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(54) Rotor for a gas turbine, gas turbine and method for tuning a gas turbine fan

(57) A gas turbine engine fan having blades (22) embedded with a composite material (26). The size and the stiffness of the composite material control the vibratory characteristics of the blade (22) without affecting the external blade profile. Accordingly, the gas turbine engine fan may use blades (22) having similar external profiles with differing vibratory characteristics. The gas turbine engine fan can then be tuned using the blades with differing vibratory characteristics. Tuning the gas turbine engine fan minimizes the non-integral gas turbine engine fan vibrations.

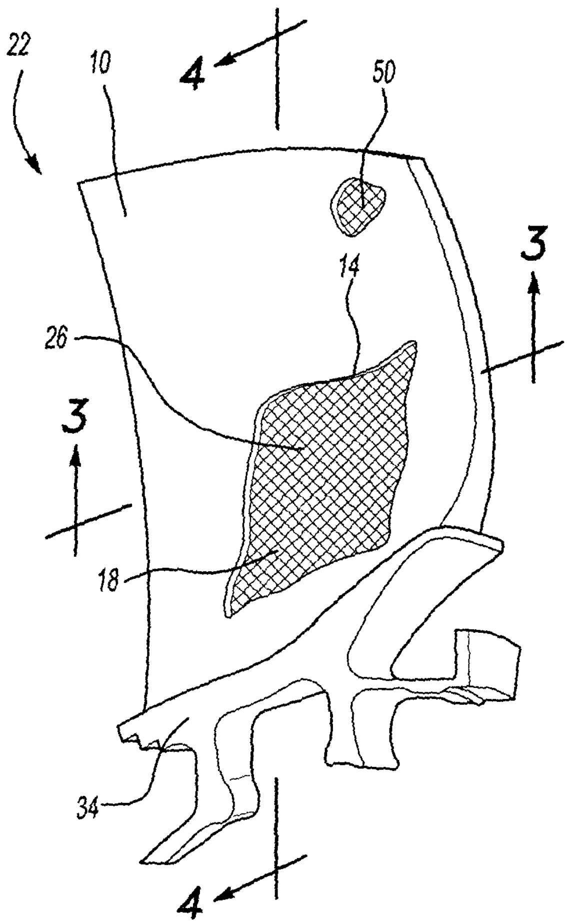

Fig-2

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a gas turbine engine fan, and more particularly to tuning the gas turbine engine fan to reduce non-integral vibrations.

[0002] One goal of gas turbine engine design, specifically rotor and fan blade design, is to minimize non-integral vibrations caused by flutter and flow shedding. Tuning of the gas turbine engine fan has been shown to reduce non-integral vibrations in the gas turbine engine.

[0003] One known method of tuning the gas turbine engine fan involves varying the natural frequencies of individual fan blades by removing material from the blade edges. This method is commonly referred to as "clipping." Removing material from the blade edges changes the natural frequency of the blade, and, in so doing, may reduce the non-integral vibrations in the fan. This method typically involves modifying the blade edges after the blade is manufactured.

[0004] Another method of tuning the gas turbine engine fan involves having fan blades with different thicknesses on the same rotor. Typically, this method uses fan blades on the rotor alternating between blades of different external profiles. Thus, both "thick" and "thin" blades are used and both "thick" and "thin" blades are manufactured.

[0005] Both of these approaches, "clipping" and "thick - thin," have undesirable aerodynamic consequences. Preferably, fan blades on a rotor will have the same general profile.

[0006] Accordingly, there is a desire to tune a gas turbine engine fan without changing the fan blade profile. It is also desirable to incorporate the tuning method into the current manufacturing process of the gas turbine engine fan.

SUMMARY OF THE INVENTION

[0007] A turbine blade has a blade shell and a blade core each having a stiffness. Adjusting the stiffness of the blade shell or blade core may change the naturally frequency of the blade. In addition to the natural frequency of the blade, these adjustments may modify other tunable characteristics, e.g., weight.

[0008] The blade core is typically embedded in the blade shell. Accordingly, the blade core size can be modified without affecting the profile of the turbine blade. In addition, the blade core can be eliminated without changing the profile of the turbine blade. Thus, a turbine rotor disk containing multiple fan blades may contain fan blades with different sized blade cores. A turbine rotor disk may also contain one or more fan blades without blade cores.

[0009] A metal matrix composite (MMC) may be used as a blade core. An area of MMC material within the blade can be readily introduced to current turbine blade production techniques. A size of the MMC material may be adjusted to tune the gas turbine engine fan. Similarly, a stiffness of the MMC material may be adjusted to tune the gas turbine engine fan. Preferably, the MMC material is contained within alternating blades disposed upon the turbine rotor disk.

[0010] The present invention therefore provides a method of tuning a fan blade without altering the profile of the fan blade. In addition, the method of the present invention can be readily introduced to current blade manufacturing techniques.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiment. The drawings that accompany the detailed description can be briefly described as follows.

Figure 1 is a section view of a gas turbine engine.
Figure 2 is a perspective view of a gas turbine engine fan blade.
Figure 3 is a section view through line 3 of Figure 2.
Figure 4 is a section view through line 4 of Figure 2.
Figure 5 is a perspective view of the rotor and blades according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] Referring to Figure 1, a section view of a gas turbine engine 38 is shown. A rotor disk 30 rotates a plurality of blades 22 about an axis 42. The rotating plurality of blades 22 moves air through the gas turbine engine 38 and may introduce non-integral vibrations, such as flutter and flow shedding, to the gas turbine engine 38. Non-integral vibrations may be controlled by varying the stiffness of one or more of the plurality of blades 22. While disclosed as a fan section of a gas turbine engine 38, the present invention may be incorporated into another sections of the gas turbine engine 38, such as a rotor section 46 of the gas turbine engine 38. The gas turbine engine 38 also includes a compressor 44 and a combustion section 48

[0013] Figure 2 illustrates a blade 22 tuned with materials of a dissimilar stiffness. The blade 22 has a blade shell portion 10 defining a cavity 14 containing a blade core portion 18. The blade shell portion 10 has a first stiffness and the blade core portion 18 has a second stiffness. Varying the relationship between the first stiffness and the second stiffness controls the overall stiffness of the blade 22. Although the cavity 14 is described in singular terms, it should be understood that the cavity 14 may comprise a second cavity 50 within the blade shell portion 10. For example, the blade core portion 18 may comprise a porous material containing the blade shell portion 10 within the pores.

[0014] Figure 2 also illustrates attachment structure 34. The attachment structure 34 operates to secure the blade 22 to the rotor disk 30. Preferably, the attachment structure 34 facilitates removal of the blade 22 from the rotor. Generally, the blade shell portion 10 defines an airfoil extending from the attachment structure 34.

[0015] Referring next to Figures 3 and 4, the cavity 14 is shown within the blade 22. Figure 3 illustrates a section view of the blade 22 through line 3 of Figure 2. Figure 4 illustrates a section view of the blade 22 through line 4 of Figure 2. The cavity 14 defined by the blade shell portion 10 is defined within the blade 22. Varying the size of the blade shell portion 10 may vary the size of the cavity 14 and, in so doing, may accommodate different sized blade core portions 18. Varying the size of the blade shell portion 10 and the blade core portion 18 allows a designer to control the overall stiffness and characteristics of the blade 22.

[0016] As shown, the cavity 14 containing the blade core portion 18 is typically embedded within the blade shell portion 10. Embedding the cavity 14 enables blades 22 to be produced with similar profiles and dissimilar stiffnesses. For example, because the cavity 14 is embedded in the blade shell portion 10, blades 22 containing the cavity 14 may maintain the same profile as blades 22 not containing a cavity 14. In addition, the size of the cavity 14 may be changed without affecting the profile of the blade 22, provided the cavity 14 remains contained within the blade shell portion 10. Accordingly, a plurality of blades 22 may be disposed upon the rotor disk 30, and the blades 22 may or may not contain the blade core portion 18, as shown in Figure 5. Preferably, a plurality of blades 22 disposed upon the rotor disk 30 comprises alternating the blades 22 with and without the embedded blade core portion 18. The blades 22 have identical profiles and thus improve on the prior art dissimilar profiles, which have undesirable aerodynamic characteristics.

[0017] The blades 22 are ordinarily formed by diffusion bonding; two blade 22 halves are joined under extreme temperatures and pressures. A metal matrix composite (MMC) 26 material withstands these extremes. The MMC 26 is sandwiched between the two blade 22 halves as the blade 22 halves are bonded together.

[0018] Blades 22 may be made of Ti-6-4, while the MMC 26 may be Ti-6-4 with silicon carbide fiber additive. Varying the amount and orientation of the silicon carbide fiber additive alters the stiffness of the MMC 26. Of course, this invention extends to many other appropriate materials. In addition, stiffness can be varied by varying geometry, etc. Also while an alternate orientation of two different stiffnesses is disclosed, other arrangements of different stiffnesses could be utilized within the scope of this invention.

[0019] It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that the method and apparatus within the scope of these claims and their equivalents be covered thereby.

Claims

1. A rotor (30) for a gas turbine engine, comprising:

a rotor mounting a first group of blades (22);
said rotor also mounting a second group of blades (22) having a shell portion (10) and a core portion (18); and
wherein said second group of blades (22) has a stiffness different from said first group of blades (22).

2. The rotor for a gas turbine engine of claim 1, wherein said core portion (18) is embedded in said shell portion (10).

3. The rotor for a gas turbine engine of claim 1 or 2, wherein adjusting the stiffness of said core portion (18) tunes said second group of blades (22).

4. The rotor for a gas turbine engine of any preceding claim, wherein adjusting said shell portion (10) size and said core portion (18) size tunes said second group of blades (22).

5. The rotor for a gas turbine engine of any preceding claim, further comprising a plurality of core portions (18), wherein said plurality of core portions (18) has a plurality of stiffnesses.

6. The rotor for a gas turbine engine of any preceding claim, wherein said blade core portion (18) comprises a composite material (26).

7. The rotor for a gas turbine engine of claim 6, wherein said composite material is a metal matrix composite (26).

8. The rotor for a gas turbine engine of any preceding claim, wherein said second group of blades (22) are disposed between alternating ones of said first group of blades (22).

9. The rotor for a gas turbine engine of any preceding claim, wherein said rotor (30) and said blades (22) form part of a fan section for the gas turbine engine.

10. The rotor for a gas turbine engine of any preceding claim, wherein said first group of blades (22) includes a shell portion (10) and a core portion (18).

11. A gas turbine engine (38), comprising:

a fan section;
a compressor (44);
a combustion section (48);
a turbine (46);
at least one of said fan and said turbine including a rotor having a plurality of blades (22), said plurality of blades comprising a material with a first stiffness and a material with a second stiffness within one or more of said plurality of blades; and
wherein varying said second stiffness tunes said one or more of said plurality of blades (22).

12. The gas turbine engine of claim 11, wherein said material with a second stiffness is disposed within alternating ones of said plurality of blades (22).

13. The gas turbine engine of claim 11 or 12, wherein profiles of the plurality of blades (22) are generally similar.

14. The gas turbine engine of claim 11, 12 or 13, wherein said material with a second stiffness is a metal matrix composite (26).

15. The gas turbine engine of any of claims 11 to 14, wherein said material with a second stiffness is embedded in said material with a first stiffness.

16. The gas turbine engine of any of claims 11 to 15, wherein said material with a second stiffness comprises a composite material (26).

17. The gas turbine engine of claim 16, wherein said material with a second stiffness comprises a metal matrix composite (26).

18. The gas turbine engine of any of claims 11 to 17, wherein said rotor (30) and said blades (22) are part of said fan.

19. A method of tuning a gas turbine engine fan, comprising the steps of:

a) mounting a first fan blade (22) with a first stiffness to a rotor (30);
b) mounting a second fan blade (22) with a second stiffness to the rotor (30); and
c) repeating steps a-b selectively mounting the first fan blade and the second fan blade creating a gas turbine engine fan with blades of selected stiffness.

20. The method of claim 19, further comprising the step of varying said first stiffness, wherein varying said first stiffness alters vibratory characteristics of said first fan blade (22).

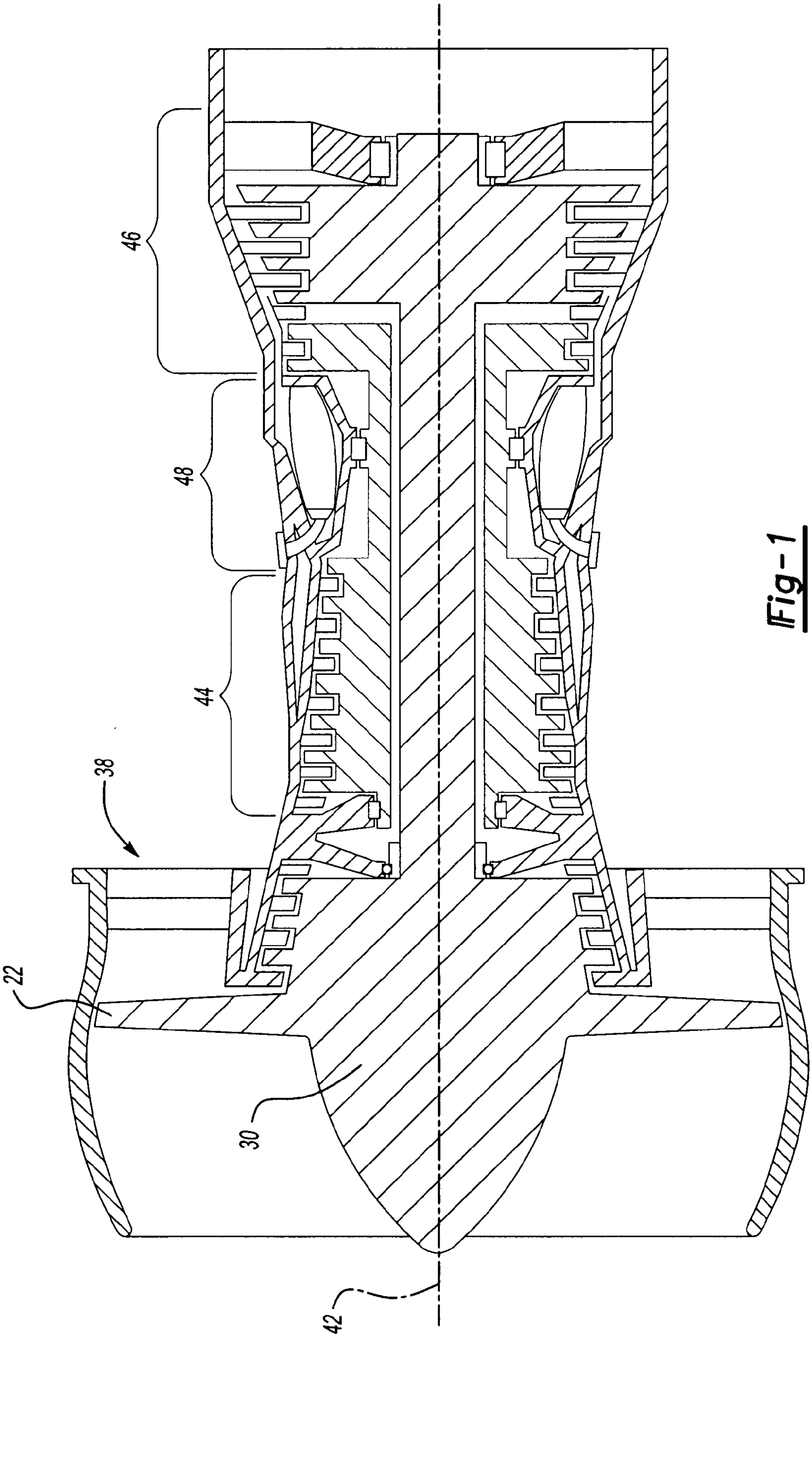

Fig-1

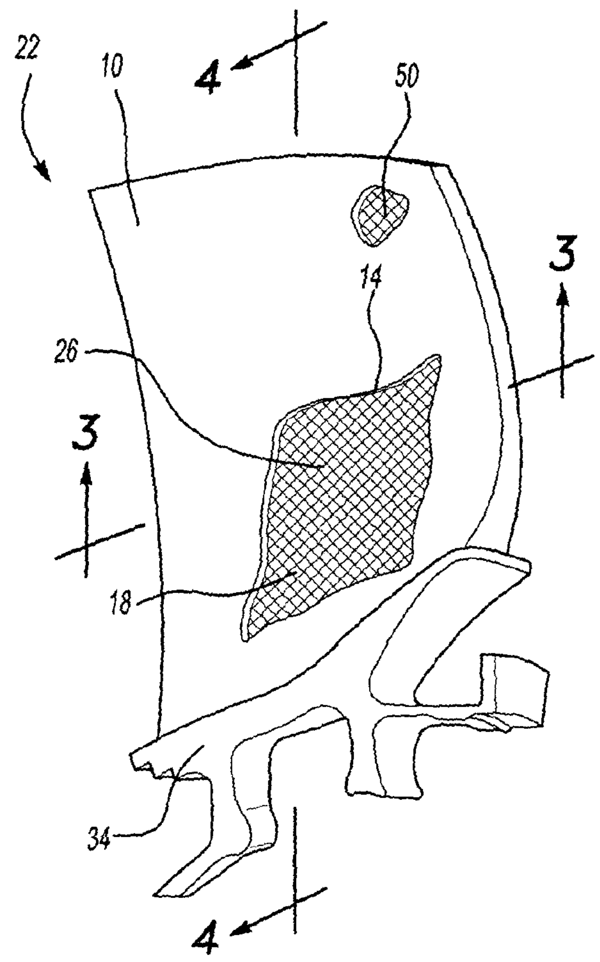

Fig-2

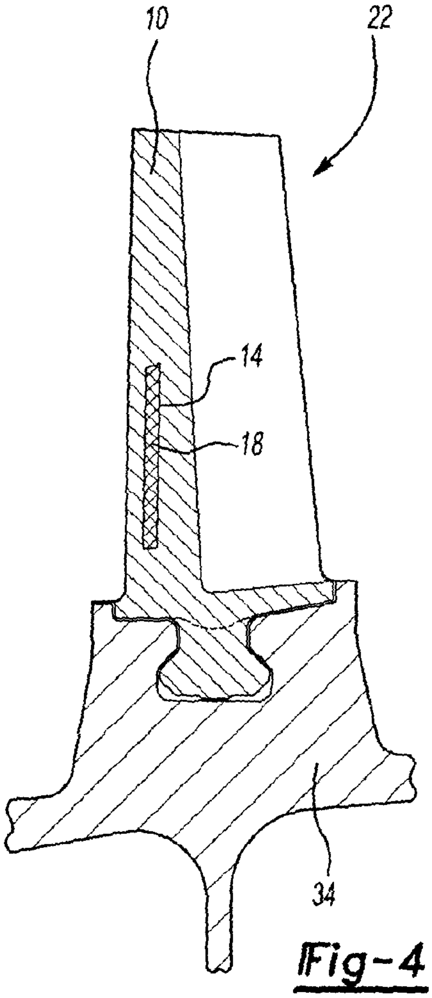

Fig-4

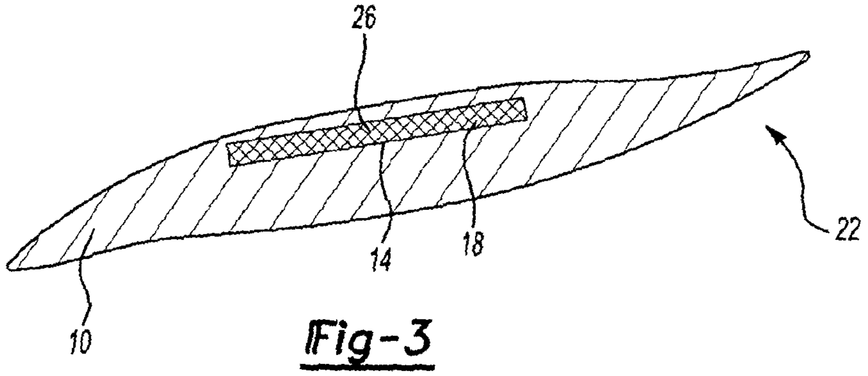

Fig-3

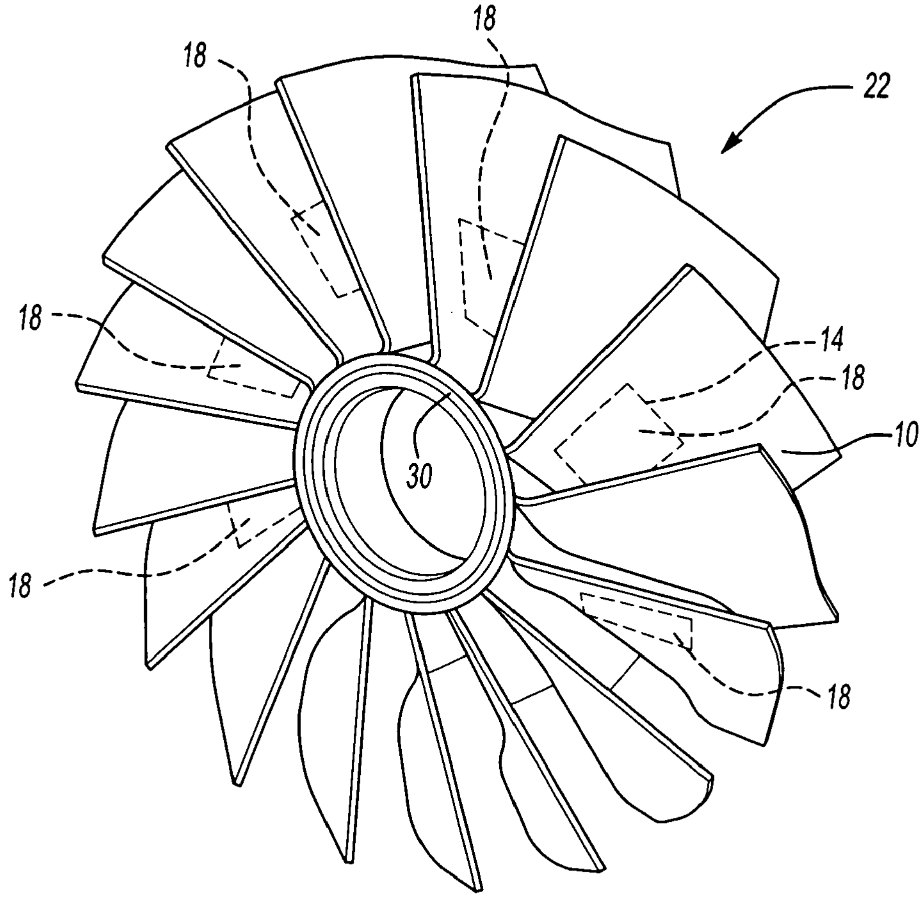

Fig-5