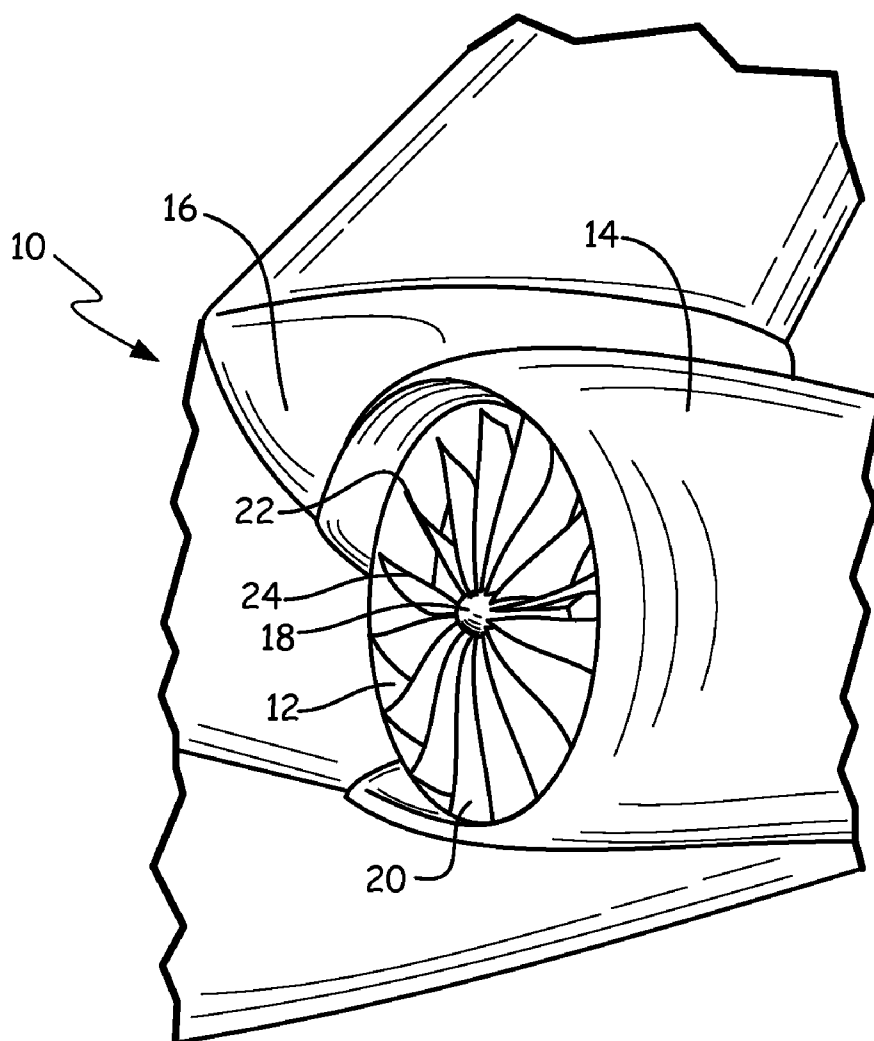




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(19) **United States**(12) **Patent Application Publication**
Suciu et al.(10) **Pub. No.: US 2014/0169972 A1**(43) **Pub. Date: Jun. 19, 2014**(54) **FAN WITH INTEGRAL SHROUD****Publication Classification**(71) Applicant: **UNITED TECHNOLOGIES CORPORATION**, Hartford, CT (US)(51) **Int. Cl.**
F01D 5/22 (2006.01)(72) Inventors: **Gabriel L. Suciu**, Glastonbury, CT (US); **Jesse M. Chandler**, South Windsor, CT (US); **Brian D. Merry**, Andover, CT (US)(52) **U.S. Cl.**
CPC **F01D 5/225** (2013.01)
USPC **416/189**(73) Assignee: **UNITED TECHNOLOGIES CORPORATION**, Hartford, CT (US)(57) **ABSTRACT**(21) Appl. No.: **13/716,959**

An integrally bladed rotor for use in a gas turbine engine includes a central hub; a plurality of airfoils extending from the central hub, each airfoil with a tip, a leading edge and a trailing edge; and a shroud with a metallic portion connecting to the tip of each airfoil to rotate with the airfoils.

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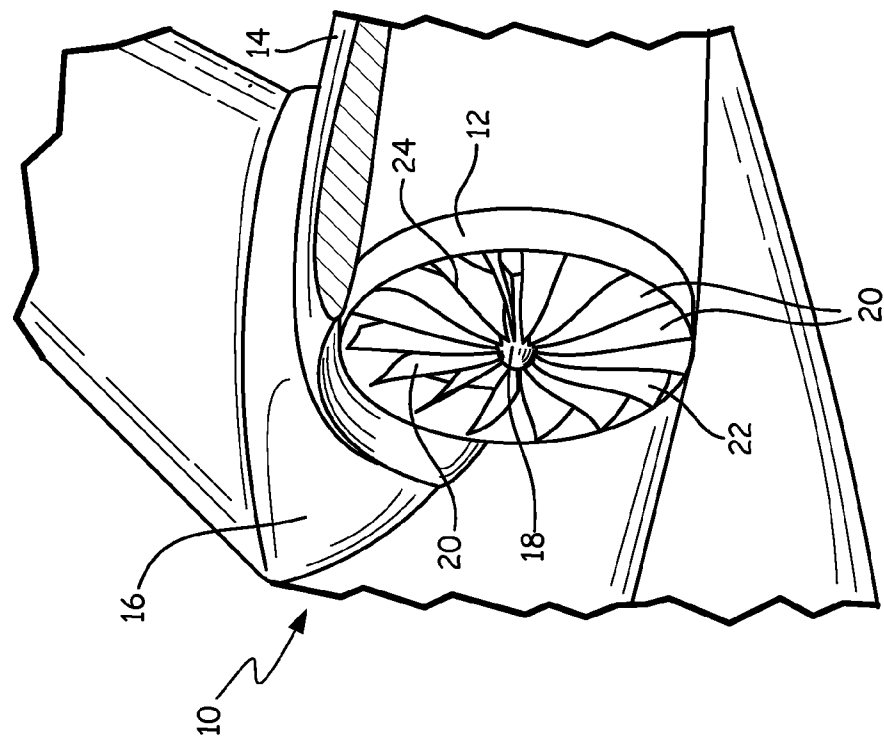


FIG. 1A

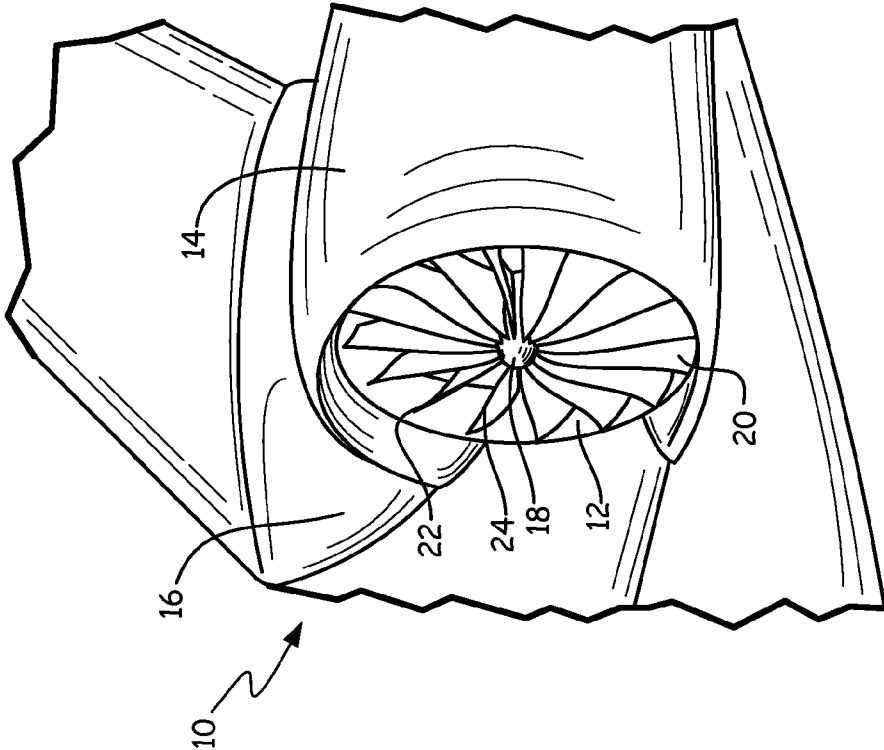


FIG. 1B

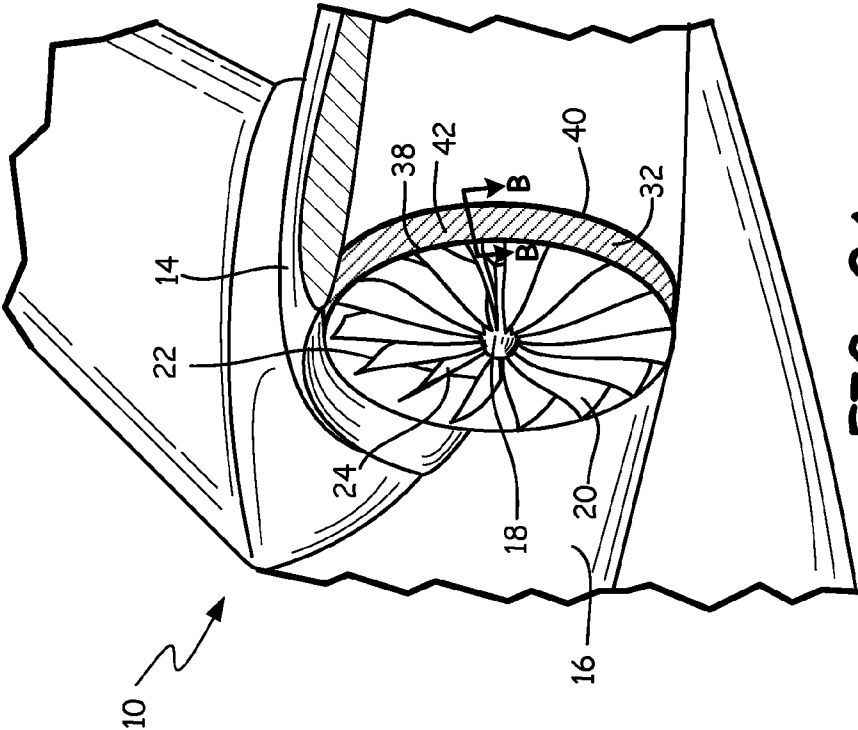


FIG. 2A

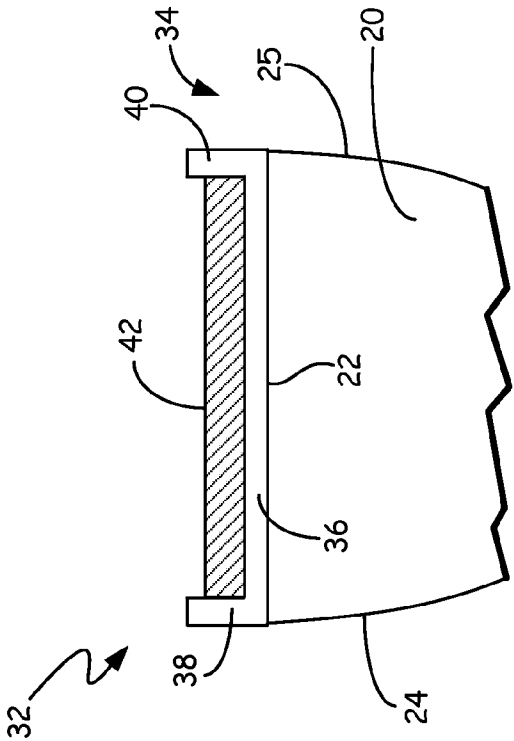


FIG. 2B

FAN WITH INTEGRAL SHROUD

BACKGROUND

[0001] Fans blades in gas turbine engines are sensitive to blade vibrations or flutter. This is especially pronounced when fans have a lower pressure ratio, for example when an engine is connected directly to an aircraft body (instead of under a wing). The connection directly to the aircraft body leads to more turbulent air entering the fan. A method of minimizing flutter in this scenario is to use a variable area fan nozzle ("VAFN") to change the area at the back end of the fan. The VAFN can create or eliminate back pressure to get the fan out of the flutter range.

SUMMARY

[0002] An integrally bladed rotor for use in a gas turbine engine includes a central hub; a plurality of airfoils extending from the central hub, each airfoil with a tip, a leading edge and a trailing edge; and a shroud with a metallic portion connecting to the tip of each airfoil to rotate with the airfoils.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. 1A is a front view of a fan with an integral shroud in a fan casing.

[0004] FIG. 1B is a perspective view of the fan with integral shroud of FIG. 1A with the fan casing partially cut away.

[0005] FIG. 2A is a perspective view of a second embodiment of a fan with a shroud.

[0006] FIG. 2B is a cross-sectional view of the shroud of FIG. 2A.

DETAILED DESCRIPTION

[0007] FIG. 1A is a front view of fan 10 with an integral shroud 12 in fan casing 14. FIG. 1B is a perspective view of fan 10 with integral shroud 12 with fan casing 14 partially cut away. A partial portion of an aircraft body 16 is also shown. Fan 10 is an integrally bladed rotor type fan, with hub 18 and a plurality of airfoils 20 extending radially from hub 18. Each airfoil 20 includes tip 22, leading edge 24 and trailing edge (not shown).

[0008] In the embodiment shown, hub 18, airfoils 20 and shroud 12 are formed as an integral unit. They can be formed, for example, of a metallic material, for example, aluminum or titanium (including alloys) and machined into shape desired. In alternate embodiments, shroud 12 can be formed separately and connected to integrally bladed rotor fan 10.

[0009] Shroud 12 connects to tips 22 of airfoils 20, extending from leading edge 24 to trailing edge, and rotates with airfoils 20. Shroud 12 is spaced apart from case 14 with a tight clearance, for example, 0 mm (0 inches) to 2.54 mm (0.100 inches). Fan 10 acts to pull air into engine as airfoils 20 and shroud 12 spin in case 14.

[0010] As can be seen in FIGS. 1A-1B, integrally bladed rotor fan 10 is mounted to aircraft body 16. At this position, the boundary layer of air coming into the fan can have distortions, which can lead to vibrations or flutter in airfoils 20. As too much flutter in airfoils 20 could result in damage and/or a catastrophic failure of the airfoil 20, the minimization of flutter is desirable.

[0011] Shroud 12 connects to tips 22 of airfoils 20 to stabilize airfoils by providing a second connection to airfoils 20; the first connection being to hub 18 at the inner diameter and the second connection to shroud 12, at outer diameter. These

stabilizing connections reduce the airfoil vibratory effects of fan 10, even when receiving a turbulent airflow. In past systems, blade flutter due to this turbulent airflow was controlled by using a variable area fan nozzle ("VAFN") downstream from the fan. The VAFN was able to reduce flow through the fan by controlling the area at the back end of the fan, and thus increasing or decreasing back pressure. Although this was an effective way of reducing blade flutter, the VAFN is a large and heavy system which reduced efficiency of the overall engine.

[0012] Fan 10 with integral shroud 12 controls vibration and flutter in airfoils 20 without the need for a VAFN, reducing size and weight as compared to past systems. By forming shroud 12 integral to the fan 10, shroud 12 can also help to eliminate some stresses in airfoils 20 as it can carry some of blade load when fan 10 is in operation. Integrally formed shroud 12 will also eliminate blade tip 22 leakage in fan 10 (which can lead to loss of efficiency and potential stalls), and the tight clearance between shroud 12 and casing 14 will minimize performance losses caused by air going outside of the shroud 12.

[0013] FIG. 2A is a perspective view of a second embodiment of fan 10 with hybrid shroud 32, with part of fan casing 14 cut away, and FIG. 2B is a cross-sectional view of shroud 32. A partial portion of an aircraft body 16 is also shown. Fan 10 is an integrally bladed rotor type fan, with hub 18 and a plurality of airfoils 20 extending radially from hub 18. Each airfoil 20 has tip 22, leading edge 24 and trailing edge 25. Shroud 32 includes metallic portion 34 (with circumferentially curved portion 36, first ridge 38 and second ridge 40) and composite portion 42.

[0014] Shroud 32 metallic portion 34 connects to tips 22 of airfoils 20, and can be formed integral to fan 10 or can be formed separate and attached to tips 22. Circumferentially curved portion 36 of shroud connects to tips 22 and extends from leading edge 24 to trailing edge 25 of airfoils 20. First flange 38 extends perpendicular from circumferentially curved portion 36 outward, away from airfoils 20 at leading edge 24. Second flange 40 extends perpendicular from circumferentially curved portion 36 outward, away from airfoils 20 at trailing edge 25. Composite portion 42 can be a composite wrap that wraps circumferentially around circumferentially curved portion 36 between first flange 38 and second flange 40.

[0015] As in FIGS. 1A-1B, shroud 32 spins with fan 10 as fan pulls air into engine within case 14. Hybrid shroud 32 with metallic portion 34 and composite portion 42 allows for a high-strength, light-weight shroud 32 that can help stabilize airfoils 20 at outer diameter (tip 22) to reduce blade vibrations and flutter even when fan 10 is ingesting a very turbulent airflow. Metallic portion 34 of shroud 32 can be formed integral to fan 10 airfoils 20, ensuring high strength in connection at tips 22, and composite portion 42 can be wrapped around to reinforce metallic portion 34 without adding a lot of additional weight. Shroud 32 can also increase hoop strength of fan 10.

[0016] In summary, fan 10 with integral shroud 12, 32 reduces or eliminates vibrations or flutter in blades, eliminating the need for heavy and large VAFNs used in past systems to reduce flutter. Integral shroud 12, 32 connects to airfoil tips 22 to stabilize blade at outer diameter, thereby allowing fan 10 airfoils 20 to resist vibrations even when ingesting very turbulent airflows.

[0017] An integrally bladed rotor for use in a gas turbine engine includes a central hub; a plurality of airfoils extending from the central hub, each airfoil with a tip, a leading edge and a trailing edge; and a shroud with a metallic portion connecting to the tip of each airfoil to rotate with the airfoils.

[0018] Additional and/or alternative embodiments include the shroud being integral to the airfoils; the shroud being the same material as the airfoils; the entire shroud being metallic; the shroud comprising a metallic portion and a composite portion; the metallic portion comprising a metallic portion curved in the circumferential direction extending from the leading edge to the trailing edge of each airfoil, a first radial outward flange extending from the metallic portion at the leading edge, and a second radial outward flange extending from the metallic portion at the trailing edge; the composite portion wrapping around the metallic portion between the first radial outward flange and the second radial outward flange; a fan casing surrounding the integrally bladed rotor; the fan casing being spaced apart from the shroud with a tight clearance; the integrally bladed rotor being metallic; and/or the integrally bladed rotor being composite.

[0019] A fan includes an integrally bladed rotor with a plurality of blades with tips; a shroud extending around the blades and securing to the tips of each blade; and a fan casing surrounding the shroud, wherein the shroud is at least partially metallic.

[0020] Additional and/or alternative embodiments include the integrally bladed rotor and the shroud being entirely metallic; the integrally bladed rotor and the shroud being the same material; the integrally bladed rotor and the shroud being formed integrally; the shroud comprising a metallic portion and a composite portion; the metallic portion comprising a ring having an inner surface connected to the tips of the blades and an outer surface that includes a circumferential channel; the composite portion wrapping around the metallic portion in the circumferential channel; and/or the fan casing being spaced apart from the shroud with a tight clearance.

[0021] While the invention has been described with reference to an exemplary embodiment(s), it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

1. An integrally bladed rotor for use in a gas turbine engine comprising:

a central hub;

a plurality of airfoils extending from the central hub, each airfoil with a tip, a leading edge and a trailing edge; and a shroud with a metallic portion connecting to the tip of each airfoil to rotate with the airfoils.

2. The integrally bladed rotor of claim 1, wherein the shroud is integral to the airfoils.

3. The integrally bladed rotor of claim 1, wherein the shroud is the same material as the airfoils.

4. The integrally bladed rotor of claim 1, wherein the entire shroud is metallic.

5. The integrally bladed rotor of claim 1, wherein the shroud comprises:

a metallic portion; and

a composite portion.

6. The integrally bladed rotor of claim 5, wherein the metallic portion comprises:

a metallic portion curved in the circumferential direction extending from the leading edge to the trailing edge of each airfoil;

a first radial outward flange extending from the metallic portion at the leading edge; and

a second radial outward flange extending from the metallic portion at the trailing edge.

7. The integrally bladed rotor of claim 6, wherein the composite portion wraps around the metallic portion between the first radial outward flange and the second radial outward flange.

8. The integrally bladed rotor of claim 1, and further comprising:

a fan casing surrounding the integrally bladed rotor.

9. The integrally bladed rotor of claim 8, wherein the fan casing is spaced apart from the shroud with a tight clearance.

10. The integrally bladed rotor of claim 1, wherein the integrally bladed rotor is metallic.

11. The integrally bladed rotor of claim 1, wherein the integrally bladed rotor is composite.

12. A fan comprising:

an integrally bladed rotor with a plurality of blades with tips;

a shroud extending around the blades and securing to the tips of each blade; and

a fan casing surrounding the shroud, wherein the shroud is at least partially metallic.

13. The fan of claim 12, wherein the integrally bladed rotor and the shroud are entirely metallic.

14. The fan of claim 12, wherein the integrally bladed rotor and the shroud are the same material.

15. The fan of claim 12, wherein the integrally bladed rotor and the shroud are formed integrally.

16. The fan of claim 12, wherein the shroud comprises:

a metallic portion; and

a composite portion.

17. The fan of claim 16, wherein the metallic portion comprises:

a ring having an inner surface connected to the tips of the blades and an outer surface that includes a circumferential channel.

18. The fan of claim 17, wherein the composite portion wraps around the metallic portion in the circumferential channel.

19. The fan of claim 12, wherein the fan casing is spaced apart from the shroud with a tight clearance.

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