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(54) Title: COMPOUND FILLET FOR GUIDE VANE

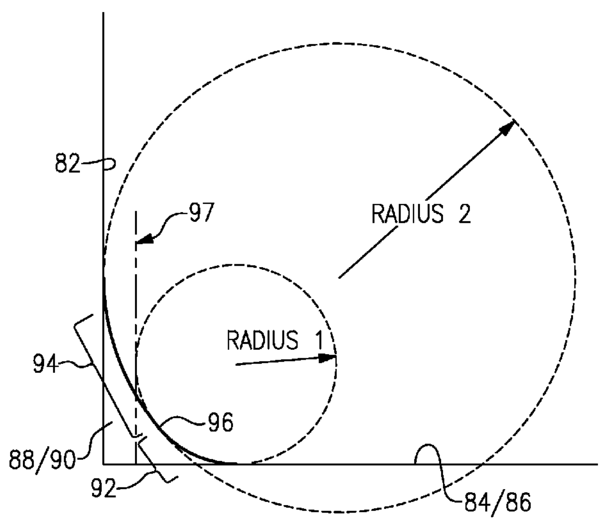

FIG.3

(57) Abstract: A guide vane has an airfoil and a platform at least at one end of the airfoil. A compound fillet blends the airfoil into the platform. The compound fillet has a first portion at a first radius of curvature adjacent to the platform, and a second portion at a second radius of curvature blending from the first portion into the airfoil. The second radius of curvature is different than the first radius of curvature.

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COMPOUND FILLET FOR GUIDE VANE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application Serial No. 61/754096, filed January 18, 2013.

BACKGROUND OF THE INVENTION

[0002] This application relates to a structural guide vane for use in a gas turbine engine.

[0003] Gas turbine engines are known and, typically, include a fan delivering air into a bypass duct, where it provides propulsion for an associated aircraft and further providing air into a compressor. The air is compressed and the compressed air passes downstream into a combustor. The air is mixed with fuel and ignited and products of the combustion pass downstream over turbine rotors, driving them to rotate. The turbine rotors, in turn, drive compressor rotors and the fan.

[0004] Historically, a fan drive turbine drove the fan in a direct drive manner. This required the fan speed to be somewhat higher than may have been desirable.

[0005] More recently, it has been proposed to include a gear reduction between the fan drive turbine and the fan rotor. With this change, the fan can rotate at a slower speed than the rotor. The fan diameter has increased with this change. In addition, a bypass ratio or volume of air delivered into the bypass duct compared to the volume of air delivered into the compressor has increased.

[0006] The increased size in the fan has also required an increase in size in associated structure. In particular, structural guide vanes are included in the fan and are utilized to direct the air. As the fan itself is increased in diameter, so has the structural guide vanes. With this change, it has been proposed to form the structural guide vanes out of lighter weight material. In particular, while traditional fan guide vanes have been formed with titanium, aluminum has been proposed. The aluminum is lighter weight than titanium, but is also not as strong.

[0007] There are areas of an aluminum structural vane subject to high cycle fatigue, low cycle fatigue, impact concerns and/or corrosion concerns. In particular, a fillet or the area where an airfoil of the guide vane merges into a platform is an area of concern.

SUMMARY OF THE INVENTION

[0008] In a featured embodiment, a guide vane has an airfoil and a platform at least at one end of the airfoil. A compound fillet blends the airfoil into the platform. The compound fillet has a first portion at a first radius of curvature adjacent to the platform. A second portion at a second radius of curvature blends the first portion into the airfoil. The second radius of curvature is different than the first radius of curvature.

[0009] In another embodiment according to the previous embodiment, the structural guide vane is for use in a fan section of a gas turbine engine.

[0010] In another embodiment according to any of the previous embodiments, the airfoil has a platform at each of two ends.

[0011] In another embodiment according to any of the previous embodiments, the compound fillet blends the airfoil into a platform that will be a radially inward platform when the guide vane is mounted in a gas turbine engine.

[0012] In another embodiment according to any of the previous embodiments, the airfoil and platform are formed, at least in part, of aluminum.

[0013] In another embodiment according to any of the previous embodiments, the second radius of curvature is greater than the first radius of curvature.

[0014] In another embodiment according to any of the previous embodiments, a ratio of the first radius of curvature to the second radius of curvature is equal to, or between, .05 and .55.

[0015] In another featured embodiment, a fan section has a fan rotor with fan blades. At least one guide vane is positioned adjacent to the fan blades, with the guide vane having an airfoil and a platform at least at one end of the airfoil. A compound fillet blends the airfoil into the platform. The compound fillet has a first portion at a first radius of curvature adjacent to the platform. A second portion at a second radius of curvature blends the first portion into the airfoil. The second radius of curvature is different than the first radius of curvature.

[0016] In another embodiment according to the previous embodiment, the airfoil has a platform at each of two ends.

[0017] In another embodiment according to any of the previous embodiments, the compound fillet blends the airfoil into a platform that will be a radially inward platform when the guide vane is mounted in a gas turbine engine.

[0018] In another embodiment according to any of the previous embodiments, the airfoil and platform are formed, at least in part, of aluminum.

[0019] In another embodiment according to any of the previous embodiments, the second radius of curvature is greater than the first radius of curvature.

[0020] In another embodiment according to any of the previous embodiments, a ratio of the first radius of curvature to the second radius of curvature is equal to, or between, .05 and .55.

[0021] In another featured embodiment, a gas turbine engine has at least one of a fan section, a compressor section and a turbine section. The at least one fan section, compressor section and turbine section has rotating blades and a guide vane mounted adjacent to the rotating blades. The guide vane has an airfoil and a platform at least at one end of the airfoil. A compound fillet blends the airfoil into the platform. The compound fillet has a first portion at a first radius of curvature adjacent to the platform. A second portion at a second radius of curvature blends the first portion into the airfoil. The second radius of curvature is different than the first radius of curvature.

[0022] In another embodiment according to the previous embodiment, the guide vane is in the fan section.

[0023] In another embodiment according to any of the previous embodiments, the airfoil has a platform at each of two ends.

[0024] In another embodiment according to any of the previous embodiments, the compound fillet blends the airfoil into a platform that will be a radially inward platform when the guide vane is mounted in a gas turbine engine.

[0025] In another embodiment according to any of the previous embodiments, the airfoil and platform are formed, at least in part, of aluminum.

[0026] In another embodiment according to any of the previous embodiments, the second radius of curvature is greater than the first radius of curvature.

[0027] In another embodiment according to any of the previous embodiments, a ratio of the first radius of curvature to the second radius of curvature is equal to, or between, .05 and .55.

[0028] These and other features may be best understood from the following drawings and specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Figure 1 schematically shows a gas turbine engine.

[0030] Figure 2 shows a fan guide vane.

[0031] Figure 3 shows a method of generating a compound fillet for the Figure 2 fan guide vane.

DETAILED DESCRIPTION

[0032] 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.

[0033] 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.

[0034] 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.

[0035] 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.

[0036] 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 five. 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.

[0037] 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. As shown, the engine 20 does include a fan exit guide vane 200. 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 $[(\text{Tram } ^\circ\text{R}) / (518.7\ ^\circ\text{R})]^{0.5}$. The "Low corrected fan tip speed" as disclosed herein according to one non-limiting embodiment is less than about 1150 ft / second.

[0038] A gas turbine such as shown in Figure 1 has a fan diameter that is greatly increased over the prior art. As the fan diameter has increased the weight of structure within the fan would increase also, if weight reduction methods were not taken. One method that has been utilized is to use aluminum, rather than titanium, or other stronger materials. Further, as shown in Figure 2, there may be a solid structural guide vane 80, which may be used in place of the fan exit guide vane 200 of Figure 1. On the other hand, this application extends to hollow vanes.

[0039] Thus, it becomes important to ensure that there are not areas of unduly high stress, to minimize high cycle fatigue, and low cycle fatigue, impact and/or corrosion concerns.

[0040] As shown in Figure 2, an airfoil 82 extends between platforms 84 and 86. Fillets 88 and 90 blend the airfoil 82 into the platforms 84/86 at a radially inner end 91 and a radially outer end 93, respectively.

[0041] As shown in Figure 3, the fillets 88/90 may both be compound, and have at least two cylindrical portions. On the other hand, the fillet 90 (which will be at an inner diameter) may be compound with the other fillet 88, a simple fillet (on a single radius of curvature). The compound fillet is defined by two radii and an offset from either the airfoil (82) or platform face (84, 86). The case depicted in Figure 3 is a compound fillet with airfoil offset; denoting the tertiary face used to construct the fillet is offset from the airfoil, not platform. The small circular radius is positioned to be tangent to the platform surface (84,86) and tangent to the offset face (97). The large circular radius is positioned to be tangent to the airfoil surface (82) and the small circular radius. The combination of the adjoining arc segments from the small and large radius circles (92,94) at location (96) form the compound fillet bridging the airfoil (82) and platform surfaces (84, 86)

[0042] The compound could also vary along the chord of the airfoil 82. The small and large radii can vary as a function of chord. This would be referred to as a variable compound fillet.

[0043] This compound blend significantly reduces stress in geometries where maintaining an appropriate stiffness and mass is necessary. Applicant has found it is desirable to have a large radius on the airfoil side of the blend (the second portion 94) so that the change in stiffness from a thin airfoil section to the thicker fillet is smooth and gradual. A smaller radius (forming section 92) reduces a stiffness adjacent to the platform runout so that the airfoil to fillet transition is not as abrupt, and stress at the airfoil to fillet runout is minimized.

[0044] The feature is particularly useful in vanes generally formed of aluminum.

[0045] It is preferred that a ratio of the radius of the first portion 92 (radius 1) to the radius of the second portion 94 (radius 2) is equal to, or between, five percent and fifty-five percent. In one embodiment the radius 1 might be .35 in, while the radius 2 might be 2.0 in. On the other hand, a compound radius where radius 1 is greater than radius 2, may also come within the scope of this application. Broadly, the compound radius simply requires the first and second radii be different.

[0046] Further, in designing and selecting the offset, there is a trade off in that the greater the offset from the platform 84/86, as well as the offset from the airfoil 82, there is more material which effects the aerodynamic operation of the vane 80. On the other hand, the greater the offset the more relief of stress that occurs.

[0047] A worker of ordinary skill in this art would recognize how to balance these competing features.

[0048] 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 guide vane comprising:

an airfoil and a platform at least at one end of said airfoil; and

a compound fillet blending said airfoil into said platform, said compound fillet having a first portion at a first radius of curvature adjacent to said platform, and a second portion at a second radius of curvature blending from said first portion into said airfoil, with said second radius of curvature being different than said first radius of curvature.

2. The guide vane as set forth in claim 1, wherein said structural guide vane is for use in a fan section of a gas turbine engine.

3. The guide vane as set forth in claim 1, wherein said airfoil having a platform at each of two ends.

4. The guide vane as set forth in claim 1, wherein said compound fillet blends said airfoil into a platform that will be a radially inward platform when the guide vane is mounted in a gas turbine engine.

5. The guide vane as set forth in claim 1, wherein said airfoil and said platform are formed, at least in part, of aluminum.

6. The guide vane as set forth in claim 1, wherein the second radius of curvature is greater than said first radius of curvature.

7. The guide vane as set forth in claim 6, wherein a ratio of the first radius of curvature to the second radius of curvature is equal to, or between, .05 and .55.

8. A fan section comprising:

a fan rotor having fan blades;

at least one guide vane positioned adjacent to said fan blades, with said guide vane having an airfoil and a platform at least at one end of said airfoil; and

a compound fillet blending said airfoil into said platform, said compound fillet having a first portion at a first radius of curvature adjacent to said platform, and a second portion at a second radius of curvature blending from said first portion into said airfoil, with said second radius of curvature being different than said first radius of curvature.

9. The fan section as set forth in claim 8, wherein said airfoil having a platform at each of two ends.

10. The fan section as set forth in claim 8, wherein said compound fillet blends said airfoil into a platform that is a radially inner platform.

11. The fan section as set forth in claim 8, wherein said airfoil and said platform are formed, at least in part, of aluminum.

12. The fan section as set forth in claim 8, wherein the second radius of curvature is greater than said first radius of curvature.

13. The fan section as set forth in claim 12, wherein a ratio of the first radius of curvature to the second radius of curvature is equal to, or between, .05 and .55.

14. A gas turbine engine comprising:

at least one of a fan section, a compressor section and a turbine section, with said at least one of said fan section, said compressor section and said turbine section having rotating blades and a guide vane mounted adjacent to said rotating blades, with said guide vane having an airfoil and a platform at least at one end of said airfoil; and

a compound fillet blending said airfoil into said platform, said compound fillet having a first portion at a first radius of curvature adjacent to said platform, and a second portion at a second radius of curvature blending from said first portion into said airfoil, with said second radius of curvature being different than said first radius of curvature.

15. The gas turbine engine as set forth in claim 14, wherein said guide vane is in said fan section.

16. The gas turbine engine as set forth in claim 14, wherein said airfoil having a platform at each of two ends.

17. The gas turbine engine as set forth in claim 14, wherein said compound fillet blends said airfoil into a platform that is a radially inner platform.

18. The gas turbine engine as set forth in claim 14, wherein said airfoil and said platform are formed, at least in part, of aluminum.

19. The gas turbine engine as set forth in claim 14, wherein the second radius of curvature is greater than said first radius of curvature.

20. The gas turbine engine as set forth in claim 19, wherein a ratio of the first radius of curvature to the second radius of curvature is equal to, or between, .05 and .55.

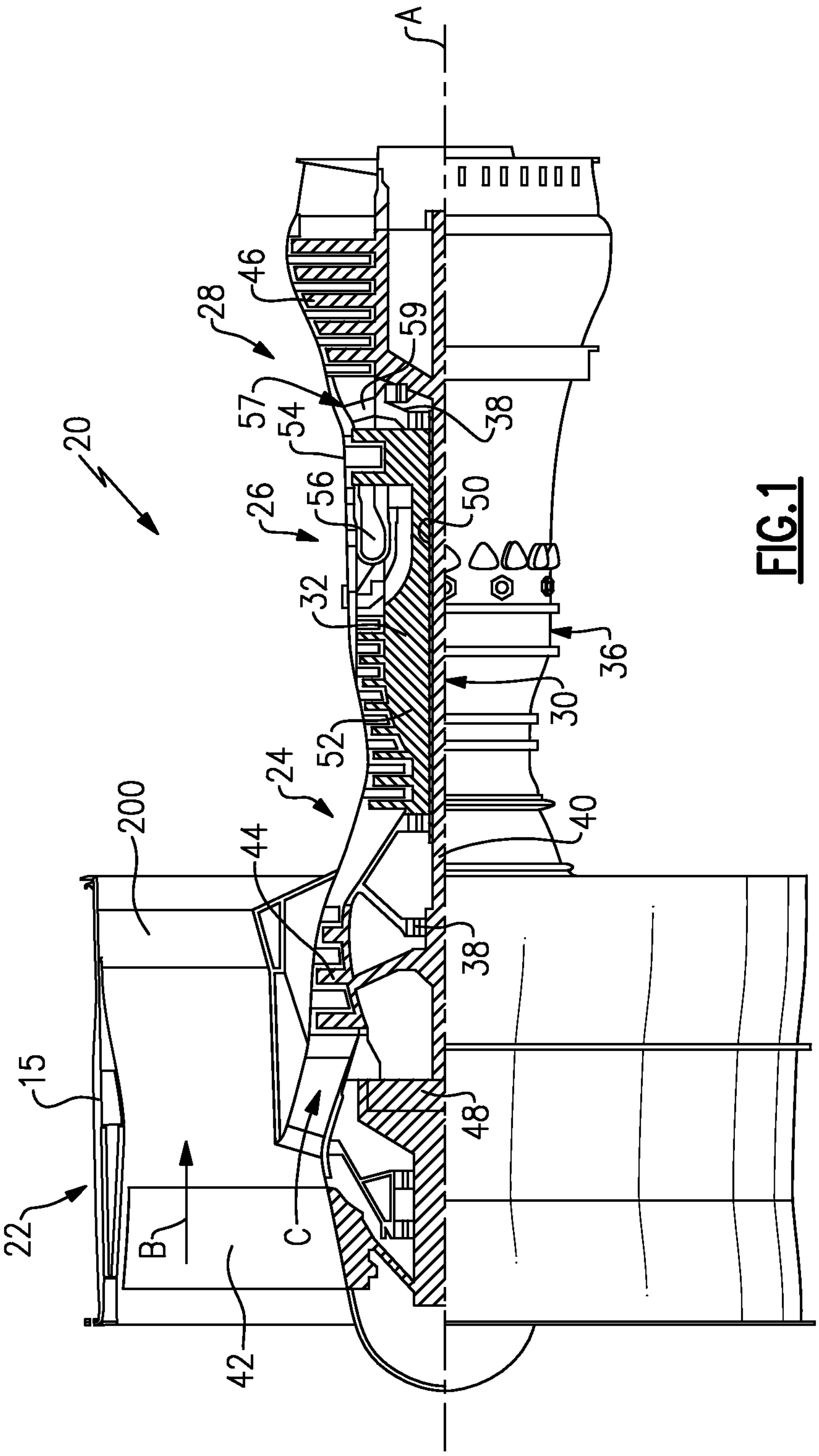
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FIG.1

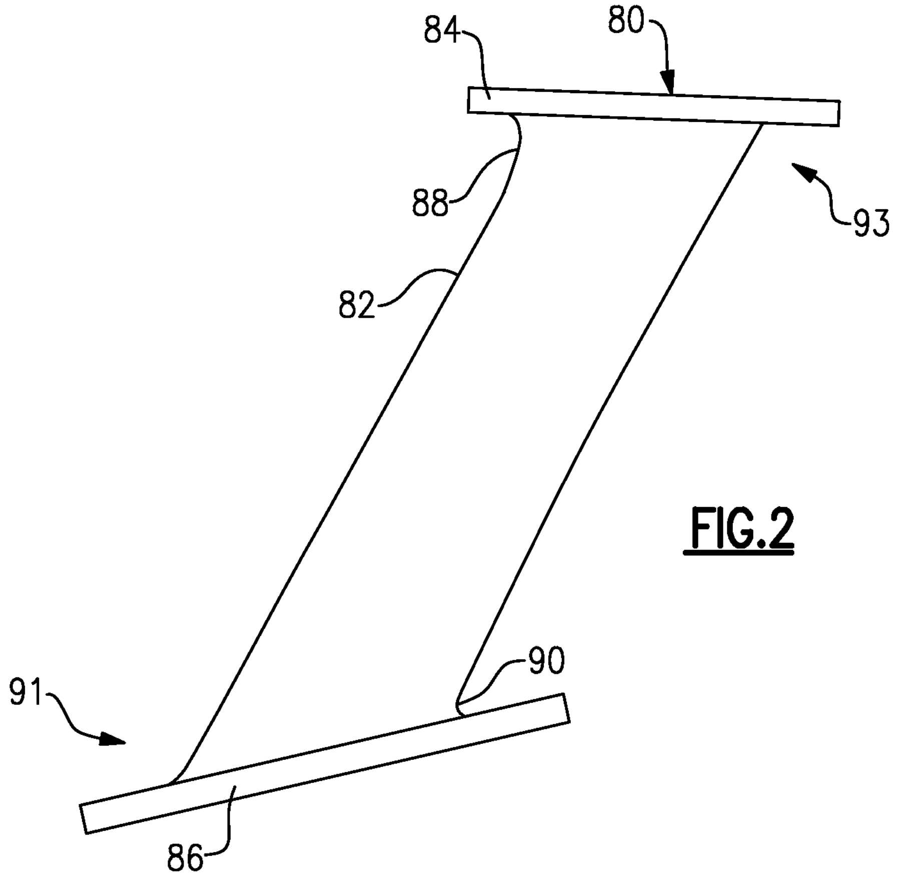

FIG.2

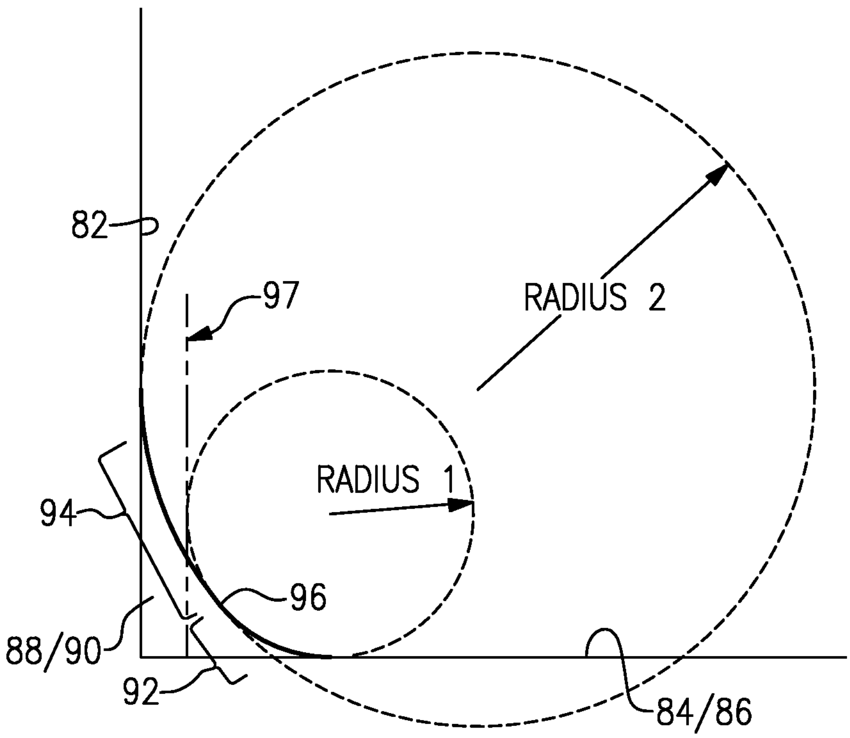

FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/026553

A. CLASSIFICATION OF SUBJECT MATTER

F02K 3/04(2006.01)i, F02K 3/00(2006.01)i, F02C 7/04(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)
F02K 3/04; B23P 15/02; F01D 5/14; F01D 17/16; F01D 17/00; F01D 5/30; F01D 9/00; F02K 3/00; F02C 7/04

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: fillet, airfoil, aerofoil, platform, radius, curvature, aluminum, guide, vane, fan, and rotor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010-0284815 A1 (PARKER et al.) 11 November 2010 See abstract; paragraph [0025]; claims 1,6-8,10 and figures 2,8.	1,3,4,6,7,14,16,17,19,20
Y		2,5,8-13,15,18
Y	EP 1790831 A2 (GENERAL ELECTRIC COMPANY) 30 May 2007 See abstract; claim 1.	2,8-13,15
A		1,3-7,14,16-20
Y	US 4,343,593 A (HARRIS, DAVID J.) 10 August 1982 See abstract; claim 5.	5,11,18
A		1-4,6-10,12-17,19,20
A	US 2006-0275112 A1 (LEE et al.) 7 December 2006 See abstract; paragraph [0027]; claim 1 and figure 1.	1-20
A	EP 2184442 A1 (ALSTOM TECHNOLOGY LTD.) 12 May 2007 See abstract; claim 1 and figures 1,3.	1-20

☐ 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
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"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
08 November 2013 (08.11.2013)	**08 November 2013 (08.11.2013)**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

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