United States Patent [19]

Tracy

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[54] **STABILIZED ROTARY BLADES**

[75] Inventor: **Alfred C. Tracy**, Los Angeles, Calif.

[73] Assignee: **McDonnell Douglas Corporation**, Santa Monica, Calif.

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[52] **U.S. Cl.** **416/196,** 416/190, 416/191

[51] **Int. Cl.** **F01d 5/22**

[58] **Field of Search** 416/190, 191, 196, 416/210

[56] **References Cited**

UNITED STATES PATENTS

2,772,854	12/1956	Anxionnaz	416/196 X
2,914,299	11/1959	Mitchell	416/196 UX
3,104,093	9/1963	Craig et al.	416/210

FOREIGN PATENTS OR APPLICATIONS

1,426,798	3/1969	Germany	416/196

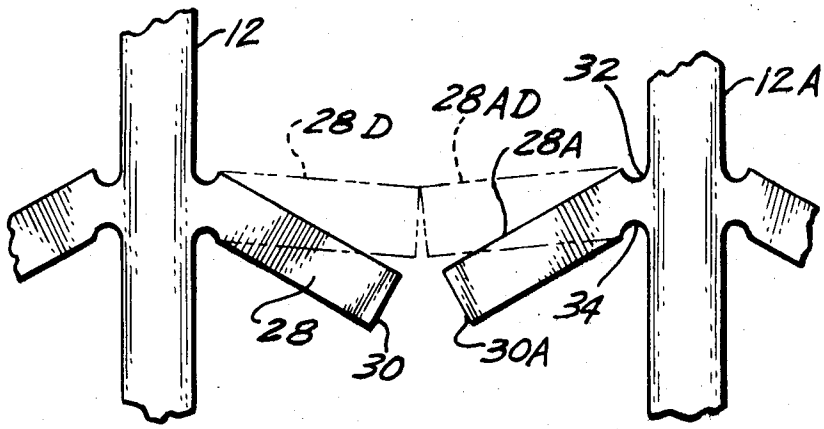
Primary Examiner—Everette A. Powell, Jr.

Attorney—Walter J. Jason et al.

[57] **ABSTRACT**

Projections near the tips of high speed rotary blades are actuated by centrifugal force to ensure uniform spacing between the blade tips as a means of reducing buzz-saw noise.

3 Claims, 5 Drawing Figures



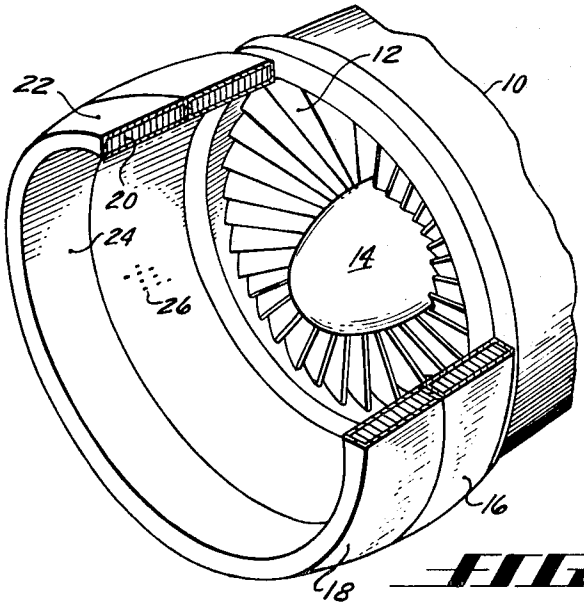


FIG. 1

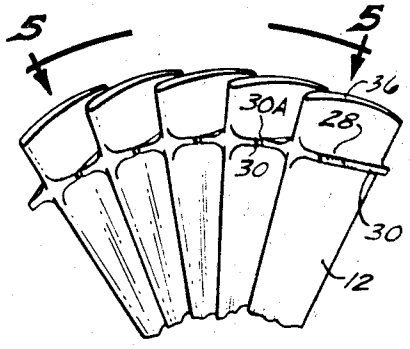


FIG. 4

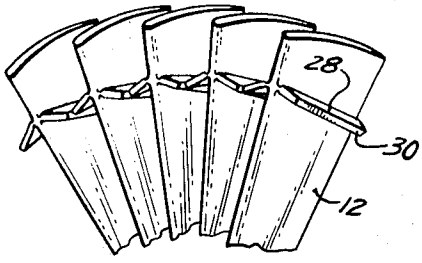


FIG. 2

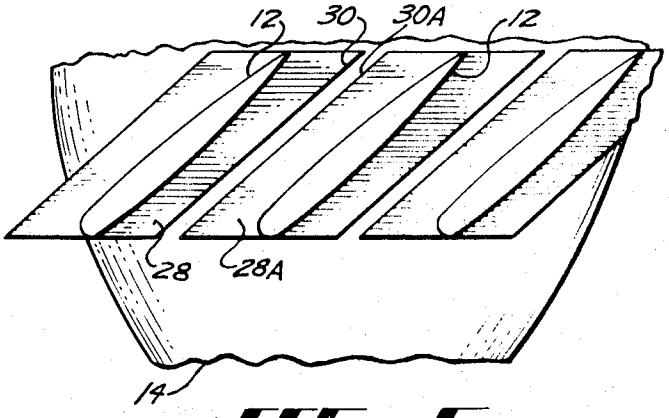


FIG. 5

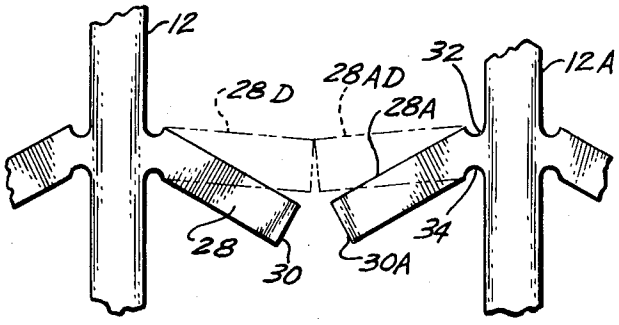


FIG. 3

STABILIZED ROTARY BLADES

BACKGROUND OF THE INVENTION

In modern high speed turbo engines for aircraft, the tendency is to use turbofan engines with as high an engine bypass ratio as possible. This calls for increasingly larger fan blades. Through the necessity of damping and because of other stress problems, the root support structure of the blades must be loose. Dimensional variations in spacing at the tips of the blades thus may become quite large, producing uneven acoustical pulses with a fundamental or lowest frequency starting with the first rotational frequency and all harmonics thereof. The highest frequency would be the frequency of a blade passage over a point on its periphery and in the case of an aircraft engine would be on the order of 2,000 cps. In a perfect situation, in which there were no buzz-saw noise, there would be no variation in the blades characteristics, such as angle of attack, tip spacing, camber, contour, etc. By stabilizing the tips of the blades in accordance with the present invention, there is great improvement in the reduction of buzz-saw noise generated by the rotor tips. Theoretically, blades spaced perfectly and of identical manufacture will produce no harmonics below the 38th in the case of the DC–10 jet engines and it is the fifth through the 20th harmonic that causes the buzz-saw noise. Attempts have been made to reduce the intensity of this noise through treatment in the cabin side walls and attempts have been made to reduce the compressor whine and the turbine whine by perforated linings in the in-take and the exhaust. While these treatments affect the harmonics of the buzz-saw noise, they do not reduce the lower frequency buzz-saw noise source through the stabilization of rolling deflections of each blade and through the control of spacing between the blades.

SUMMARY OF THE PRESENT INVENTION

In accordance with the present invention, turbine blades are designed with side arms near the three-quarter span position. These arms are deflected slightly inwardly toward the rotor hub and utilizes the centrifugal force that occurs during the normal running of the engine to bend the arms in an elastic deflection such that adjacent blade arms come in contact with each other and thus limit the spacing between the blades. These elastically deflected arms stabilize the dimensions between the blades and will also add to the damping of each blade, reducing the blade vibration an appreciable amount. A bend relief at the root of the arm may be desired in some instances for greater flexibility and greater deflection under the centrifugal loading.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view with parts broken away to more clearly show the rotor blades in an aircraft turbofan engine;

FIG. 2 is an enlarged view of a portion of the blades showing the extended arms near the blade tips;

FIG. 3 is a front view enlargement showing the arms in normal position and their deflection position due to centrifugal force;

FIG. 4 is a view similar to that of FIG. 2 wherein the arms have been extended by centrifugal force upon rotation of the blades; and

FIG. 5 is a plan view taken along the line 5—5 in FIG. 4.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENT

Reference is now made to FIG. 1 wherein there is shown the housing **10** about an aircraft engine and within which the blades **12** of the turbine are rotatably mounted upon a rotor or hub **14.** The housing **10** typically may have a diameter 8 or 9 feet and the blades may have a length on the order of 3 or 4 feet. These blades should be as light as possible, yet must be free from destructive vibration or flutter. These blades are subjected to large twisting and bending moments. Because of stress reasons the blades are loosely attached to the rotor within hub **14** such that considerable mechanical clatter may be heard when the engines are being shut down such as when the aircraft has taxied to the unloading station at the end of the flight. However, it is not this clatter that the present invention overcomes but it is the uninherent, uneven spacing of the blades as they pass a point on the periphery of the housing that generates the low frequency sawtooth noise when the engines are operating. For example, if there were **39** blades and the rotational speed were 60 cycles per second, then the blade passage frequency would be 2,340 cps. Any variation in angle of attack or tip spacing, camber, contour, or other characteristic will produce a buzz-saw noise within a range of from 200 cps to 1,000 cps. Just forwardly of the blades are engine housing extensions **16** and **18** having an outer surface compatible with the outer surface of the housing **10** and inner surfaces compatible with the inner surface of housing **10.** These sections preferably are made of high strength-to-weight panels to form rings having a honeycomb or cellular material sandwiched between the inner and outer faces **22** and **24.** By providing a plurality of openings **26** within the inner surface **24** some of the sound waves may be damped within the inner cavities. This particular approach is more clearly set forth in co-pending patent application Ser. No. 286,457 filed Sept. 5, 1972 by Arnold W. Guess and Guenter M. Schindler and forms no part of the present invention except in combination therewith.

Referring now to FIG. 2 there is shown a plurality of blades **12** having laterally extending arms **28** extending from both sides of the blades within the outer one-fourth of the length of the blade **12.** These arms are of a generally flat plate-like structure having an outer edge surface **30** extending relatively parallel to the surface of the blade **12** from which the arm **28** extends. The outer edge **30** of arm **28** is bent downwardly somewhat in the direction of the hub and in this position the adjacent arms will have a small gap therebetween.

A front enlarged view may be seen in FIG. 3 wherein adjacent blades **12** and **12A** are shown spaced apart but there is a clearance or a spacing on the order of 0.001 to 0.005 inch between the free edges **30** and **30A** of the adjacent arms **28** and **28A** when in this inwardly directed non-deflecting position. The elasticity of the arms **28, 28A** at their juncture with the blades **12** and **12A** is such that there may be an outwardly directed deflection on the order of 0.015 to 0.020 inch due to centrifugal force when the blades are rotating at conventional speed. This outward deflection moves the arms **28, 28A** to their dotted line positions **28D** and **28AD** with the letter D designating its deflected position. These arms **28** and **28A** may have a bend relief **32** on the compression side and a bend relief **34** on its ten-

sion side of the juncture between the arms and the blades. The extent of this bend relief, of course, depends upon the elasticity of the material used and the amount of deflection desired for the amount of centrifugal force determined by the rotation of the blades. It is conceivable that in some cases such bend reliefs may not be necessary and in fact fillets may be used.

In FIG. 4 there is shown a fan of blades **12** having a plurality of arms **28** extending therefrom about a circumference near the outer ends **36** of the blades. These arms **28** are shown extended outwardly and in near-abutting relationship due to centrifugal force as the blower blades rotate. These arms **28** have filleted connections to the blades since a bend relief is not necessary in this particular application.

Reference is made to the plan view in FIG. **5** taken along the line **5—5** in FIG. **4.** Inasmuch as the turbine blades **12** are angularly oriented relative to the axis of the hub **14,** the arms **28** also are angularly oriented such that the outer edges **30** are generally parallel with the surface of the blades as previously mentioned until centrifugal force deflects the adjacent arms **28, 28A** into abutting contact there is a gap between the adjacent outer edges **30** and **30A**. This gap, of course, closes when the rotors reach conventional speed and centrifugal force causes the outward deflection of the arms.

Having thus described an illustrative embodiment of the present invention, it is to be understood that other modifications and variations will occur to those skilled in the art and it is to be understood that these deviations from the illustrative embodiment are to be considered part of the present invention as claimed.

I claim:

1. In combination with a turbofan engine having a plurality of blades attached to a rotor hub and a housing having a circumferential inner surface in close radial proximity to the tips of said blades,

means for reducing noise caused by irregular spacing of said blade tips and thus varying the frequency of blade tip passage over a point on the inner surface of the housing about the periphery within which said blade tips rotate,

said means comprising side arms extending laterally outwardly from the surfaces of said blades and radially inwardly toward said hub,

said arms having outer edge surfaces positioned radially inwardly from the connection of said arms to said blades,

said arms deflecting radially outwardly due to centrifugal force when said blades are rotated at a preselected frequency, the outer edge surfaces of adjacent arms on adjacent blades abutting each other when said blades rotate at said preselected frequency.

2. The combination as in claim **1** wherein said arms are of equal length thereby to cause equal spacing of said blade tips when said blades are rotated at said preselected frequency.

3. The combination as in claim **1** wherein said outer edge surfaces are substantially parallel to the surfaces of said blades in the arm thickness direction and in the arm length direction to define abutting planes parallel to said blade surfaces.

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