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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 April 2014 (10.04.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/055109 A1

(51) International Patent Classification:
F01D 9/02 (2006.01) *F02K 3/00* (2006.01)
F02C 7/28 (2006.01)

(21) International Application Number:
PCT/US2013/028515

(22) International Filing Date:
1 March 2013 (01.03.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/708,306 1 October 2012 (01.10.2012) US

(71) Applicant: **UNITED TECHNOLOGIES CORPORATION** [US/US]; One Financial Plaza, Hartford, Connecticut 06101 (US).

(72) Inventors: **KLINETOB, Carl, Brian**; 83 Sheepskin Hollow Road, East Haddam, Connecticut 06423 (US). **STILIN, Nicholas, D.**; 790 Candlewood Hill Road, Higganum, Connecticut 06441 (US).

(74) Agent: **OLDS, Theodore, W.**; Carlson, Gaskey & Olds/Pratt & Whitney, c/o CPA Global, P.O. Box 52050, Minneapolis, Minnesota 55402 (US).

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

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: GUIDE VANE SEAL

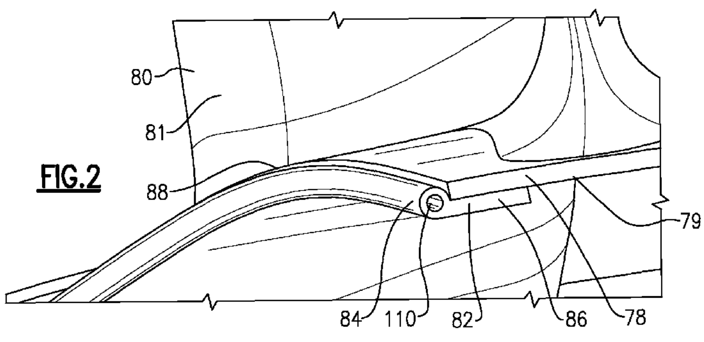

FIG.2

(57) Abstract: A seal for use with a static guide vane of a gas turbine engine has a strap member extending to a generally cylindrical bulb. The bulb forms a diameter, and is spaced a distance defined between an end of the strap remote from the bulb, to a point on the bulb furthest from the end. A ratio of the diameter to the distance is between 0.2 and 0.5. A static guide vane and a gas turbine engine are also disclosed.

WO 2014/055109 A1

GUIDE VANE SEAL

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application No. 61/708,306, which was filed October 1, 2012.

BACKGROUND

[0002] This application relates to a seal to seal a gap between adjacent platform edges of guide vanes for use in a gas turbine engine.

[0003] Gas turbine engines are known, and typically include a fan delivering air into a compressor section. The air is compressed and delivered into a combustion section where it is mixed with fuel and ignited. Products of this combustion pass downstream over turbine rotors driving them to rotate. The turbine rotors drive compressor and fan rotors. Historically, a common turbine rotor has driven a compressor rotor and the fan.

[0004] More recently, a gear reduction has been placed to drive the fan, such that the fan and compressor rotors can rotate at different speeds. This has allowed the size of the fan to increase dramatically. The fan typically delivers air into the compressor, but also delivers a portion of air as bypass flow into a bypass duct. With the increase in fan size, a bypass ratio, or the ratio of the air delivered into the bypass duct compared to the air delivered into the compressor has increased.

[0005] With the increase in bypass flow, the air delivered into the compressor becomes more valuable, and all air delivered into the compressor is desirably utilized efficiently. Thus, it becomes more important to limit leakage.

[0006] Within the compressor and fan sections, there are guide vanes positioned intermediate blade rows on the fan or compressor rotors. These guide vanes have platform edges which extend circumferentially towards an adjacent guide vane. There is often a gap between these edges.

[0007] Seals have been proposed to cover this gap, and prevent air from leaking inwardly or outwardly of the guide vanes. The seals to date have required relatively complex structure formed into the platforms, and also require complex assembly techniques.

SUMMARY

[0008] In a featured embodiment, a seal for use with a static guide vane of a gas turbine engine has a strap member extending to a generally cylindrical bulb. The generally cylindrical bulb forms to a diameter, and is spaced a distance defined between an end of the strap remote from the bulb, to a point on the bulb furthest from the end. A ratio of the diameter to the distance is between 0.2 and 0.5.

[0009] In another embodiment according to the previous embodiment, the bulb includes a hollow opening.

[0010] In another embodiment according to any of the previous embodiments, the seal is formed of a silicone rubber.

[0011] In another featured embodiment, a static guide vane for use in a gas turbine engine has an airfoil extending between two radial platforms, with a suction side and a pressure side to both the airfoil and platforms. A seal is secured to a side of each of the platforms remote from the airfoil. The seal has a strap secured to the side of the platforms. An enlarged bulb sits outwardly of an edge of the platform.

[0012] In another embodiment according to the previous embodiment, a vane is designed for use in a compressor section of a gas turbine engine.

[0013] In another embodiment according to any of the previous embodiments, there is a seal on only one of the suction and pressure sides at each of the two platforms.

[0014] In another embodiment according to any of the previous embodiments, the bulb has a diameter, and a distance defined between an end of the strap remote from the bulb to a point on the bulb furthest spaced from the distance. A ratio of the diameter to the distance is between 0.2 and 0.5.

[0015] In another embodiment according to any of the previous embodiments, the seal is formed of a silicone rubber.

[0016] In another featured embodiment, a gas turbine engine has a fan, a compressor, a combustor, and a turbine. One of the fan, compressor and turbine is provided with a row of static guide vanes, which have an airfoil extending between two radial platforms, with a suction side and a pressure side to both the airfoil and platforms. There are circumferentially adjacent static guide vanes, with a seal secured to a side of each of the platforms remote from the airfoil on one of the circumferentially adjacent vanes. No seal is secured to the other. The seal has a strap secured to the side of the platforms. An enlarged bulb sits outwardly of an edge of the platform and in engagement with the other of the static guide vanes.

[0017] In another embodiment according to the previous embodiment, the bulb has a diameter, and a distance defined between an end of the strap remote from the bulb to a point on the bulb furthest spaced from the end. A ratio of the diameter to the distance is between 0.2 and 0.5.

[0018] In another embodiment according to any of the previous embodiments, the is in the compressor.

[0019] In another embodiment according to any of the previous embodiments, one of the circumferentially adjacent guide vanes is the same one at both of the platforms.

[0020] In another embodiment according to any of the previous embodiments, the seal is formed of a silicone rubber.

[0021] These and other features may be best understood from the following specification and drawings, the following which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Figure 1 schematically shows a gas turbine engine.

[0023] Figure 2 shows a detail of a guide vane.

[0024] Figure 3A shows one side of a guide vane.

[0025] Figure 3B shows an opposed of the guide vane.

[0026] Figure 4 shows adjacent guide vanes and seals.

[0027] Figure 5 shows a detail of a seal.

DETAILED DESCRIPTION

[0028] Figure 1 schematically illustrates a gas turbine engine 20. The gas turbine engine 20 is disclosed herein as a two-spool turbofan that generally incorporates a fan section 22, a compressor section 24, a combustor section 26 and a turbine section 28. Alternative engines might include an augmentor section (not shown) among other systems or features. The fan section 22 drives air along a bypass flow path B in a bypass duct defined within a nacelle 15, while the compressor section 24 drives air along a core flow path C for compression and communication into the combustor section 26 then expansion through the turbine section 28. Although depicted as a turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with turbofans as the teachings may be applied to other types of turbine engines including three-spool architectures.

[0029] The engine 20 generally includes a low speed spool 30 and a high speed spool 32 mounted for rotation about an engine central longitudinal axis A relative to an engine static structure 36 via several bearing systems 38. It should be understood that various bearing systems 38 at various locations may alternatively or additionally be provided.

[0030] The low speed spool 30 generally includes an inner shaft 40 that interconnects a fan 42, a low pressure compressor 44 and a low pressure turbine 46. The inner shaft 40 is connected to the fan 42 through a geared architecture 48 to drive the fan 42 at a lower speed than the low speed spool 30. The high speed spool 32 includes an outer shaft 50 that interconnects a high pressure compressor 52 and high pressure turbine 54. A combustor 56 is arranged between the high pressure compressor 52 and the high pressure turbine 54. A mid-turbine frame 57 of the engine static structure 36 is arranged generally between the high pressure turbine 54 and the low pressure turbine 46. The mid-turbine frame 57 further supports bearing systems 38 in the turbine section 28. The inner shaft 40 and the outer shaft 50 are concentric and rotate via bearing systems 38 about the engine central longitudinal axis A which is collinear with their longitudinal axes.

[0031] The core airflow is compressed by the low pressure compressor 44 then the high pressure compressor 52, mixed and burned with fuel in the combustor 56, then expanded over the high pressure turbine 54 and low pressure turbine 46. The mid-turbine frame 57 includes airfoils 59 which are in the core airflow path. The turbines 46, 54 rotationally drive the respective low speed spool 30 and high speed spool 32 in response to the expansion.

[0032] The engine 20 in one example is a high-bypass geared aircraft engine. In a further example, the engine 20 bypass ratio is greater than about six (6), with an example embodiment being greater than ten (10), the geared architecture 48 is an epicyclic gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3 and the low pressure turbine 46 has a pressure ratio that is greater than about 5. In one disclosed embodiment, the engine 20 bypass ratio is greater than about ten (10:1), the fan diameter is significantly larger than that of the low pressure compressor 44, and the low pressure turbine 46 has a pressure ratio that is greater than about 5:1. Low pressure turbine 46 pressure ratio is pressure measured prior to inlet of low pressure turbine 46 as related to the pressure at the outlet of the low pressure turbine 46 prior to an exhaust nozzle. The geared architecture 48 may be an epicycle gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.5:1. It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine and that the present invention is applicable to other gas turbine engines including direct drive turbofans.

[0033] A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section 22 of the engine 20 is designed for a particular flight condition -- typically cruise at about 0.8 Mach and about 35,000 feet. The flight condition of 0.8 Mach and 35,000 ft, with the engine at its best fuel consumption - also known as “bucket cruise Thrust Specific Fuel Consumption (‘TSFC’)” - is the industry standard parameter of lbm of fuel being burned divided by lbf of thrust the engine produces at that minimum point. “Low fan pressure ratio” is the pressure ratio across the fan blade alone, without a Fan Exit Guide Vane (“FEGV”) system. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.45. “Low corrected fan tip speed” is the actual fan tip speed in ft/sec divided by an industry standard temperature correction of $[(\text{Tram } °\text{R}) / (518.7\ °\text{R})]^{0.5}$. The “Low corrected fan tip speed” as disclosed herein according to one non-limiting embodiment is less than about 1150 ft / second.

[0034] Figure 2 shows a guide vane 80 which is illustrated as a static compressor guide vane. It should be understood that guide vanes utilized in a fan section or even the turbine section may also benefit from teachings of this application. In guide vane 80, an airfoil 81 extends away from an inner platform 78. As shown at 88, an edge of the platform 78 curves relative to the center line A of the engine such as shown in Figure 1.

[0035] A seal 82 has a strap portion 86 secured to an underside 79 of the platform 78.

[0036] A bulb 84 is positioned outward of the edge 88. The bulb 84 is shown to have a hole 110. The seal 82 may be an extrusion, and may be formed of any elastomer that may be appropriate for the environmental conditions that the seal 82 will see during use. Silicone rubber may be used.

[0037] As shown in Figure 3A, the vane 80 has a radially inner platform 102 and a radially outer platform 101 on one side. As shown in Figure 3B, there is also the platform 78 at an inner end, and the platform 100 at a radially outer end of an opposed side. A seal 82 is placed on the Figure 3B side of the platform 78, and a seal 188 at the radially outer platform 100. It should be understood that the platforms 100 and 101 are actually a single platform, as are the platforms 78 and 102 and each wrap around leading and trailing edges of the airfoils 81.

[0038] The combination of Figures 3A and 3B simply show that the seals 82 and 188 are placed on only one side of a vane 80. It should be understood that the seals at the radially inner and outer ends could be placed on opposed sides of the airfoil 81. That is, a seal could be placed on the pressure side of the airfoil 81 at, say, the radially outer location, and on the suction side of the airfoil 81 at a radially inner location. However, as shown in combination, there is typically a seal at only one side of the vane 80 at each of the radially inner and outer locations.

[0039] Figure 4 shows the seal 82 having the bulb 84 secured to platform 78, but also abutting an edge of the platform side 102. Thus, the seal 82 provides an effective seal at the radially inner edge. Similarly, the seal 188 is shown bonded to the platform 112, and abutting the platform 101. Again, the seal 188 will provide an effective seal at the radially outer location. It would also be possible to place a seal on all four platforms of a guide vane 80, and simply not have any on adjacent vanes 80.

[0040] Figure 5 shows a detail of the seal 82, but would this would also be true of the seal 188. A diameter D of the bulb 84 is defined, and in one embodiment was .125 inch (.3175 cm). A length d from an outermost point 200 of the bulb to an innermost location 201 of the strap 86 is defined. In one embodiment, d was .4375 inch (1.111 cm). In embodiments, a ratio of D to d was between 0.2 and 0.5.

[0041] Although an embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

CLAIMS

1. A seal for use with a static guide vane of a gas turbine engine comprising:

a strap member extending to a generally cylindrical bulb, said generally cylindrical bulb form to a diameter, and spaced a distance defined between an end of said strap remote from bulb, to a point on said bulb furthest from said end, and a ratio of said diameter to said distance being between 0.2 and 0.5.

2. The seal as set forth in claim 1, wherein said bulb includes a hollow opening.

3. The seal as set forth in claim 1, wherein said seal is formed of a silicone rubber.

4. A static guide vane for use in a gas turbine engine comprising:

an airfoil extending between two radial platforms, with a suction side and a pressure side to both said airfoil and said platforms; and

a seal secured to a side of each of said platforms remote from said airfoil, said seal having a strap secured to said side of said platforms, and an enlarged bulb sitting outwardly of an edge of said platform.

5. The vane as set forth in claim 4, wherein said vane is designed for use in a compressor section of a gas turbine engine.

6. The vane as set forth in claim 4, wherein there is a seal on only one of said suction and pressure sides at each of said two platforms.

7. The vane as set forth in claim 4, wherein said bulb having a diameter, and a distance defined between an end of said strap remote from said bulb to a point on said bulb furthest spaced from said distance, and a ratio of said diameter to said distance being between 0.2 and 0.5.

8. The vane as set forth in claim 4, wherein said seal is formed of a silicone rubber.

9. A gas turbine engine comprising:

a fan, a compressor, a combustor, and a turbine; and

one of said fan, said compressor and said turbine being provided with a row of static guide vanes, the static guide vanes having an airfoil extending between two radial platforms, with a suction side and a pressure side to both said airfoil and said platforms, and there being circumferentially adjacent static guide vanes, with a seal secured to a side of each of said platforms remote from said airfoil on one of said circumferentially adjacent vanes, and no seal secured to the other, said seal having a strap secured to said side of said platforms, and an enlarged bulb sitting outwardly of an edge of said platform and in engagement with the other of said static guide vanes.

10. The engine as set forth in claim 9, wherein said bulb having a diameter, and a distance defined between an end of said strap remote from said bulb to a point on said bulb furthest spaced from said end, and a ratio of said diameter to said distance being between 0.2 and 0.5.

11. The engine as set forth in claim 9, wherein said vane is in the compressor.

12. The engine as set forth in claim 9, wherein said one of said circumferentially adjacent guide vanes is the same one at both of said platforms.

13. The engine as set forth in claim 9, wherein said seal is formed of a silicone rubber.

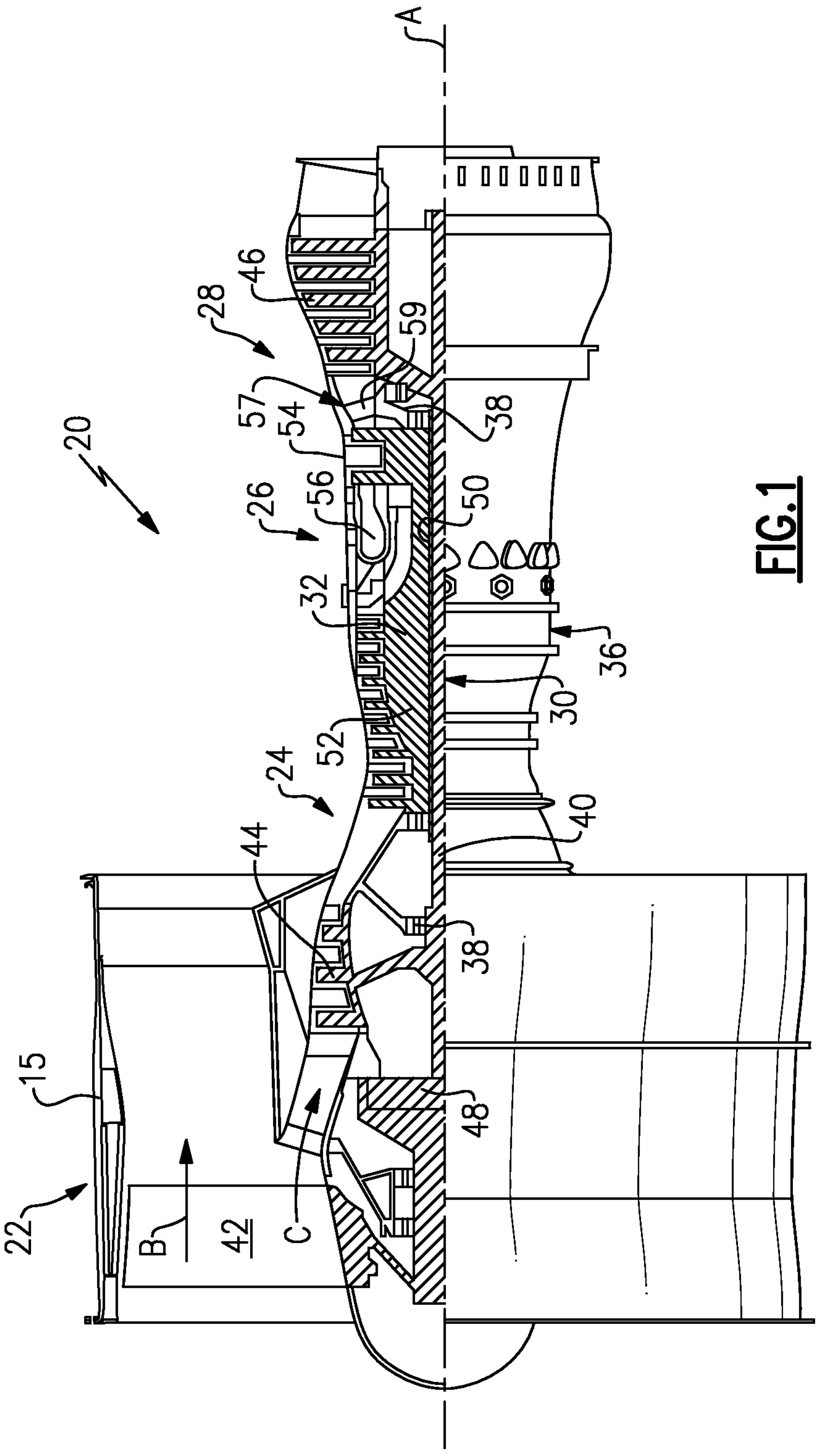

FIG.1

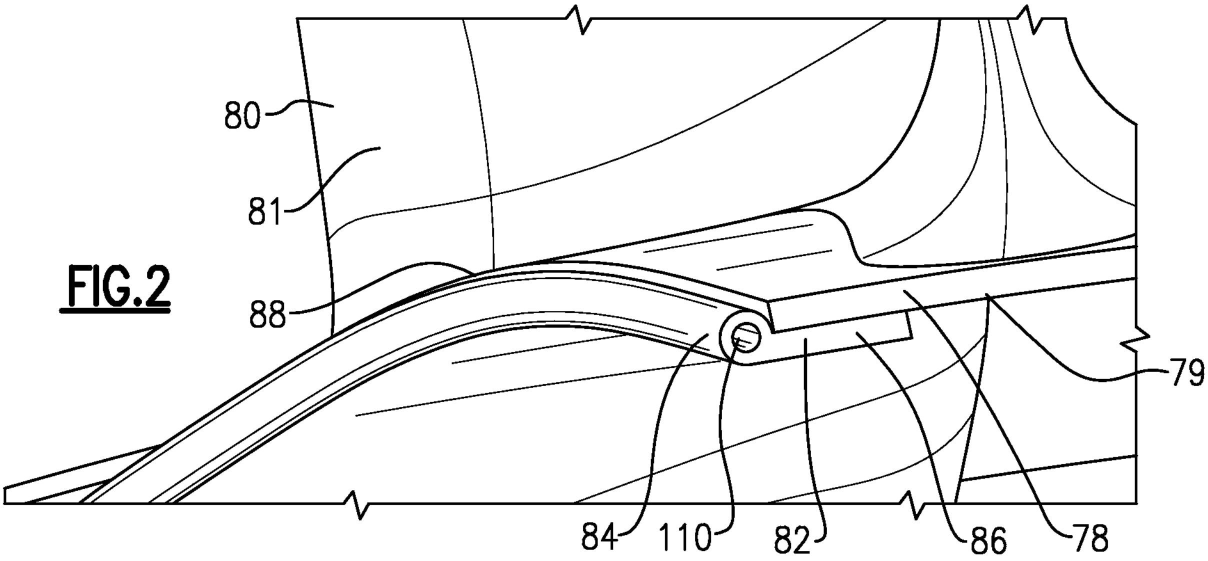

FIG.2

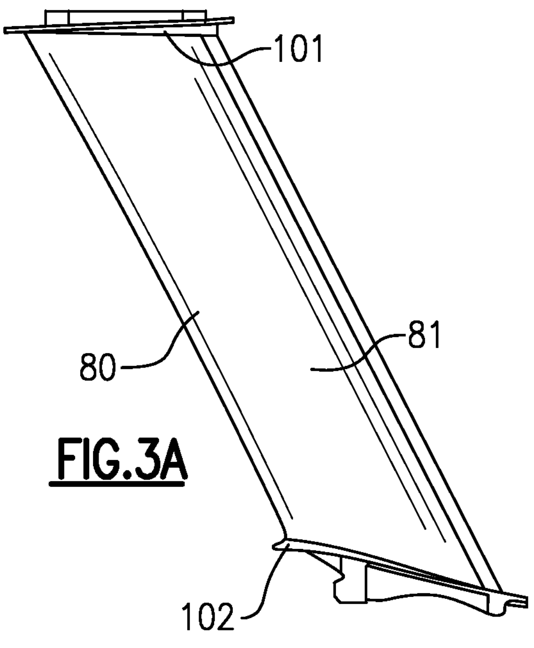

FIG.3A

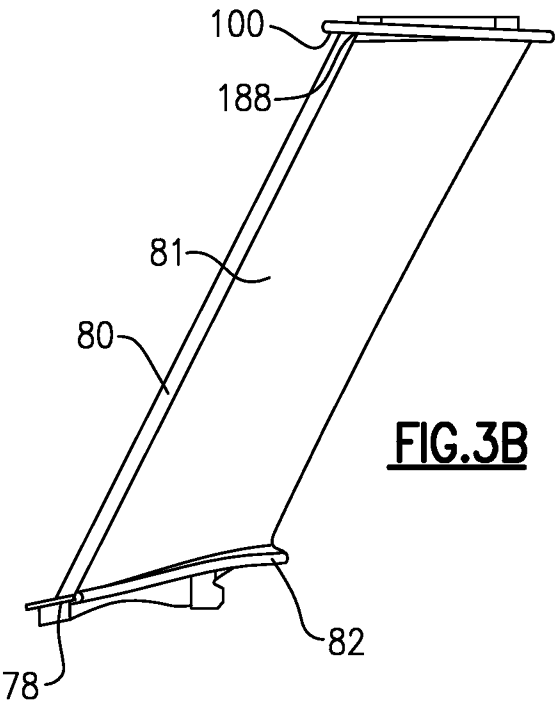

FIG.3B

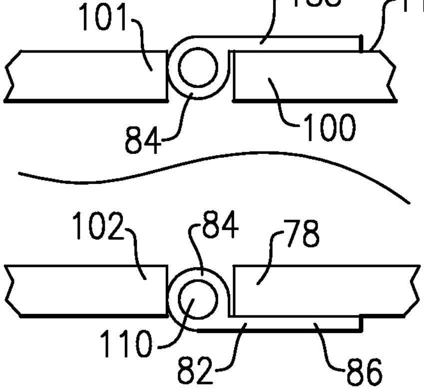

FIG.4

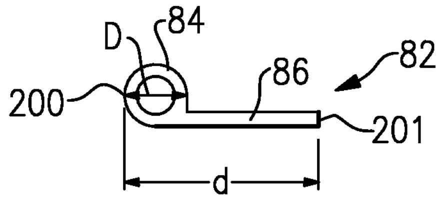

FIG.5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/028515

A. CLASSIFICATION OF SUBJECT MATTER

F01D 9/02(2006.01)i, F02C 7/28(2006.01)i, F02K 3/00(2006.01)i

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 F01D 9/02; F16J 15/02; F01D 5/22; F16J 15/06; F02C 7/28; F02K 3/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: blade, vane, airfoil, platform, seal, bulb, cavity and strap

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2312186 A1 (GENERAL ELECTRIC COMPANY) 20 April 2011 See abstract; paragraphs [0002],[0009],[0011],[0014],[0015],[0017]-[0020]; figures 1-10.	1-13
A	US 2003-0049129 A1 (SCOTT et al.) 13 March 2003 See abstract; paragraphs [0015]-[0020]; figures 1-3.	1-13
A	US 2008-0018056 A1 (EVANS, DALE E.) 24 January 2008 See abstract; paragraphs [0015]-[0019]; figures 3,4.	1-13
A	US 6,514,045 B1 (BARTON et al.) 04 February 2003 See abstract; column 2, lines 21-65; figures 1-6.	1-13
A	US 2007-0158919 A1 (BENNETT, STEPHEN P.) 12 July 2007 See abstract; paragraphs [0021]-[0024]; figures 1-5.	1-13

☐ Further documents are listed in the continuation of Box C. ☒ 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
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 December 2013 (06.12.2013)	**09 December 2013 (09.12.2013)**

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer
HAN, Joong Sub
Telephone No. +82-42-481-5606

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/028515

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2312186 A1	20/04/2011	None	
US 2003-0049129 A1	13/03/2003	US 6579065 B2	17/06/2003
US 2008-0018056 A1	24/01/2008	EP 1881160 A2	23/01/2008
		GB 0614640 D0	30/08/2006
		US 7942636 B2	17/05/2011
US 6514045 B1	04/02/2003	DE 60020190 D1	23/06/2005
		DE 60020190 T2	13/10/2005
		EP 1067274 A1	10/01/2001
		EP 1067274 B1	18/05/2005
		GB 9915637 D0	01/09/1999
US 2007-0158919 A1	12/07/2007	DE 602006007941 D1	03/09/2009
		EP 1808578 A1	18/07/2007
		EP 1808578 B1	22/07/2009
		GB 0600641 D0	22/02/2006
		GB 2434184 A	18/07/2007
		GB 2434184 B	12/12/2007
		US 7360769 B2	22/04/2008