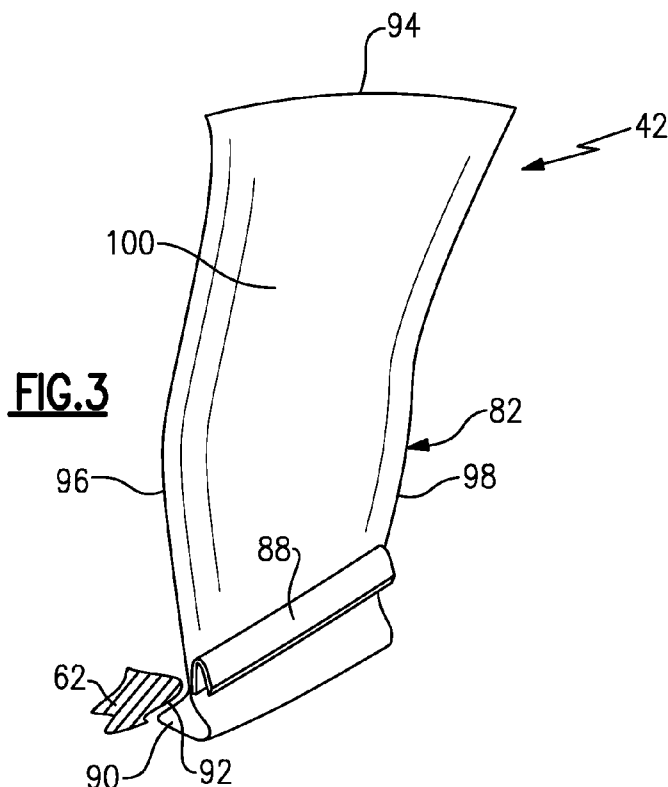




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[Continued on next page]

(54) Title: GAS TURBINE ENGINE FAN BLADE PLATFORM SEAL



(57) Abstract: A fan section for a gas turbine engine includes a fan blade having an airfoil with an exterior surface. A platform seal is adhered to the airfoil. A fan section for a gas turbine engine includes a fan hub having a slot. A fan blade includes an airfoil extending from a root to a tip. The root is received in the slot. A platform is secured to the fan hub and is arranged between adjacent fan blades. A seal has a base secured to opposing sides of the fan blade and a flap integral with and extending from the base portion and canted toward the root and engaging the platform to provide a sealed inner flow path.



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GAS TURBINE ENGINE FAN BLADE PLATFORM SEAL

BACKGROUND

[0001] This disclosure relates to a fan blade for a gas turbine engine. More particularly, the application relates to a seal arrangement for the fan section inner flow path surface.

[0002] A gas turbine engine typically includes a fan section, a compressor section, a combustor section and a turbine section. Air entering the compressor section is compressed and delivered into the combustor section where it is mixed with fuel and ignited to generate a high-speed exhaust gas flow. The high-speed exhaust gas flow expands through the turbine section to drive the compressor and the fan section. The compressor section typically includes low and high pressure compressors, and the turbine section includes low and high pressure turbines.

[0003] One type of gas turbine engine includes a fan drive gear system having a fan section with relatively large fan blades. One type of fan section utilizes platforms between adjacent fan blades that are supported by a fan hub to which the fan blades are also secured. Typically, the platform includes seals adhered to platform walls adjacent to the fan blades exterior airfoil surface. The seals obstruct a gap between the platform and the fan blade to provide a more aerodynamic inner flow path surface by eliminating leakage at the fan blade-platform interface.

[0004] The platforms may be difficult to install between the fan blades since the seals must be deformed as the platforms are inserted from a radially outward direction toward the rotational axis of the fan section. The seals must be lubricated and pushed down.

SUMMARY

[0005] In one exemplary embodiment, a fan section for a gas turbine engine includes a fan blade having an airfoil with an exterior surface. A platform seal is adhered to the airfoil.

[0006] In a further embodiment of any of the above, the seal extends about a perimeter of the airfoil.

[0007] In a further embodiment of any of the above, the perimeter includes pressure and suction sides and leading and trailing edges.

[0008] In a further embodiment of any of the above, the seal includes a base and a flap adjoining the base. The flap is canted toward a root of the blade, which supports the airfoil.

[0009] In a further embodiment of any of the above, the seal has a generally U-shaped cross-section.

[0010] In a further embodiment of any of the above, the seal has a generally Y-shaped cross-section.

[0011] In a further embodiment of any of the above, the seal includes a notch provided between the base and flap to provide a weakened area increasing flexibility of the flap relative to the base.

[0012] In a further embodiment of any of the above, the seal is generally L-shaped.

[0013] In a further embodiment of any of the above, the seal is constructed from an elastomeric material.

[0014] In a further embodiment of any of the above, the elastomeric material is a silicone rubber.

[0015] In a further embodiment of any of the above, the fan section includes an epoxy securing the seal to the fan blade.

[0016] In a further embodiment of any of the above, the seal is covered in a fabric. The fabric is adhered to the airfoil.

[0017] In a further embodiment of any of the above, the fan section includes a fan hub. A root of the fan blade is received by a slot in the fan hub and a platform is secured to the fan hub and arranged between adjacent fan blades. A seal is provided on opposing sides of the fan blade and engages the platform to provide a sealed inner flow path.

[0018] In another exemplary embodiment, a fan section for a gas turbine engine includes a fan hub having a slot. A fan blade includes an airfoil extending from a root to a tip. The root is received in the slot. A platform is secured to the fan hub and is arranged

between adjacent fan blades. A seal has a base secured to opposing sides of the fan blade and a flap integral with and extending from the base portion and canted toward the root and engaging the platform to provide a sealed inner flow path.

[0019] In a further embodiment of any of the above, the seal extends about the perimeter of the airfoil.

[0020] In a further embodiment of any of the above, the seal has a generally U-shaped cross-section.

[0021] In a further embodiment of any of the above, the seal has a generally Y-shaped cross-section.

[0022] In a further embodiment of any of the above, the seal is generally L-shaped.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The disclosure can be further understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0024] Figure 1 schematically illustrates a gas turbine engine embodiment.

[0025] Figure 2A is a perspective view of a portion of a fan section having fan blades and discrete platforms.

[0026] Figure 2B is a schematic cross-sectional view through a portion of the fan section shown in Figure 2A.

[0027] Figure 2C is a schematic perspective view of the fan section with the nose cone removed.

[0028] Figure 3 is a perspective view of an example fan blade for the gas turbine engine of Figure 1.

[0029] Figure 4A is a cross-sectional view of one example fan blade and seal arrangement.

[0030] Figure 4B is a cross-sectional view of another example fan blade and seal arrangement.

[0031] Figure 4C is a cross-sectional view of yet another example fan blade and seal arrangement.

[0032] Figure 4D is a cross-sectional view of the example fan blade and seal arrangement shown in Figure 3.

[0033] Figure 5 is a plan view illustrating a seal wrapped about a perimeter of the fan blade.

DETAILED DESCRIPTION

[0034] Figure 1 schematically illustrates an example gas turbine engine 20 that includes a fan section 22, a compressor section 24, a combustor section 26 and a turbine section 28. Alternative engines might include an augmenter section (not shown) among other systems or features. The fan section 22 drives air along a bypass flow path B while the compressor section 24 draws air in along a core flow path C where air is compressed and communicated to a combustor section 26. In the combustor section 26, air is mixed with fuel and ignited to generate a high pressure exhaust gas stream that expands through the turbine section 28 where energy is extracted and utilized to drive the fan section 22 and the compressor section 24.

[0035] Although the disclosed non-limiting embodiment depicts a turbofan gas turbine engine, 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; for example a turbine engine including a three-spool architecture in which three spools concentrically rotate about a common axis and where a low spool enables a low pressure turbine to drive a fan via a gearbox, an intermediate spool that enables an intermediate pressure turbine to drive a first compressor of the compressor section, and a high spool that enables a high pressure turbine to drive a high pressure compressor of the compressor section.

[0036] The example 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.

[0037] The low speed spool 30 generally includes an inner shaft 40 that connects a fan having fan blades 42 and a low pressure (or first) compressor section 44 to a low pressure (or first) turbine section 46. The inner shaft 40 drives the fan blades 42 through a speed change device, such as a geared architecture 48, to drive the fan blades 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 (or second) compressor section 52 and a high pressure (or second) turbine section 54. The inner shaft 40 and the outer shaft 50 are concentric and rotate via the bearing systems 38 about the engine central longitudinal axis A.

[0038] A combustor 56 is arranged between the high pressure compressor 52 and the high pressure turbine 54. In one example, the high pressure turbine 54 includes at least two stages to provide a double stage high pressure turbine 54. In another example, the high pressure turbine 54 includes only a single stage. As used herein, a “high pressure” compressor or turbine experiences a higher pressure than a corresponding “low pressure” compressor or turbine.

[0039] The example low pressure turbine 46 has a pressure ratio that is greater than about 5. The pressure ratio of the example low pressure turbine 46 is measured prior to an inlet of the low pressure turbine 46 as related to the pressure measured at the outlet of the low pressure turbine 46 prior to an exhaust nozzle.

[0040] 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 as well as setting airflow entering the low pressure turbine 46.

[0041] The core airflow C is compressed by the low pressure compressor 44 then by the high pressure compressor 52 mixed with fuel and ignited in the combustor 56 to produce high speed exhaust gases that are then expanded through the high pressure turbine 54 and low pressure turbine 46. The mid-turbine frame 57 includes vanes 59, which are in the core airflow path and function as an inlet guide vane for the low pressure turbine 46. Utilizing the vane 59 of the mid-turbine frame 57 as the inlet guide vane for low pressure turbine 46 decreases the length of the low pressure turbine 46 without increasing the axial length of the mid-turbine frame 57. Reducing or eliminating the number of vanes in the low

pressure turbine 46 shortens the axial length of the turbine section 28. Thus, the compactness of the gas turbine engine 20 is increased and a higher power density may be achieved.

[0042] The disclosed gas turbine engine 20 in one example is a high-bypass geared aircraft engine. In a further example, the gas turbine engine 20 includes a bypass ratio greater than about six (6), with an example embodiment being greater than about ten (10). The example geared architecture 48 is an epicyclical gear train, such as a planetary gear system, star gear system or other known gear system, with a gear reduction ratio of greater than about 2.3.

[0043] In one disclosed embodiment, the gas turbine engine 20 includes a bypass ratio greater than about ten (10:1) and the fan diameter is significantly larger than an outer diameter of the low pressure compressor 44. It should be understood, however, that the above parameters are only exemplary of one embodiment of a gas turbine engine including a geared architecture and that the present disclosure is applicable to other gas turbine engines.

[0044] 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 pound-mass (lbm) of fuel per hour being burned divided by pound-force (lbf) of thrust the engine produces at that minimum point.

[0045] “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 1.50. In another non-limiting embodiment the low fan pressure ratio is less than about 1.45.

[0046] “Low corrected fan tip speed” is the actual fan tip speed in ft/sec divided by an industry standard temperature correction of $[(T_{\text{ram}} \text{ } ^\circ\text{R}) / (518.7 \text{ } ^\circ\text{R})]^{0.5}$. The “Low corrected fan tip speed”, as disclosed herein according to one non-limiting embodiment, is less than about 1150 ft/second.

[0047] The fan section 22 is shown in more detail in Figures 2A-2C. The fan section 22 includes multiple circumferentially arranged fan blades 42. The fan blades 42 include non-integral, discrete platforms 60, or spacers, arranged between adjacent fan blades

42. Referring to Figures 2A and 2B, the fan blades 42 are mounted to a fan hub 62. A nose cone 64 is arranged forward of the fan blades 42 to provide an aerodynamic inner flowpath through the fan section 22 along with the platforms 60. The nose cone 64 is provided by a spinner 66 secured to the fan hub 62 by fasteners 68. A cap 70 is secured to the spinner 66 by fasteners 72.

[0048] Referring to Figure 2B, the platform 60 includes first and second flanges 74, 76 secured to corresponding attachment features on the fan hub 62 respectively by fasteners 78, 80. The fasteners 68, 72, 78, 80 are schematically depicted in Figures 2A and 2B by simple, thickened lines for clarity.

[0049] Referring to Figure 2C, each fan blade 42 has an airfoil 82. Each platform 60 has an outer surface 84, which together form a ring with the other platforms 60, spaced about axis A to provide an aerodynamic inner flow path surface. Though close fitting, a circumferential gap 86 exists between each platform outer surface 84 and an adjacent fan blade 42. Each gap 86 is blocked with a seal 88 to minimize a loss of airflow through the gas turbine engine 10.

[0050] Referring to Figure 3, the fan blade 42 is illustrated having a root 90 received in a correspondingly shaped slot 92 of the fan hub 62. The fan blade 42 includes an airfoil 82 extending from the root 90 to a tip 94. The airfoil 82 extends from leading and trailing edges 96, 98 and spaced apart pressure and suction sides to provide an exterior surface 100. In the example, the fan blade 42 is “platformless” in that it lacks a platform extending circumferentially from the base of the airfoil. Instead, the discrete platforms 60 are used, which are sealed to improve the aerodynamic efficiency of the fan section 22, as described above.

[0051] To this end, the seal 88 is secured to the fan blade 42, for example, to the airfoil 82, as shown in Figures 3 and 4D. The seal 88 may be constructed from an elastomeric material, such as a silicone rubber and/or covered by a protective fabric that also aids in bonding. The adhesive is applied to the fabric to secure the seal 88 to the airfoil 82. The seal 88 may be secured to the fan blade 42 using an adhesive 110, such as an epoxy.

[0052] Seals having various profiles may be used, as schematically illustrated in Figures 4A-4D. Of course, it should be understood that other seal profiles may be desirable. Generally, the seals include flaps that are angled toward the root of the fan blade. As a result,

the platforms can be installed more easily from a position radially outward from the fan hub since the flaps will simply deflect inward toward the fan blade during installation. The flaps load in the radial outward direction during engine operation, which improves sealing against an adjacent lateral wall 106 of the platform, as shown in Figure 2C.

[0053] Referring to Figure 4A, a Y-shaped seal 188 includes a base 118 having an integral flap 114 extending toward the fan blade root. A notch 112 is provided between the flap 114 and the base 118 to provide a weakened area that increases the flexibility of the flap 114 downward toward the root. The adhesive 120 secures the base 118 to the exterior surface 100.

[0054] Referring to Figure 4B, a simplified Y-shaped seal 288 is illustrated. The base 218 is secured to the exterior surface 100 by adhesive 220. The flap 214, which has a generally uniform thickness, is canted toward the root. The larger base of the Y-shaped configuration provides additional bonding surface for the seal.

[0055] A generally L-shaped seal 388 is illustrated in Figure 4C. The base 318 and the flap 314 are oriented at an obtuse angle relative to one another. The base 318 is secured to the exterior surface 100 by adhesive 320.

[0056] As shown in Figures 3 and 4D, a generally U-shaped seal 88 is provided in which a smooth contour is provided between the base 108 and flap 104. The base 108 is secured to the exterior surface 100 by adhesive 110.

[0057] In the example shown in Figure 3, a pair of separate seals 88 is provided on the pressure and suction sides. As shown in Figure 5, the seal 88 may be provided about the perimeter 102 of the exterior surface 100 to extend around the leading and trailing edges 96, 98. Of course, any shaped seal may be used. Also, if desired, the seal may wrap about only about one of the leading and trailing edges.

[0058] Although an example embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of the claims. For that reason, the following claims should be studied to determine their true scope and content.

CLAIMS

What is claimed is:

1. A fan section for a gas turbine engine comprising:
a fan blade having an airfoil with an exterior surface; and
a platform seal adhered to the airfoil.
2. The fan section according to claim 1, wherein the seal extends about a perimeter of the airfoil.
3. The fan section according to claim 2, wherein the perimeter includes pressure and suction sides and leading and trailing edges.
4. The fan section according to claim 1, wherein the seal includes a base and a flap adjoining the base, the flap is canted toward a root of the blade, which supports the airfoil.
5. The fan section according to claim 4, wherein the seal has a generally U-shaped cross-section.
6. The fan section according to claim 4, wherein the seal has a generally Y-shaped cross-section.
7. The fan section according to claim 6, wherein the seal includes a notch provided between the base and flap to provide a weakened area increasing flexibility of the flap relative to the base.
8. The fan section according to claim 4, wherein the seal is generally L-shaped.

9. The fan section according to claim 1, wherein the seal is constructed from an elastomeric material.

10. The fan section according to claim 9, wherein the elastomeric material is a silicone rubber.

11. The fan section according to claim 9, comprising an epoxy securing the seal to the fan blade.

12. The fan section according to claim 9, wherein the seal is covered in a fabric, the fabric adhered to the airfoil.

13. The fan section according to claim 1, comprising a fan hub, and a root of the fan blade received by a slot in the fan hub, and a platform secured to the fan hub and arranged between adjacent fan blades, a seal provided on opposing sides of the fan blade and engaging the platform to provide a sealed inner flow path.

14. A fan section for a gas turbine engine comprising:
a fan hub having a slot;
a fan blade including an airfoil extending from a root to a tip, the root received in the slot;
a platform secured to the fan hub and arranged between adjacent fan blades;
and
a seal having a base secured to opposing sides of the fan blade, and a flap integral with and extending from the base portion and canted toward the root and engaging the platform to provide a sealed inner flow path.

15. The fan section according to claim 14, wherein the seal extends about the perimeter of the airfoil.

16. The fan section according to claim 14, wherein the seal has a generally U-shaped cross-section.

17. The fan section according to claim 14, wherein the seal has a generally Y-shaped cross-section.

18. The fan section according to claim 14, wherein the seal is generally L-shaped.

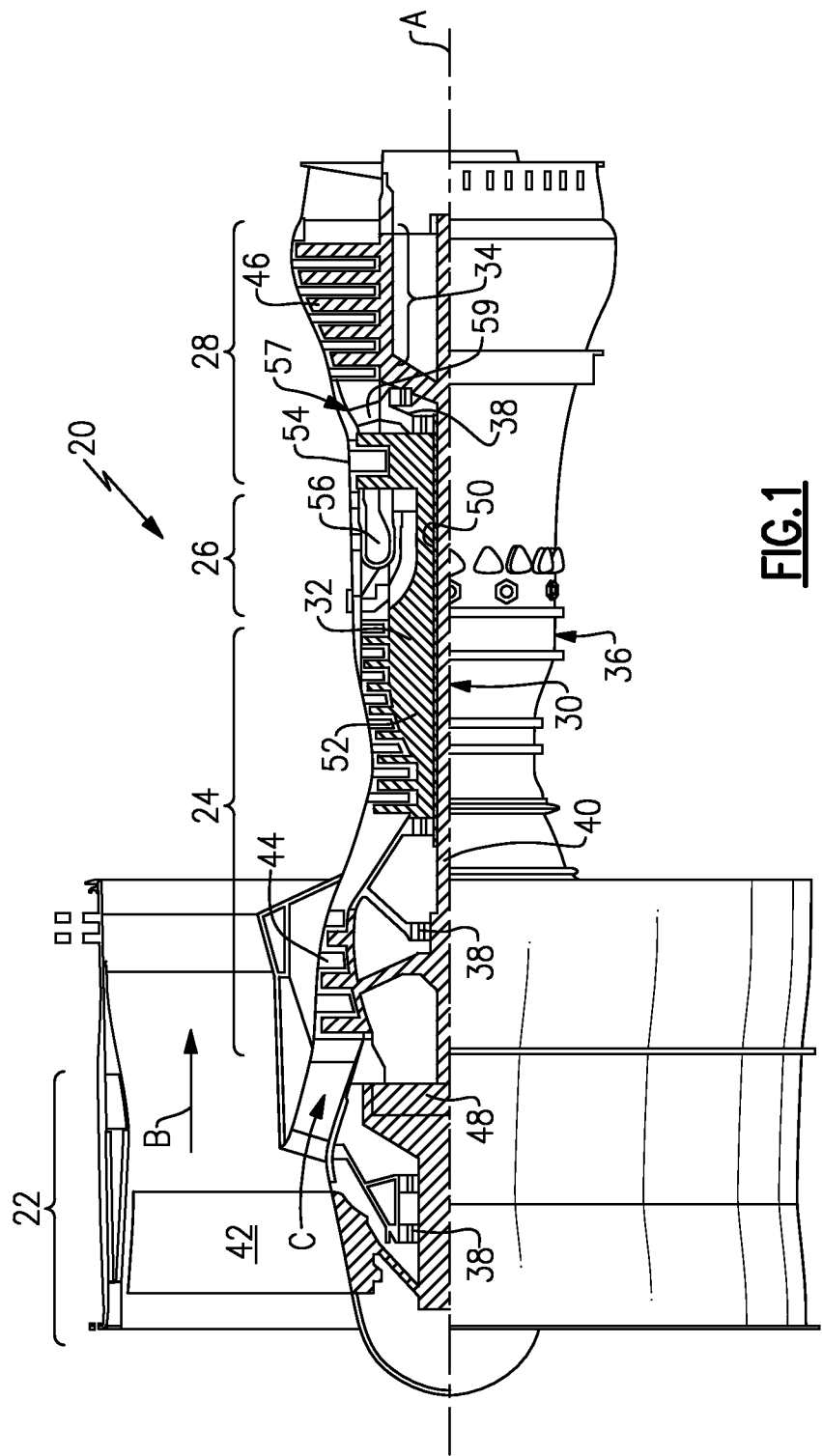


FIG.2A

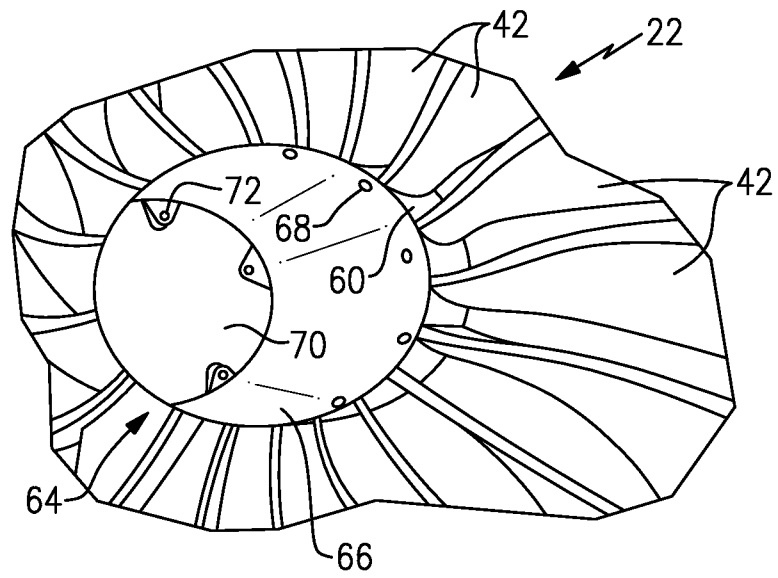


FIG.2B

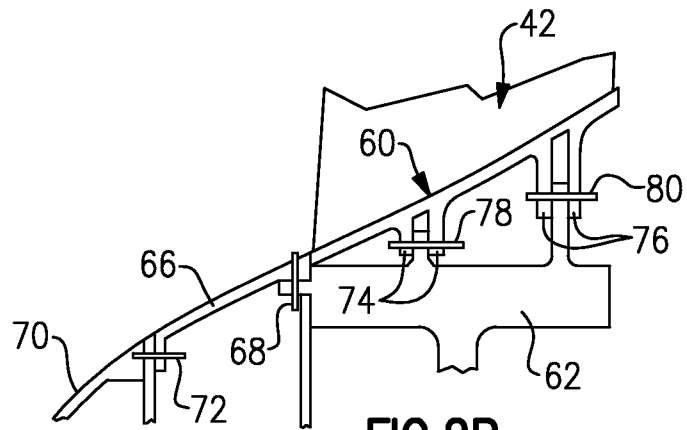
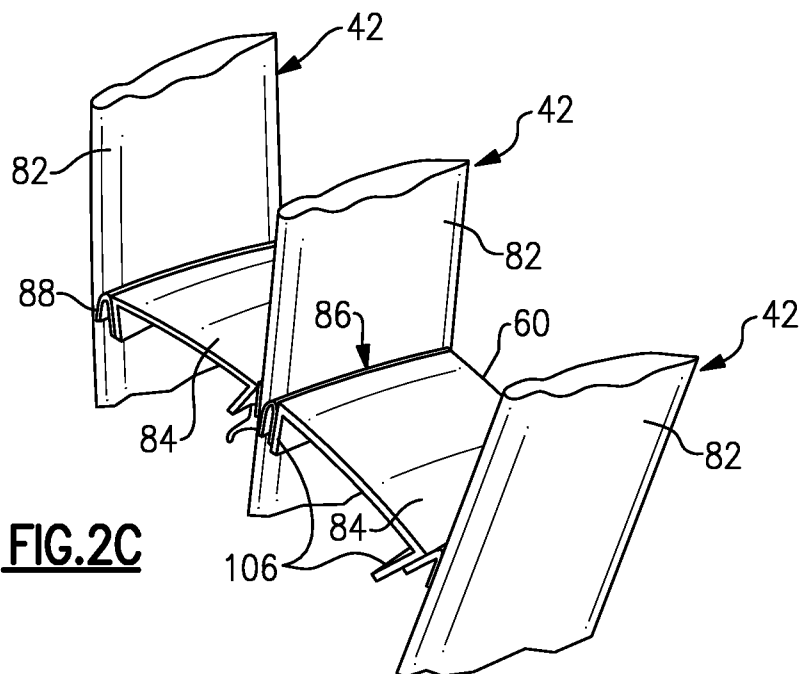
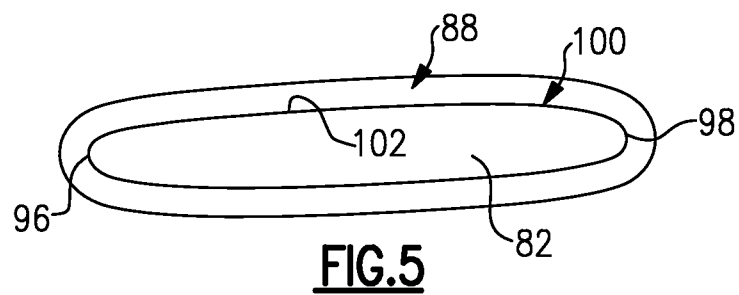
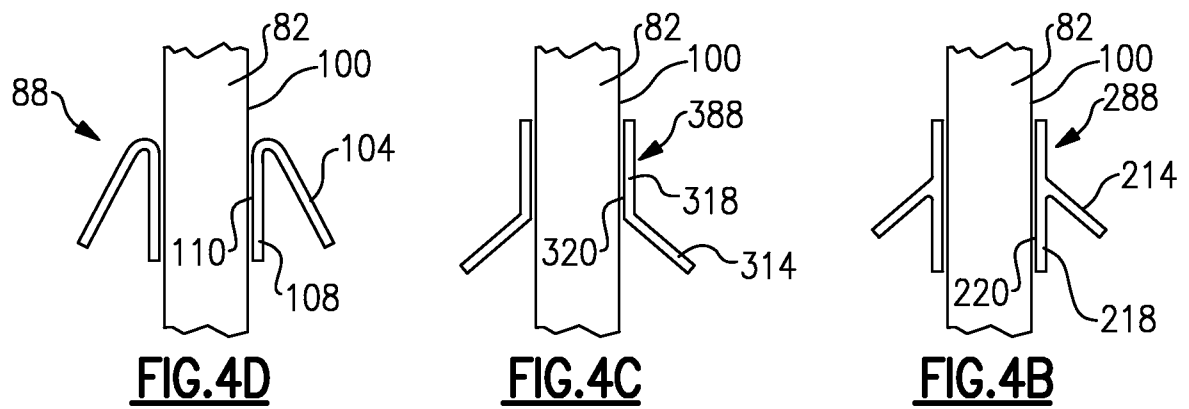
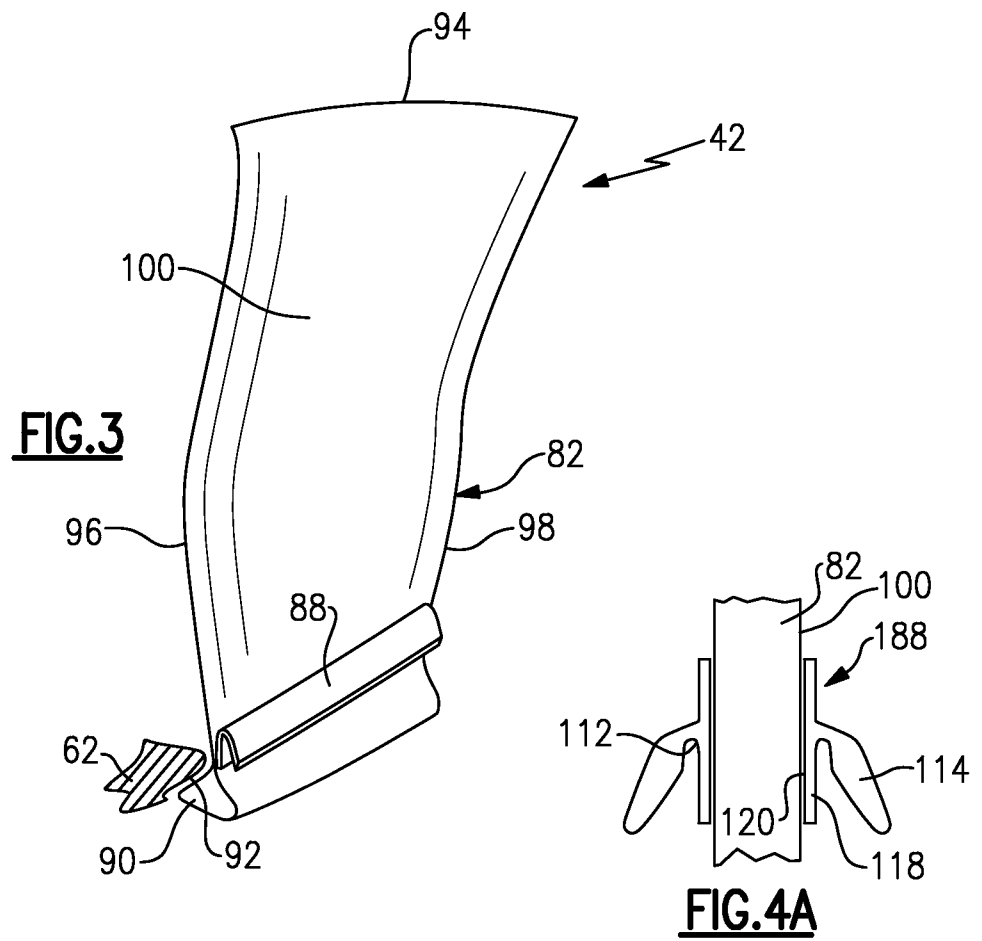


FIG.2C





INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/070096**A. CLASSIFICATION OF SUBJECT MATTER****F01D 5/20(2006.01)i, F01D 11/08(2006.01)i, F02C 7/28(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)

F01D 5/20; F02C 7/28; F16J 15/02; F01D 5/22; F01D 5/00; F02C 7/18; F01D 5/02; F01D 11/08

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, seal, epoxy, fabric, and platform

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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A	US 2011-0243744 A1 (FORGUE et al.) 6 October 2011 See abstract, paragraphs [0003],[0029], claim 10, and figures 1,3.	1-18
A	US 2011-0217158 A1 (GRISSINO et al.) 8 September 2011 See abstract, claim 1, and figure 3.	1-18



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/070096

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