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Vuillemin(10) **Pub. No.: US 2013/0115083 A1**(43) **Pub. Date: May 9, 2013**(54) **TURBINE ENGINE HAVING TWO
UNDUCTED PROPELLERS****Publication Classification**(75) Inventor: **Alexandre Alfred, Gaston Vuillemin,**
Fontainebleau (FR)(73) Assignee: **SNECMA, Paris (FR)**(21) Appl. No.: **13/810,833**(22) PCT Filed: **Jul. 13, 2011**(86) PCT No.: **PCT/FR2011/051690**

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USPC **416/1; 416/129**(57) **ABSTRACT**

A turbine engine including two outer coaxial counter-rotating unducted propellers, of an upstream propeller and a downstream propeller, respectively. The blades of the downstream propeller are retractable in the lengthwise direction thereof so as to reduce the diameter of the propeller. The reduction in the diameter of the downstream propeller makes it possible to reduce noise caused by vortices generated by the upstream propeller.

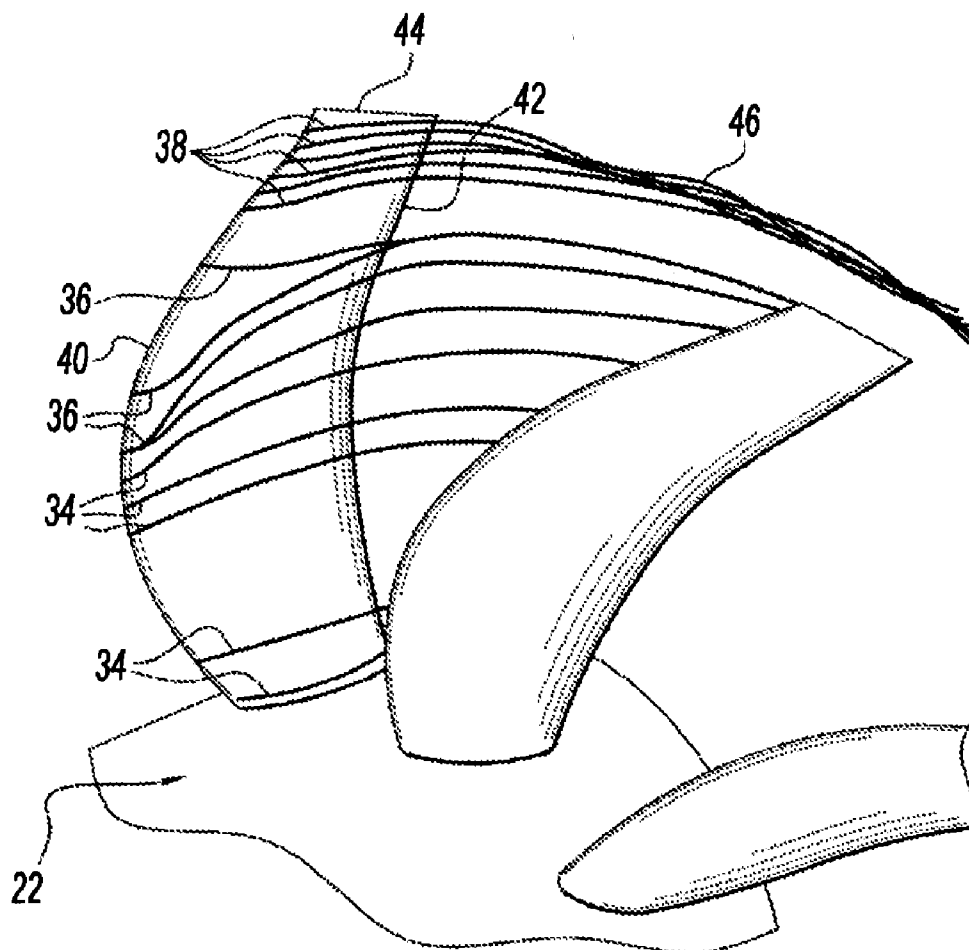


Fig. 2

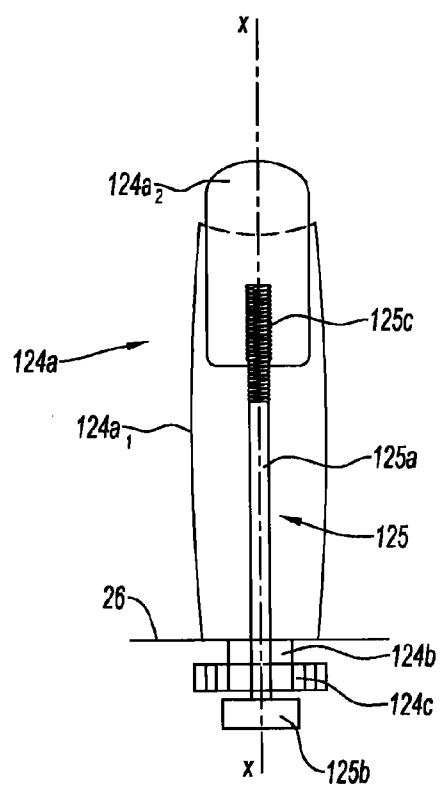


Fig. 3

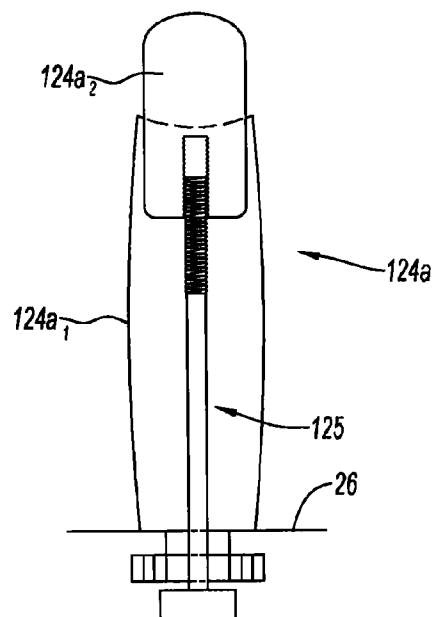


Fig. 4

TURBINE ENGINE HAVING TWO UNDUCTED PROPELLERS

[0001] The present invention relates to the field of aircraft turbine engines having two unducted propellers or fans.

[0002] An engine of this type, known in this field as an "open rotor" or "unducted fan" engine comprises a gas turbine engine powering one or more free turbines with contra-rotating coaxial rotors each associated with a fan. The two fans extend substantially radially on the outside of the nacelle of the turbine engine and are themselves coaxial and contra-rotating. The two fans are driven either directly, in which case the two fans are mounted at the periphery of the two turbine rotors, or via a mechanical gearbox, the two fans then each being connected to one output of the gearbox.

[0003] Unducted fan turbine engines are being researched at the present time because they offer the advantage of performing well while being capable of supplying significant thrust and consuming less fuel than other equivalent ducted fan turbine engines.

[0004] However, the high noise levels generated by the mechanisms of aerodynamic interaction between the two fans are penalizing in this type of propulsion.

[0005] One of the sources of this noise stems from the interaction of vortices, generated at the blade tips of the upstream fan, with the blades of the downstream fan. The vortex generated by the upstream fan interacts with the downstream fan very vigorously, generating high levels of noise.

[0006] Ways of reducing fan noise seek to control the flow around the profiles but such means have not, in the current state of the art, yet reached maturity.

[0007] One solution for eliminating this noise is to use two fans of different diameters, the outside diameter of the downstream fan being smaller than that of the upstream fan so that the vortices generated by the upstream fan pass around the outside of the envelope of the downstream fan and do not interact with that fan. Such a solution is unsatisfactory because it results in a reduction in the thrust produced by the downstream fan and therefore in reduction in engine performance. It might be possible to increase the load on the downstream fan to compensate for the reduction in diameter thereof, but that would also increase the aeromechanical difficulty in designing the pair of fans which would become very complicated and difficult to achieve.

[0008] Another solution is developed in patent application FR 2 938 502 in the name of Snecma. It proposes a turbomachine at least some of the blades of the upstream fan of which have, on their radially external end parts, air guidance means directed outward when considered from upstream to downstream and intended to divert the vortices formed at the blade tips of the upstream fan radially around the outside of the blades of the downstream fan. These guide means carried by the blades of the upstream fan guide outward at least some of the vortices formed at the tips of the blades of the upstream fan, which therefore interact a little, if at all, with the blades of the downstream fan. That makes it possible to reduce significantly—a reduction of up to 3dB—the acoustic disturbances associated with the interactions between these vortices and the downstream fan. They also allow a reduction in the intensity of the vortices generated and therefore assist in reducing noise. This solution therefore does not involve modifying the dimensions of the upstream and downstream fans, which may have substantially the same outside diameter.

[0009] However, these means do act on the flow of air through the rotor throughout all phases of flight, even when noise reduction is not required.

[0010] It is therefore an objective of the invention to reduce the levels of noise generated by the fans so as, in particular, to comply with the relatively severe acoustic certification standards applicable to the take-off and landing phases of the aircraft fitted with this engine.

[0011] It is another objective to provide good aerodynamic performance during cruising flight.

[0012] These objectives are achieved according to the invention, using a turbine engine comprising two coaxial and contra-rotating unducted external fans, these respectively being an upstream and a downstream fan, characterized in that the blades of the downstream fan are retractable in their longitudinal direction, so as to reduce the diameter of the downstream fan.

[0013] This result is achieved with a turbine engine the blades of which are telescopic with at least two blade elements which nest one inside the other and can slide one relative to the other along the longitudinal axis of the blade.

[0014] By means of the invention it becomes possible to reduce the diameter of the downstream fan enough for it not to experience the vortices in the phases during which engine noise is to be reduced, namely during aircraft take-off and landing. The blades of the downstream fan are retracted preferably enough to eliminate a significant proportion of the interactions during these phases in the vicinity of airports.

[0015] According to one embodiment, said two elements mounted so as to slide one relative to the other are formed at the free end of the blades.

[0016] According to another embodiment, said two elements are formed at the root end of the blades.

[0017] The noise emitted by the turbine engine during a phase of operation of this engine is thus reduced by reducing the length of the blades of the downstream fan during said phase of operation. Said phases of operation correspond to the take-off and landing of the aircraft.

[0018] The reduction of the blade length is advantageously compensated for by increasing the loading on the blades, notably by varying the blade pitch angle.

[0019] The invention is now described in greater, but non-limiting, detail using the attached drawings in which:

[0020] FIG. 1 is an axial section through a turbine engine with two unducted fans;

[0021] FIG. 2 is a perspective view of an unducted fan of the prior art, illustrating the shape of the stream lines around the fan blades;

[0022] FIGS. 3 and 4 depict one embodiment of the invention whereby a blade of the downstream fan has a telescopic end, viewed in two positions, one extended and the other retracted.

[0023] Reference is made to FIG. 1 which shows a turbomachine 10 of the "open rotor" type, this expression denoting a pair of unducted fans which comprises, from upstream to downstream, in the direction in which the gases flow inside the turbomachine, a compressor 12, an annular combustion chamber 14, a high-pressure upstream turbine 16 and two lower-pressure downstream turbines 18, 20 which are contra-rotating, which means to say which rotate in two opposite directions about the longitudinal axis A of the turbomachine.

[0024] Each of these downstream turbines 18, 20 rotates as one with an external fan 22, 24 extending radially on the outside of the nacelle 26 of the turbomachine. The nacelle is

a substantially cylindrical envelope extending along the axis A around the compressor 12, the combustion chamber 14 and the turbines 16, 18 and 20.

[0025] The flow of air 28 entering the compressor 12 is compressed and then mixed with fuel and burnt in the combustion chamber 14. The combustion gases are then injected into the turbines to drive the rotation of the fans 22, 24 which supply most of the thrust generated by the turbomachine. The combustion gases exit the turbines and are expelled through a jet pipe 30 (arrows 32) to increase the thrust.

[0026] The fans 22, 24 are coaxial and arranged one behind the other. In the known way, each of these fans 22, 24 comprises a plurality of blades 22a and 24a respectively, which are uniformly distributed about the axis A of the turbomachine. Each blade extends substantially radially in a plane perpendicular to the axis of rotation and comprises an upstream edge forming the leading edge of the blade, a downstream edge forming the trailing edge, a radially internal end forming the root of the blade and a radially external end forming the tip of the blade.

[0027] According to the prior art, the downstream fan 24 has substantially the same diameter as the upstream fan 22 so that these fans supply the same thrust during operation and so that all of the flow of air compressed by the upstream fan is compressed again by the downstream fan.

[0028] FIG. 2 is a partial and perspective schematic view of the upstream fan 22 of a turbomachine of the prior art, and shows how the stream lines evolve along a blade of this fan. The stream lines 34, 36, 38 pass between the fan blades and more or less follow the profile of these blades, from the leading edges 40 to the trailing edges 42 of these blades.

[0029] The stream lines 34 which pass over the radially internal end parts of the blades are more or less parallel to one another. By contrast, the stream lines 36, 38 that pass over the radially external end parts have a tendency to converge toward one another, the intensity of this phenomenon increasing with increasing closeness to the blade tips 44. The stream lines 36 at the blade tips 20 curl around one another and form vortices 46 which impinge on the blades of the downstream fan 24, these impingements being what causes very significant acoustic disturbance.

[0030] According to the invention, provision is made to allow the blades of the downstream fan to retract longitudinally with a view to reducing the noise emitted by the interaction of the upstream fan on the downstream fan.

[0031] FIGS. 3 and 4 depict one embodiment of the invention. The invariable-geometry blades 24a of the downstream fan are replaced by variable-length blades 124a. According to the embodiment of FIG. 3, the blade 124a is telescopic with two elements 124a1 and 123a2 sliding one inside the other along the longitudinal axis XX of the blade 124. In this instance, the element 124a1 constitutes the main body of the blade and extends radially outward from the nacelle 26 starting from the blade root.

[0032] The blade root comprises a pivot 124b mounted such as to rotate in a bearing of radial axis so as to allow the blade to be rotated about its longitudinal axis XX and the pitch angle of the blade to be altered as required. The bearings for the blades of the fan are mounted in an annular cage 124c. The annular cage 124c is driven by the turbine rotor set in rotation by the combustion gases. A set up example is described in patent application FR 0 954 561 or FR 0 955 516 in the name of Snecma.

[0033] The distal end of the element 124a1 is hollow and forms a housing for the blade tip element 124a2 in which housing this element can slide between a deployed position shown in FIG. 3, in which the overall length of the blade is at its maximum, and a retracted position shown in FIG. 4.

[0034] An appropriate drive mechanism causes the end element 124a2 to move between the two positions, deployed and retracted. An example of a drive mechanism 125 is a screw jack.

[0035] The latter comprises a threaded rod 125a rotating on itself about the longitudinal axis of the blade element 124a1 and engaging with a threaded housing secured to the end element 124a2. The threaded rod is driven by a motor 125b housed inside the nacelle 26. Given that the tip element 124a2 slides inside the element 124a1 without rotating about the longitudinal axis of the blade, rotation of the threaded rod causes this element to move longitudinally.

[0036] The two possible configurations of the downstream fan thus allow either optimum-output operation or noise attenuation. In the latter position, with the blades retracted longitudinally, the diameter of the fan is reduced. The stream lines run along the blade tip and give rise to blade tip vortices on the upstream fan but these vortices are prevented from impinging on the downstream noise and from being a source of noise. Moreover, the reduction in length of the blades is compensated for by increasing the load on these blades, notably by varying the blade pitch angle.

[0037] In cruising flight configuration, during which there is no need to attenuate the noise of the fans and which corresponds to over 90% of the mission, the two fans are deployed; in particular, the blades of the downstream fan extend in a radial direction with respect to the axis of the engine to substantially the same length as the blades of the upstream fan. It is on take-off or on landing that the retracted position of the blades of the downstream fan is activated, and that represents just 10% of the mission in general.

[0038] Mechanisms other than screw jacks allow the blades of the downstream fan to be retracted longitudinally. The invention is not restricted to this mode of actuation. Moreover, other ways of modifying the geometry of the blades are equally possible. For example, the blades may be capable of moving radially inside a housing in the nacelle, the telescopic elements being not at the blade tip end but at the root end.

1-9. (canceled)

10. A turbine engine comprising:

two coaxial and contra-rotating unducted external fans, respectively of an upstream and a downstream fan, wherein a length of blades of at least one of the two fans can be varied such that the diameter of the downstream fan is less than the diameter of the upstream fan.

11. The turbine engine as claimed in claim 10, in which blades of the downstream fan are retractable along their longitudinal axis, so as to reduce the diameter of the downstream fan.

12. The turbine engine as claimed in claim 10, in which the variable-length blades are telescopic with at least two blade elements which nest one inside the other and can slide one relative to the other along the axis of the blade.

13. The turbine engine as claimed in claim 12, in which the two blade elements mounted so as to slide one relative to the other are formed at the tip of the blades.

14. The turbine engine as claimed in claim 12, in which the two blade elements are formed at a root end of the blades.

15. The turbine engine as claimed in claim **10**, in which at least the blades of the downstream fan are variable-pitch blades.

16. A method for reducing noise emitted by a turbine engine including two coaxial and contra-rotating unducted external fans, respectively of an upstream and a downstream fan, during a phase of operation of this engine, the method comprising:

modifying a length of the blades of at least one fan so that the diameter of the downstream fan is less than that of the upstream fan during the phase of operation.

17. The method as claimed in claim **16**, the turbine engine being mounted on an aircraft, the phases of operation corresponding to take-off and landing of the aircraft.

18. The method as claimed in claim **16**, whereby the reduction in blade length is compensated for by increasing loading on the blade, by varying a blade pitch angle.

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