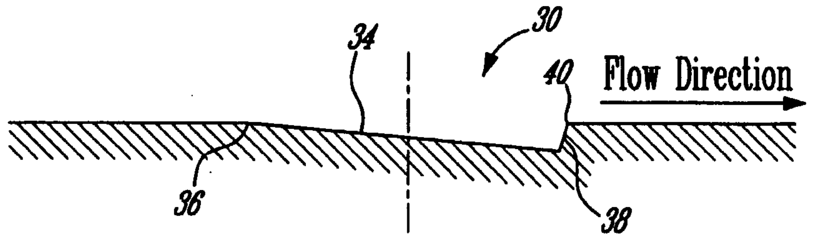

FIG. 4B

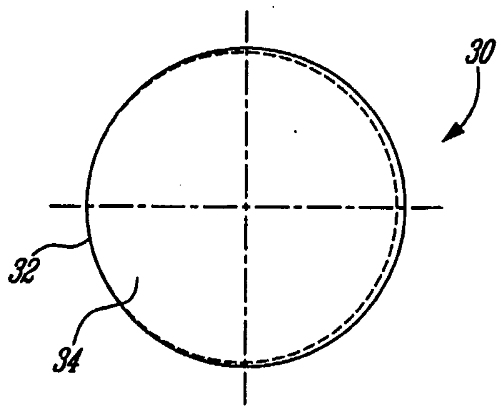

FIG. 4C

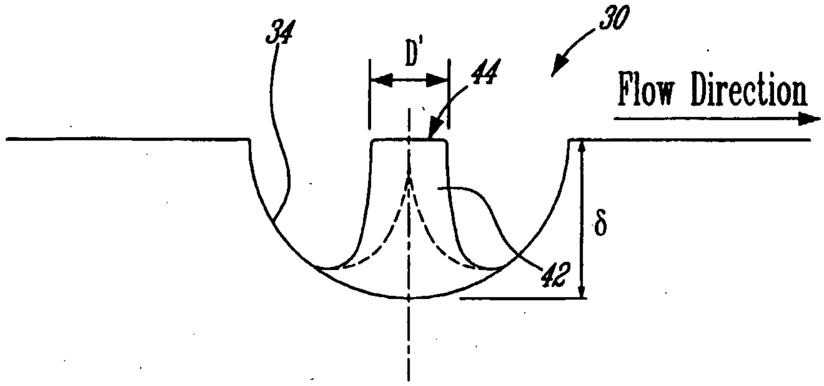

FIG. 5A

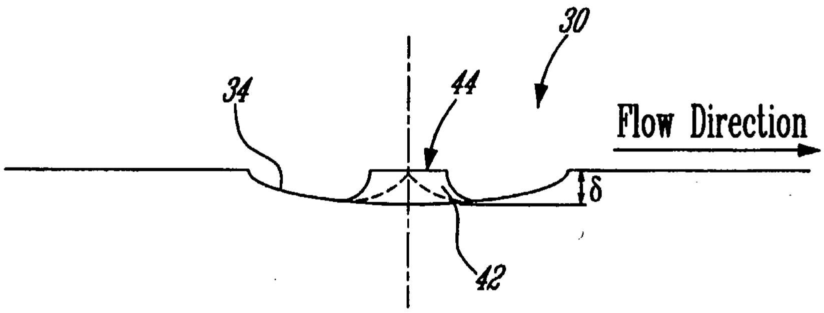

FIG. 5B

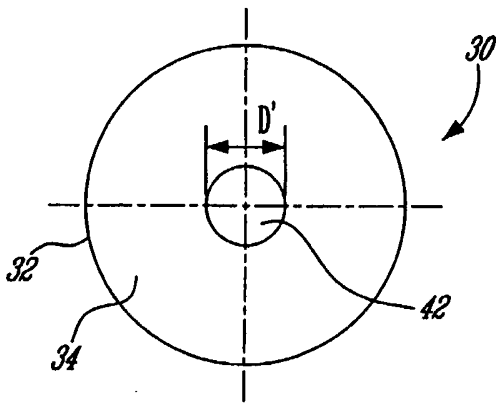

FIG. 5C

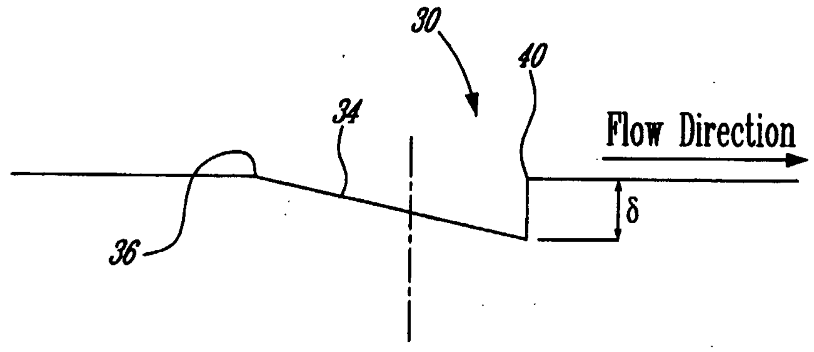

FIG. 6A

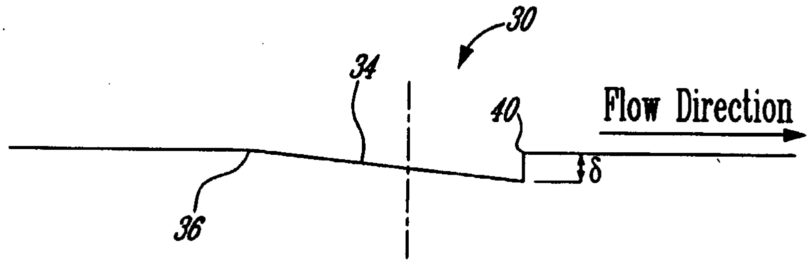

FIG. 6B

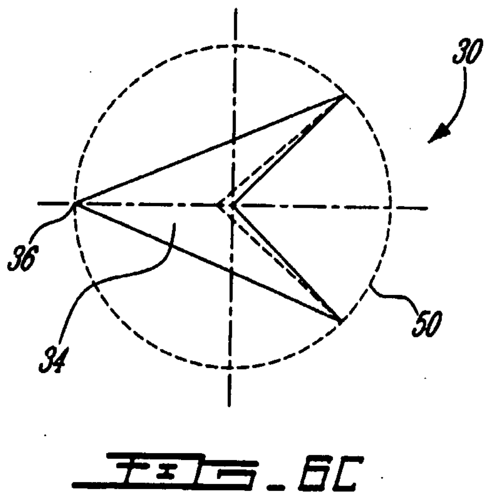

FIG. 6C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2005/001625

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***F28F 13/02*** (2006.01), ***F15D 1/06*** (2006.01), ***F01D 25/12*** (2006.01), ***F01D 5/18*** (2006.01), ***F02C 7/12*** (2006.01), ***F15D 1/12*** (2006.01)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(7): F28F 13/02, F15D 1/06, F01D 25/12, F01D 5/18, F02C 7/12, F15D 1/12
USPC: 165/133, 165/dig.510, 165/dig.515, 165/dig.516, 165/dig.517, 165/dig.529, 415/115, 415/177, 415/180, 60/806, 428/604, US cross-reference art collection: 415/914

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Canadian Patents Database, Delphion, Qpat, USPTO
Keywords: dimple, aspherical, spherical, cool*, boundary layer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US2004/0107718 A1 (BOWMAN et al.) 10 June 2004 (10-06-2004) *the whole document*	1-6, 17, 18, 20-22, 25, 26, 28-30, 33-35 7, 8, 10, 12-14, 24, 31, 32
X Y	US6183197 B1 (GENERAL ELECTRIC COMPANY) 6 February 2001 (06-02-2001) *the whole document*	1, 9, 11, 17, 19, 25, 27, 33-35 7, 8, 10, 12-14, 15, 16, 24, 28, 29, 31, 32
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A	WO2004/083651 A1 (VIDA) 30 September 2004 (30-09-2004) *the whole document*	17, 18, 20, 21, 33, 34 4, 5, 12, 13, 28, 29

[ ] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :
"A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 November 2005 (17-11-2005)	24 January 2006 (24-01-2006)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001(819)953-2476	Andrew Davidson (819) 953-4505

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