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(54) Annulus filler and corresponding stage and gas turbine engine

Ringspaltfüller und zugehörige Stufe und Gasturbinentriebwerk

Plateforme entretoise annulaire, étage et motor à turbine à gaz associés

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- **HUTTUNEN-SAARIVIRTA E ET AL: "Corrosion protection of galvanized steel by polyimide coatings: EIS and SEM investigations", PROGRESS IN ORGANIC COATINGS, ELSEVIER BV, NL, vol. 72, no. 3, 18 April 2011 (2011-04-18) , pages 269-278, XP028312757, ISSN: 0300-9440, DOI: 10.1016/J.PORGCOAT.2011.04.015 [retrieved on 2011-04-22]**

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Description

[0001] The present invention relates to annulus fillers for bridging gaps between adjacent blades of a gas turbine engine.

[0002] Conventionally, a compressor rotor stage in a gas turbine engine comprises a plurality of radially extending blades mounted on a rotor disc. The blades are mounted on the disc by inserting a root portion of the blade in a complementary retention groove in the outer face of the disc periphery. To ensure a smooth radially inner surface for air to flow over as it passes through the stage, annulus fillers can be used to bridge the spaces between adjacent blades.

[0003] Annulus fillers of this type are commonly used in the fan stage of gas turbine engines. The annulus fillers may be manufactured from relatively lightweight materials and, in the event of damage, may be replaced independently of the blades.

[0004] Annulus fillers come in various shapes and sizes depending on the design and construction of the gas turbine engine into which they are inserted. However, generally, annulus fillers have an outer lid which defines an airflow surface for air being drawn through the engine, the lid having a leading edge and a trailing edge in an axial airflow direction, and a support arrangement which connects directly or indirectly to the rotor disc to support the lid thereon. For example, the support arrangement may comprise one or more of a pin formation (e.g. for attaching the front of the annulus filler to the disc), a mounting ring formation (e.g. for attaching the rear of the annulus filler to the disc), and a hook formation (e.g. for attaching the underside of the annulus filler to the disc).

[0005] European patent applications EP2253802A2, EP2463482A2 and EP1013886A2 disclose annulus fillers. European patent applications EP2503102A2, EP2511479A2 and EP2594773A2 and "Corrosion protection of galvanised steel by polyimide coatings" (Huttunen-Saarivirta E et al.; Progress in Organic Coatings, Elsevier BV, NL, vol. 72, no. 3, 18 April 2011, pages 269-278) disclose the use of coatings or barriers to prevent corrosion.

[0006] Annulus filler release may result from bird strike on the annulus filler or from excessive blade movement. To reduce the risk of engine damage in the event of such release and to reduce weight, the annulus filler can be formed of lightweight carbon fibre reinforced composite material. However, particularly with carbon fibre composites, but also if the annulus filler is formed of other materials such as other polymer matrix composites, a problem can then arise of galvanic corrosion between the annulus filler and adjacent, typically metallic, parts of the engine. Similarly, this effect can be seen in reverse with composite adjacent parts of the engine and metallic annulus fillers.

[0007] According to the invention there is provided an annulus filler as set out in the claims.

[0008] Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 shows a longitudinal cross-section through a ducted fan gas turbine engine;

Fig. 2 shows a longitudinal cross-section of an annulus filler of the present invention;

Fig. 3 shows a perspective view from the front of the annulus filler of Fig. 2;

Fig. 4 shows a perspective view from the rear of the annulus filler of Fig. 2; and

Fig. 5 shows an enlarged longitudinal cross sectional view of the trailing edge of the annulus filler of Fig. 2.

[0009] With reference to Fig. 1, a three-shaft ducted fan gas turbine engine incorporating the invention is generally indicated at 10 and has a principal and rotational axis X-X. The engine comprises, in axial flow series, an air intake 11, a propulsive fan 12, an intermediate pressure compressor 13, a high-pressure compressor 14, combustion equipment 15, a high-pressure turbine 16, an intermediate pressure turbine 17, a low-pressure turbine 18 and a core engine exhaust nozzle 19. A nacelle 21 generally surrounds the engine 10 and defines the intake 11, a bypass duct 22 and a bypass exhaust nozzle 23. The invention can also be applied to other forms of gas turbine engine, such as two-shaft engines.

[0010] During operation, air entering the intake 11 is accelerated by the fan 12 to produce two air flows: a first air flow A into the intermediate pressure compressor 13 and a second air flow B which passes through the bypass duct 22 to provide propulsive thrust. The intermediate pressure compressor 13 compresses the air flow A directed into it before delivering that air to the high pressure compressor 14 where further compression takes place.

[0011] The compressed air exhausted from the high-pressure compressor 14 is directed into the combustion equipment 15 where it is mixed with fuel and the mixture combusted. The resultant hot combustion products then expand through, and thereby drive the high, intermediate and low-pressure turbines 16, 17, 18 before being exhausted through the nozzle 19 to provide additional propulsive thrust. The high, intermediate and low-pressure turbines respectively drive the high and intermediate pressure compressors 14, 13 and the fan 12 by suitable interconnecting shafts.

[0012] Annulus fillers may be used to bridge the spaces between adjacent blades, for example at the fan 12. This is to ensure a smooth radially inner surface for air to flow over as it passes through the fan 12.

[0013] Fig. 2 shows an example annulus filler of the present invention. The annulus filler 100 sits between two fan blades 25 and is formed from carbon fibre reinforced composite material. However, other polymer-

based composite and metallic material options can also be used for forming the annulus filler.

[0014] The annulus filler 100 comprises an outer lid 30 which defines an airflow surface for air being drawn through the gas turbine engine 10, and a support arrangement which includes a body part 32 extending the axial length of the lid. The support arrangement of the annulus filler also includes two axially spaced straps 36 at the radially inward side of the body part 32 which join to complementary hooks 38 on a rotor disc 34. However, in alternative configurations, the support arrangement and the rotor disc 34 may each have only one strap/hook, or they may each have more than two straps/hooks.

[0015] The body part 32 and the lid 30 form a stiff and lightweight box-like structure, which is able to spread and resist the loads on the annulus filler 100. For example, the box-like structure advantageously promotes in-plane tension loading of its composite material under centrifugal loads. Conveniently, the box-like structure can be formed without internal features. The box-like structure, particularly if formed without internal features, is also relatively easy to manufacture, e.g. from an annular arrangement of continuous fibre reinforcement which can then be moulded and machined. The lid may be stitched or z-pinned to the rest of the annulus filler. This can improve the through-thickness strength of the box-like structure, which may be beneficial for hail and birdstrike protection.

[0016] The support arrangement further includes a first engageable portion 40 at the leading edge of the lid 30 and a second engageable portion 42 at the trailing edge of the lid. The first engageable portion abuts with a support ring 44 attached to the rotor disc 34 and has a pin 43 which fits into a receiving hole formed in the support ring. The first engageable portion also engages a makeup piece 45 which forms an aerodynamic surface between the lid 30 and a spinner fairing 47. Alternatively, the spinner fairing itself may be extended so as to engage with the annulus filler. The second engageable portion engages, in use, with a fan rear seal 46 also attached to rotor disc 34.

[0017] The fan blades 25 may be metallic or a composite material, e.g. carbon fibre reinforced composite material.

[0018] A first galvanic corrosion barrier 48 is provided at the first engageable portion 40, as illustrated in Fig. 3. The first galvanic corrosion barrier 48 is in two parts, a first part 48a being located where the first engageable portion abuts with the support ring 44, and a second part 48b being located where the first engageable portion engages the makeup piece 45. The barrier helps to prevent corrosion by preventing direct contact between the carbon fibres of the composite material of the annulus filler 100 and the metal of the support ring and the makeup piece. However, relative to the composite material, the barrier also has a lower coefficient of friction for sliding against metal. When the annulus filler pivots about the pin 43 (e.g. under lateral forces imposed by movement of the blades 25), this helps to reduce wear at the sliding interfaces between the first engageable portion 40, and the support ring 44 and the makeup piece 45. A suitable material for the low friction first galvanic corrosion barrier 48 can be a polyimide-based plastic, such as Vespel™. However, other materials exhibiting similar characteristics of durability and low friction are also possible.

[0019] A second galvanic corrosion barrier 49 is provided at the second engageable portion 42, as illustrated in Fig. 4. The second barrier 49 also helps to prevent corrosion by preventing direct contact between the carbon fibres of the composite material of the annulus filler 100 and the metal of the fan rear seal 46. However, the second barrier has a higher coefficient of friction relative to the composite material than the first barrier 48, and provides increased friction at the interface between the second engageable portion 42 and the fan rear seal. The second barrier can be a woven glass composite layer, co-moulded with annulus filler outer part 30. The increased friction allows the annulus filler to act as a frictional damper to the fan rear seal. This in turn reduces flutter in the fan rear seal.

[0020] More particularly, as shown in Fig. 5, the second engageable portion 42 fits underneath the fan rear seal 46 and, when the engine is stationary, is spaced a distance radially inwardly therefrom. For example, a nominal cold build clearance may be in the range from 0.5-5.0 mm. In use, when the engine 10 begins to spin, the second engageable portion 42 moves outwardly under centrifugal loading. Above a certain engine speed (e.g. about 800 rpm), depending on clearance, engine application and annulus filler design, the second engageable portion contacts the fan rear seal 46, and begins to exert a force on the seal. The effect of this force is to change the unsupported length of the seal, as well as to provide a resistive force to any motion, harmonic or otherwise, of the seal. The resistance to such motion is enhanced by the relatively high coefficient of friction of the second barrier 49. Such damping effects are beneficial to the seal and can increase its life by ~50%.

[0021] While the invention has been described in conjunction with the exemplary embodiments described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. Accordingly, the exemplary embodiments of the invention set forth above are considered to be illustrative and not limiting. Various changes to the described embodiments may be made without departing from the scope of the invention.

Claims

1. An annulus filler (100) for mounting to a rotor disc (34) of a gas turbine engine and bridging the gap between two adjacent blades (25) attached to the rotor disc, the annulus filler having:

an outer lid (30) which defines an airflow surface for air being drawn through the engine, the lid having a leading edge and a trailing edge in an axial airflow direction; and
a support arrangement which is connectable to the rotor disc to support the lid on the rotor disc;

the support arrangement including a first engageable portion (40) at the leading edge of the lid and a second engageable portion (42) at the trailing edge of the lid, the engageable portions engaging in use with respective adjacent parts of the gas turbine engine, and having respective galvanic corrosion barriers (48, 49) which prevent or reduce galvanic corrosion between the material of the lid and the respective adjacent engine parts;
the annulus filler characterised in that the galvanic corrosion barrier (48) of the first engageable portion has a reduced coefficient of friction relative to the lid to facilitate relative movement between the first engageable portion and the respective adjacent engine part and thereby to reduce wear, and the galvanic corrosion barrier (49) of the second engageable portion has an increased coefficient of friction relative to the lid to reduce relative movement between the second engageable portion and the respective adjacent engine part and thereby to provide damping.

2. The annulus filler of claim 1, wherein the adjacent engine part of the first engageable portion includes a nosecone fairing or a makeup piece (45) of a nosecone fairing.

3. The annulus filler of claim 1 or 2, wherein the adjacent engine part of the second engageable portion is a fan rear seal (46).

4. The annulus filler of any one of the preceding claims wherein the lid is substantially entirely formed from polymer matrix composite material.

5. The annulus filler of any one of the preceding claims wherein the galvanic corrosion barrier of the first engageable portion is formed from a polyimide-based plastic.

6. The annulus filler of any one of the preceding claims wherein the galvanic corrosion barrier of the second engageable portion is formed from a glass fibre reinforced composite material.

7. The annulus filler of any one of the preceding claims for mounting to a fan disc and bridging the gap between two adjacent fan blades attached to the fan disc.

8. A stage for a gas turbine engine having:

a rotor disc,
a circumferential row of spaced apart blades attached to the rotor disc, and
a plurality of annulus fillers according to any one of the preceding claims bridging the gaps between adjacent blades.

9. A gas turbine engine (10) having the stage of claim 8.

Patentansprüche

1. Ringspaltfüller (100) zum Montieren an eine Rotorscheibe (34) eines Gasturbinentriebwerks und Überbrücken des Spalts zwischen zwei benachbarten Schaufeln (25), die an der Rotorscheibe angebracht sind, wobei der Ringspaltfüller Folgendes aufweist:

einen Außendeckel (30), der eine Luftströmungsfläche für Luft definiert, die durch das Triebwerk gezogen wird, wobei der Deckel in einer axialen Luftströmungsrichtung eine Vorderkante und eine Hinterkante aufweist; und
eine Stützanordnung, die mit der Rotorscheibe verbunden werden kann, um den Deckel an der Rotorscheibe zu stützen;

wobei die Stützanordnung einen ersten in Eingriff nehmbaren Abschnitt (40) an der Vorderkante des Deckels und einen zweiten in Eingriff nehmbaren Abschnitt (42) an der Hinterkante des Deckels umfasst, wobei die in Eingriff nehmbaren Abschnitte in Verwendung mit entsprechenden benachbarten Teilen des Gasturbinentriebwerks in Eingriff treten, und entsprechende Barrieren gegen galvanische Korrosion (48, 49) aufweist, die galvanische Korrosion zwischen dem Material des Deckels und den entsprechenden benachbarten Triebwerkteilen verhindern oder reduzieren;
wobei der Ringspaltfüller dadurch gekennzeichnet ist, dass die Barriere gegen galvanische Korrosion (48) des ersten in Eingriff nehmbaren Abschnitts einen reduzierten Reibungskoeffizienten relativ zu dem Deckel aufweist, um relative Bewegung zwischen dem ersten in Eingriff nehmbaren Abschnitt und dem entsprechenden benachbarten Triebwerkteil zu erleichtern und dadurch Verschleiß zu reduzieren, und die Barriere gegen galvanische Korrosion (49) des zweiten in Eingriff nehmbaren Abschnitts einen erhöhten Reibungskoeffizienten relativ zu dem Deckel aufweist, um relative Bewegung zwischen dem zweiten in Eingriff nehmbaren Abschnitt und dem entsprechenden benachbarten Triebwerkteil zu reduzieren und dadurch Dämpfung bereitzustellen.

2. Ringspaltfüller nach Anspruch 1, wobei der benachbarte Triebwerkteil des ersten in Eingriff nehmbaren

Abschnitts eine Nasenkegelverkleidung oder ein Aufbaustück (45) einer Nasenkegelverkleidung umfasst.

3. Ringspaltfüller nach Anspruch 1 oder 2, wobei der benachbarte Triebwerkteil des zweiten in Eingriff nehmbaren Abschnitts eine rückseitige Gebläsedichtung (46) ist.

4. Ringspaltfüller nach einem der vorstehenden Ansprüche, wobei der Deckel im Wesentlichen gänzlich aus Polymermatrix-Verbundwerkstoff gebildet ist.

5. Ringspaltfüller nach einem der vorstehenden Ansprüche, wobei die Barriere gegen galvanische Korrosion des ersten in Eingriff nehmbaren Abschnitts aus einem polyimidbasierten Kunststoff gebildet ist.

6. Ringspaltfüller nach einem der vorstehenden Ansprüche, wobei die Barriere gegen galvanische Korrosion des zweiten in Eingriff nehmbaren Abschnitts aus einem glasfaserverstärkten Verbundwerkstoff gebildet ist.

7. Ringspaltfüller nach einem der vorstehenden Ansprüche zum Montieren an eine Gebläsescheibe und Überbrücken des Spalts zwischen zwei benachbarten Gebläseschaufeln, die an der Gebläsescheibe angebracht sind.

8. Stufe für ein Gasturbinentriebwerk, die Folgendes aufweist:

eine Rotorscheibe,
eine umlaufende Reihe von beabstandeten Schaufeln, die an der Rotorscheibe angebracht sind, und
eine Vielzahl von Ringspaltfüllern nach einem der vorstehenden Ansprüche, die die Spalten zwischen benachbarten Schaufeln überbrücken.

9. Gasturbinentriebwerk (10), das die Stufe nach Anspruch 8 aufweist.

Revendications

1. Plateforme annulaire (100) à monter sur un disque rotor (34) d'un moteur à turbine à gaz et permettant de combler l'espace entre deux aubes adjacentes (25) fixées au disque rotor, la plateforme annulaire possédant :

un couvercle externe (30) qui définit une surface de flux d'air pour l'air qui est aspiré à travers le moteur, le couvercle possédant un bord d'attaque et un bord de fuite dans la direction d'un flux d'air axial ; et
un mécanisme de support qui est en mesure d'être connecté au disque rotor pour supporter le couvercle sur le disque rotor ;

le mécanisme de support incluant une première partie accouplable (40) au niveau du bord d'attaque du couvercle et une deuxième partie accouplable (42) au niveau du bord de fuite du couvercle, les parties accouplables venant s'accoupler en utilisation avec des pièces adjacentes respectives du moteur à turbine à gaz, et possédant des barrières contre la corrosion galvanique respectives (48, 49) qui empêchent ou réduisent la corrosion galvanique entre le matériau du couvercle et les pièces adjacentes respectives du moteur ;
la plateforme annulaire étant caractérisée en ce que la barrière contre la corrosion galvanique (48) de la première partie accouplable possède un coefficient de friction réduit par rapport au couvercle pour faciliter le déplacement relatif entre la première partie accouplable et la pièce adjacente respective du moteur et réduire de la sorte l'usure, et la barrière contre la corrosion galvanique (49) de la deuxième partie accouplable possède un coefficient de friction augmenté par rapport au couvercle pour réduire le déplacement entre la deuxième partie accouplable et la pièce adjacente respective du moteur et procurer de la sorte un amortissement.

2. Plateforme annulaire selon la revendication 1, dans lequel la partie adjacente du moteur de la première partie accouplable inclut un carénage avant ou une pièce d'assemblage (45) d'un carénage avant.

3. La plateforme annulaire selon la revendication 1 ou 2, dans lequel la pièce adjacente du moteur de la deuxième partie accouplable est un joint arrière de ventilateur (46).

4. Plateforme annulaire selon l'une quelconque des revendications précédentes, dans lequel le couvercle est sensiblement formé entièrement d'un matériau composite de matrice polymère.

5. Plateforme annulaire selon l'une quelconque des revendications précédentes, dans lequel la barrière contre la corrosion galvanique de la première partie accouplable est formée d'un plastique à base de polyimide.

6. Plateforme annulaire selon l'une quelconque des revendications précédentes, dans lequel la barrière contre la corrosion galvanique de la deuxième partie accouplable est formée d'un matériau composite renforcé à la fibre de verre.

7. Plateforme annulaire selon l'une quelconque des re-

vendications précédentes, à monter sur un disque de ventilateur et permettant de combler l'espace entre deux aubes adjacentes de ventilateur fixées au disque de ventilateur.

8. Étage d'un moteur à turbine à gaz possédant :

un disque rotor,
une rangée circonférentielle d'aubes espacées fixées au disque rotor, et
une pluralité de plateformes annulaires selon l'une quelconque des revendications précédentes permettant de combler les espaces entre des aubes adjacentes.

9. Moteur à turbine à gaz (10) possédant l'étage selon la revendication 8.

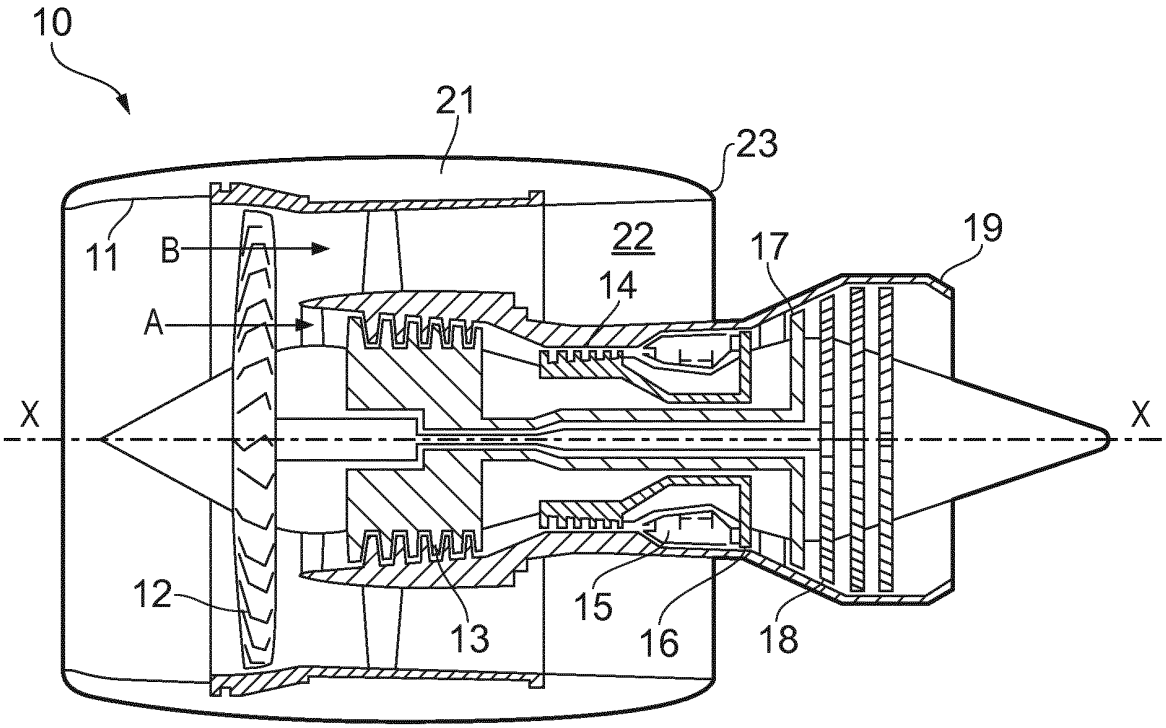

FIG. 1

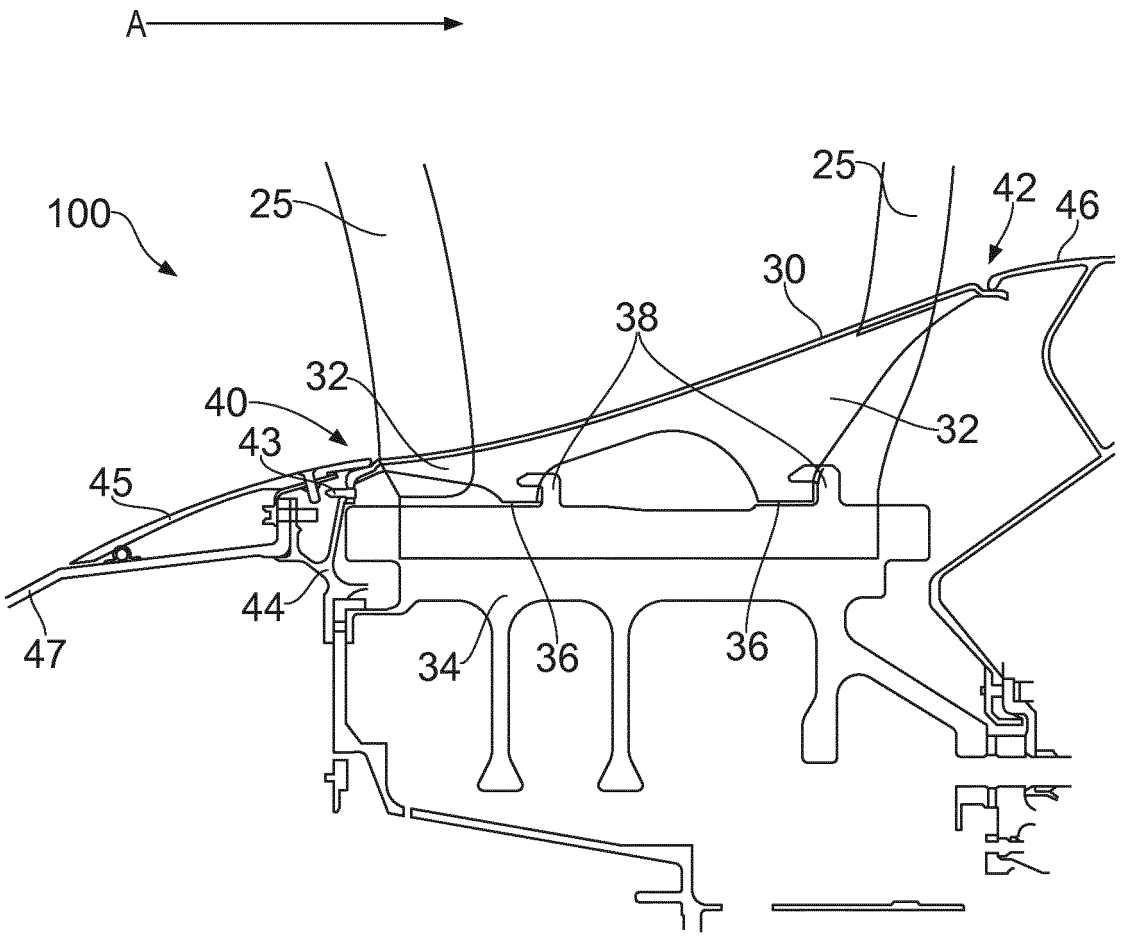

FIG. 2

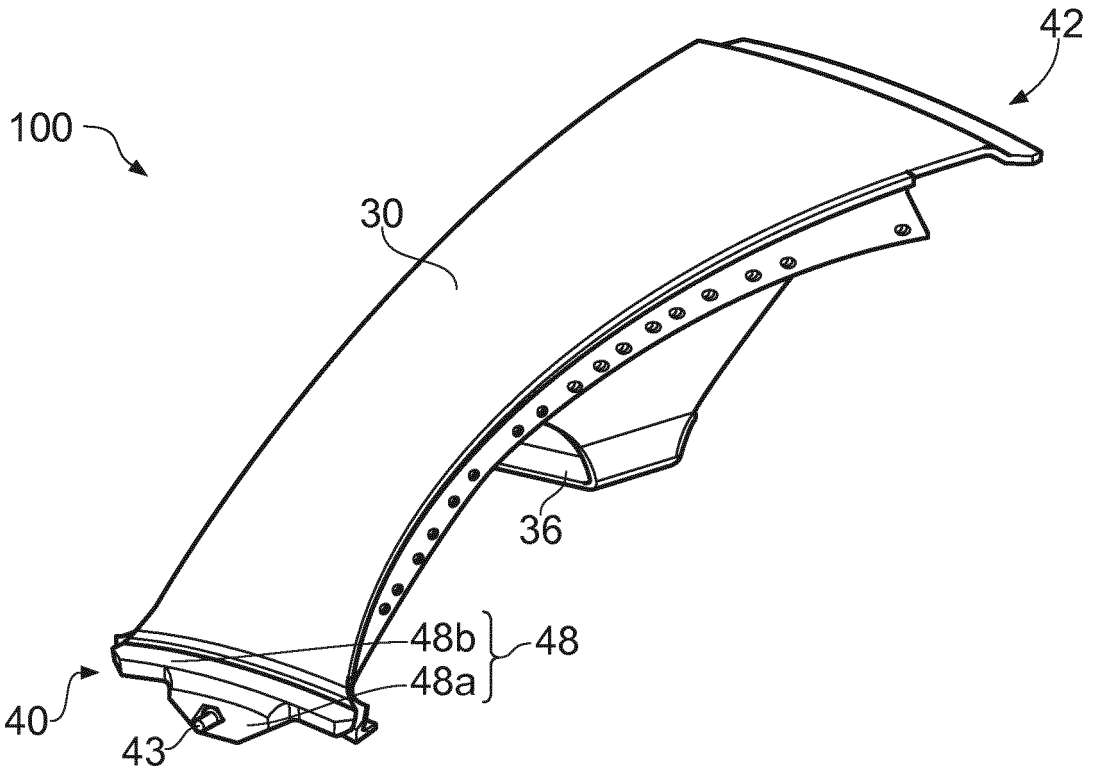

FIG. 3

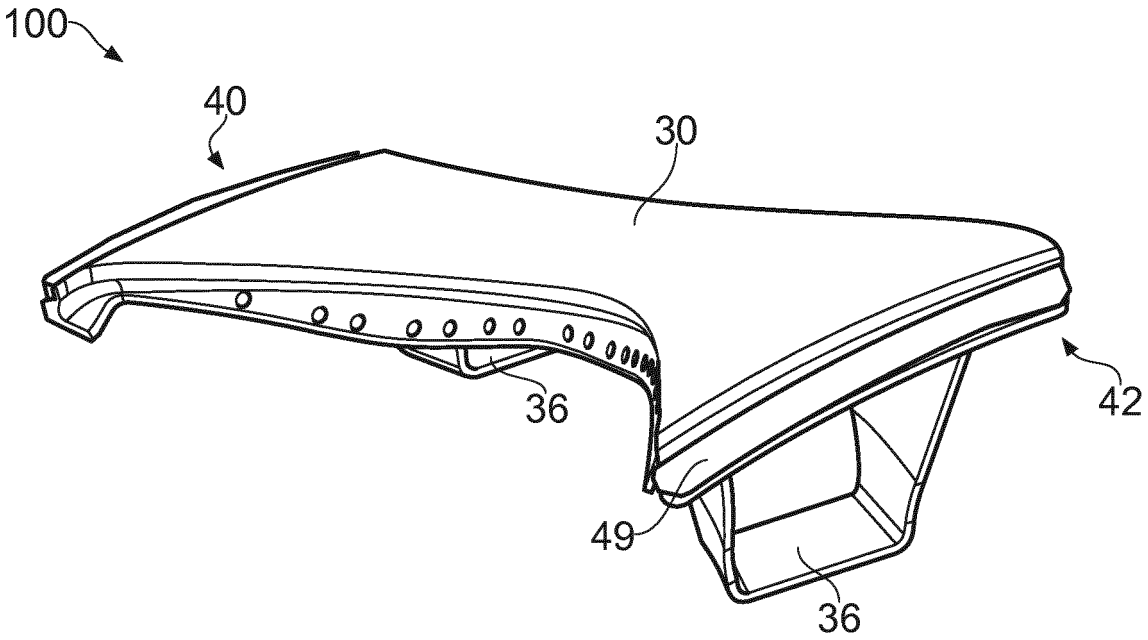

FIG. 4

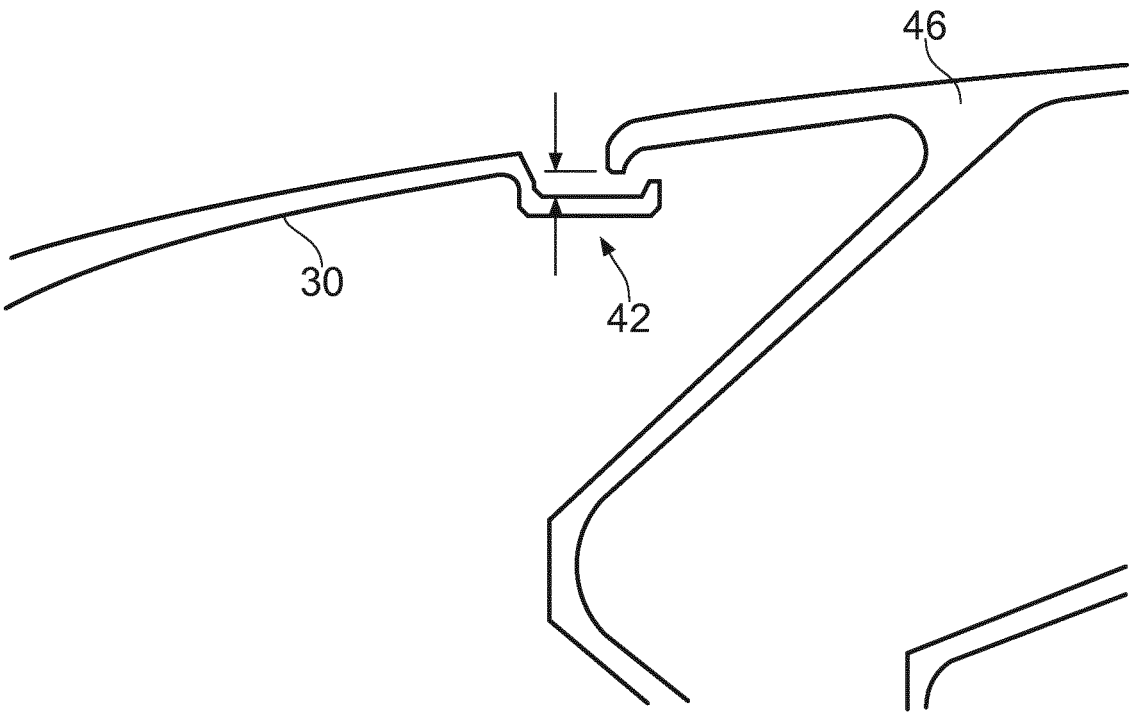

FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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