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(56) Documents Cited:
GB 2400144 A **GB 2208529 A**
US 6457935 B1

(58) Field of Search:
UK CL (Edition X) **F1V, F2B**
INT CL **F01D, F16J**
Other: **WPI; EPODOC**

(54) Abstract Title**: A seal arrangement for sealing between turbine blades**

(57) A seal arrangement for sealing between turbine blades 1, 2 comprising a filler subassembly 3 which spans the space between adjacent turbine blades 1, 2 in order to isolate the annular gas intake area 4 from the central machinery space 5. The filler subassembly comprises a filler member 7 and seal members 10, 11 located in slots at either end of the filler member. Each of the seals 10, 11 engages a respective blade 2, 1. The seal members 10, 11 and slots have cooperating inclined surfaces 12, 8 whereby when the turbine rotates in use, an upward force is generated on the seal members 10, 11 as a result of the cooperation of the surfaces 12, 8, so that they move upwardly to close the respective gap 13 between the respective edge of the filler member 7 and the associated blade 1, 2.

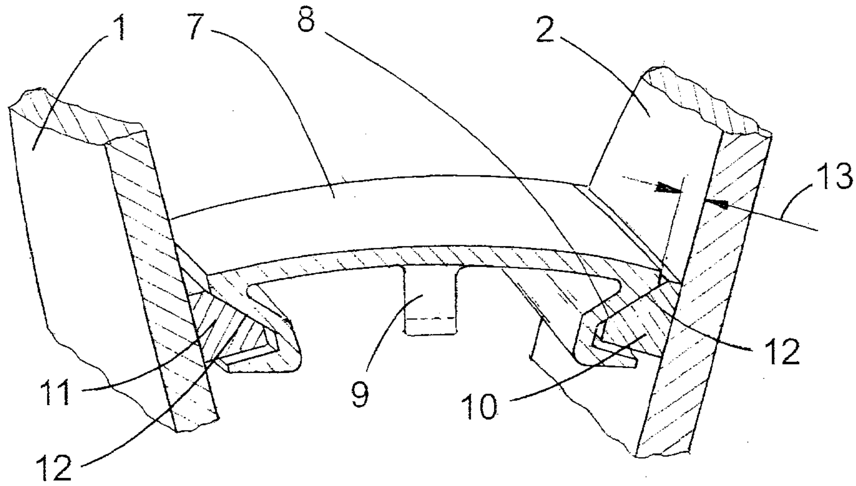

FIGURE 2

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

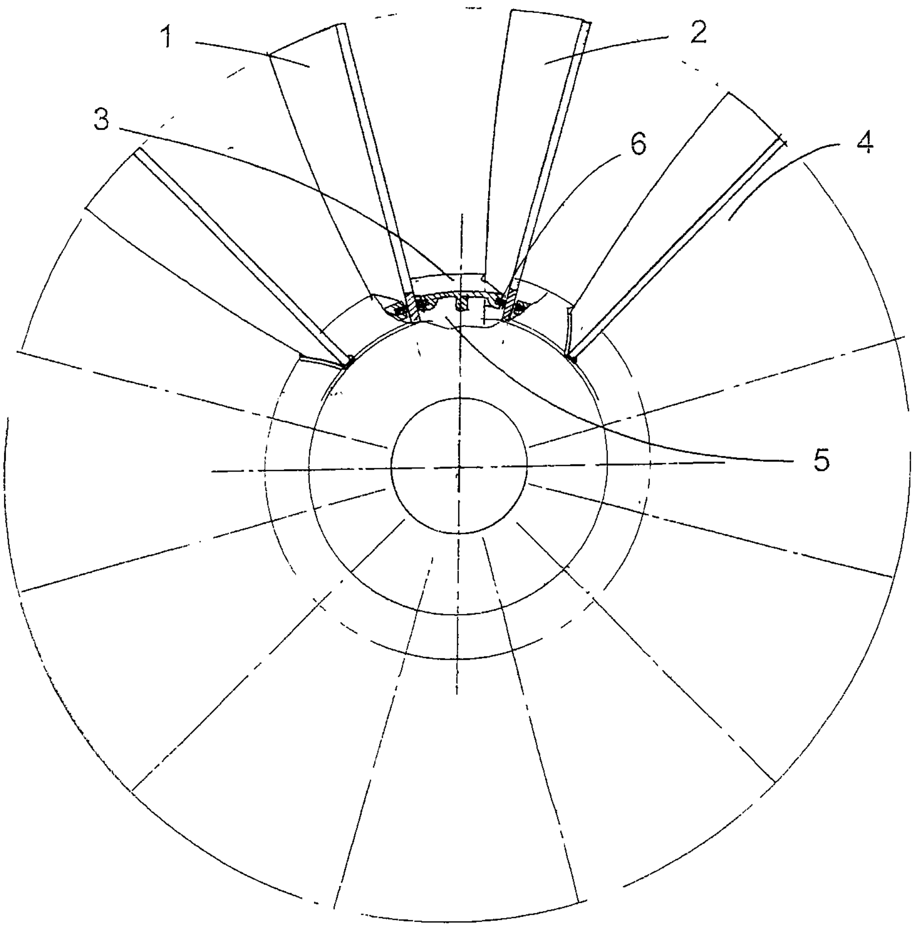

FIGURE 1

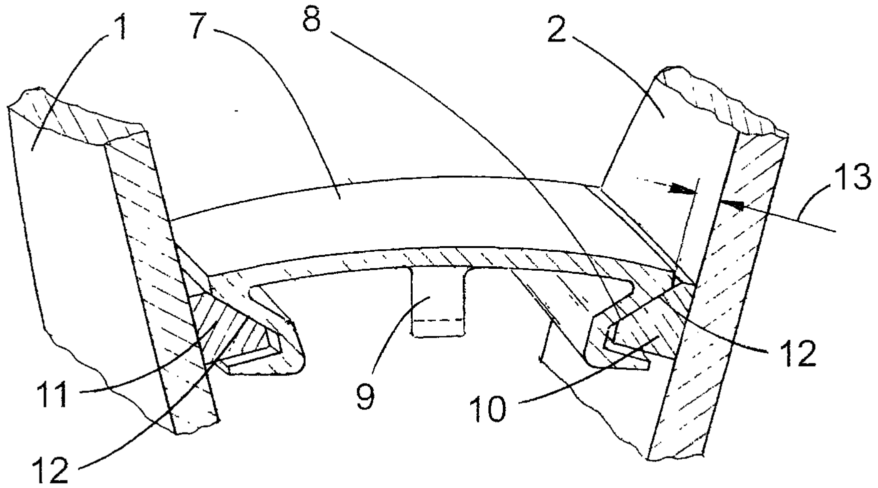

FIGURE 2

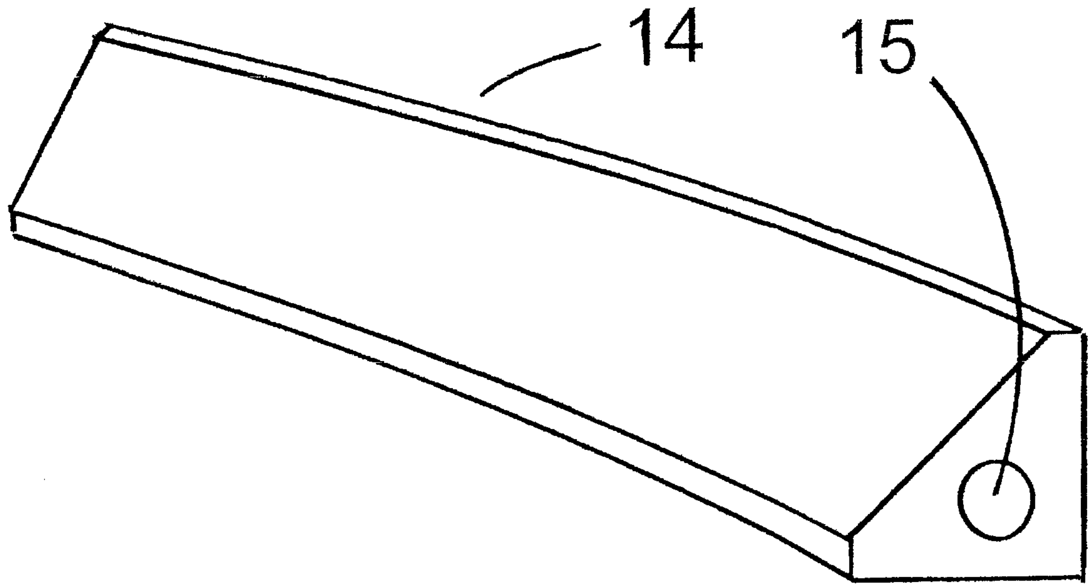

FIGURE 3

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IMPROVEMENTS TO SEALS

Field of the Invention

The invention relates to axial compressor assemblies where there is a requirement to isolate the annular shaped gas intake spaces through which the compressor fan blades are rotating from the central cylindrical spaces containing the rotor bearings and other precision machinery parts of the engine. The invention is of particular, but not exclusive benefit, to large aircraft gas turbine engines where the initial stages of the compressor occupy relatively large intake diameters.

Background to the Invention

In the case of modest size axial compressors, the annular isolation feature required to separate the gas intake path from the central machinery space can be obtained by arranging for the adjacent fan blade root fixtures to abut each other on a boundary line which is in a plane approximately mid way between adjacent fan blades.

However, on large axial compressors, particularly on those employed in aircraft gas turbine engines, the spacing between adjacent fan blades on the initial two or three stages is too large to enable the blade root fixtures to abut and the current practice is to fit lightly constructed annulus sealing membranes or "fillers" to seal up and isolate, as far as possible, the central machinery spaces from the gas being compressed by the rotating fan blades. In a typical installation the gas pressure generated by the initial stages may be for example 4 or 5 bars (60 to 75 p.s.i.) above the pressure existing in the central machinery core of the engine.

The high stresses due mainly to centrifugal forces set up in the rotating fan blades and the expansion and consequent distortion of metal alloy components due to varying temperature rises results in a situation where it is not possible to use close fitting mating components in the regions between adjacent fan blade roots. Because of this situation the annulus sealing fillers have to be provided with a significant working clearance where the boundaries of the fillers are adjacent to the blade profile. A further reason for maintaining a boundary gap is to prevent metal to metal contact resulting in fretting on the fan blade surfaces at radial distances from the turning centre where the stresses due to centrifugal force are at or near their maximum values. In practice, working gaps up to 4 to 6 millimetres (0.16 to 0.24 inches) can be present on large by-pass flow gas turbines.

The present method of sealing the gaps between the fan blade profiles and the filler and to prevent metal to metal fretting is to provide substantially rectangular section flexible strip polymer seals located in rectangular section grooves along the edges of the fillers which are adjacent to the fan blade profiles. The working life of these seals is at present significantly less than the normal service life of the adjacent metal alloy components.

Summary of the Invention

The improvements which are the subject of this invention are to replace the flexible polymer sealing strips with semi-rigid sealing strips made of polymer material, or made of a combination of materials and to so shape the seals and the seal locating grooves in the filler that centrifugal force acting on the mass of each sealing strip holds the strip in contact with one surface of the filler whilst simultaneously providing opposing forces in substantially circumferential directions which hold the said sealing strips in contact with the fan blade profiles; the said combination of substantially radial and circumferential forces being sufficient to hold the sealing strips in contact with the cooperating sealing surfaces against the forces generated by the gas pressure acting on the exposed surface areas of the strips.

Where a combination of materials is used for making the sealing strips this may be in the form of a central relatively heavy core to provide both semi-regidity and mass, the latter required to generate sufficient centrifugal force, the core being surrounded by a flexible polymer coating to provide the gas sealing surfaces and to prevent the metal to metal contact on the highly stressed regions of the fan blades.

Brief Description of the Drawings

Figure 1 is a view looking on the air entry end of an aircraft gas turbine in which the entry stage fan assembly has been partially removed through two fan blades to show a cross section of a filler sub-assembly provided with a typical current design of polymer sealing strips.

Figure 2 is an enlarged cross section of the same two blades as shown in Figure 1 but with the modified design of filler and sealing strips, the subject of this invention.

Figure 3 shows a view of a further embodiment of the sealing strip having a metal core section with a surrounding polymer coating.

Description of the Preferred Embodiments

Figure 1 shows a simplified view of the intake area of an aircraft gas turbine of current design. Two of the first stage fan blades 1 and 2 have been partially sectioned near the blade root fixings to illustrate the filler sub-assembly 3 which spans the space between the adjacent fan blades 1 and 2 in order to isolate the annular gas intake area 4 from the central machinery space 5. The polymer seal 6 which limits the gas leakage between these two spaces is of rectangular cross section form and is contained within rectangular shaped slots in the filler with one free surface abutting the fan blade profile.

Figure 2 shows an enlarged view of the sectioned area in Figure 1 with the filler sub-assembly 3 replaced by the new design of filler 7 and seals 10 and 11, the subject of this invention. The former rectangular slots have now been replaced by slots in which the former outer slot surface, which was in a direction substantially parallel to the filler outer surface has now been replaced by a slot surface 8 which is inclined as illustrated. The central inward directed protrusion 9 is an anchor extension which holds the filler sub-assembly on to the rotor shaft (not illustrated in Figure 2). The slot surface 8 inclination angle, related to a radial plane lying in the axis of rotation of the compressor and passing through the centre of gravity of the seals 10 and 11 contained within the slots, is typically 45 degrees. The cross sections of the seal strips 10 and 11 are so shaped that, along the seal strip lengths, the seals have surfaces 12 which cooperate with the inclined surfaces 8 in the filler 7 slots.

As the compressor rotation accelerates from rest, the radial centrifugal forces acting on the seal strips, increase overcoming the gravitational forces and causing each seal to exert a force on the inclined surface 8 in the filler slot. Because of the inclination of the surfaces 8 and 12 on each side of the filler two opposed outward directed forces are generated by these radial centrifugal forces acting on the seals. Provided that the surfaces inclination angles are sufficiently small relative to the aforementioned plane the outward directed forces will overcome the restraining forces due to the cooperating surfaces friction coefficient and each seal will slide upwards as drawn along the inclined outer slot surfaces causing the seals to span the clearance gap 13 between the edge of the filler and each fan blade profile. This arrangement, therefore, ensures that substantial sealing contact pressures can be generated on both the fan blade profiles and the filler inclined slot surfaces when the compressor is rotating at its normal running speeds.

Figure 3 shows a sealing strip 14 removed from the filler slot. In order to increase the stiffness of the seal when dealing with wide and varying gaps 13 it may be necessary to provide a metal alloy reinforcing wire or tube core 15 moulded, or otherwise located, in the centre of the seal section. A further embodiment, when dealing with high rotor speeds and high gas pressure differences across the gaps 13 can be to use a metal core section which is a similar shape but smaller than the required seal section and to make up the dimensional difference with a polymer coating which surrounds, or partly surrounds, the core at substantially constant thickness.

The core section may also be used to modify the mass of the seal, for example, a solid metal core using an iron based alloy can have a density of between five to seven times the density of the polymer seal material. This facility will enable the sealing pressures to be modified for any given rotor speed because these pressures will be in a linear relationship to the centrifugal forces which, in turn, are proportional to the mass of each composite material seal.

CLAIMS

1. A seal arrangement for sealing between turbine blades comprising a filler section for extending between the blades and defining oppositely facing slots at its edges and a respective seal member located in each slot for engaging its respective blade characterised in that the seal members and the slots have cooperating inclined surfaces whereby when the turbine rotates in use an upward force is generated on the seals as a result of the cooperation of the surfaces, so that the move upwardly to close the respective gap between the respective edge of the filler section and the associated blade.

2. An arrangement as claimed in claim 1 wherein the filler section includes an anchor for anchoring the filler section relative to the blades.

3. An arrangement as claimed in claim 2 wherein the seals retained by the blades and the filler section.

4. An arrangement as claimed in any one of the preceding claims wherein the seals are substantially trapezoidal in section.

5. An arrangement as claimed in any one of the preceding claims wherein the seals are semi-rigid.

6. An arrangement as claimed in claim 5 wherein the seals have a central rigid core covered with a flexible coating.

Application No: GB0425187.2 **Examiner:** Mr Kevin Hewitt

Claims searched: 1 to 6 **Date of search:** 8 March 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	GB 2400144 A (ALSTOM) See especially Fig. 1.
A	-	GB 2208529 A (GENERAL ELECTRIC) See especially damping element 49 in Figs.
A	-	US 6457935 B1 (ANTUNES et al.) See especially Fig. 1.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

F1V; F2B

Worldwide search of patent documents classified in the following areas of the IPC

F01D; F16J

The following online and other databases have been used in the preparation of this search report

WPI; EPODOC