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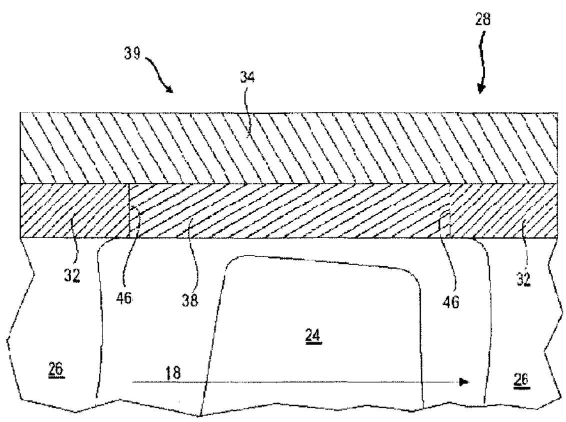
(54) Titre : COMPOSITION ABRADABLE ET JOINT D'ETANCHEITE D'UN LOGEMENT DE COMPRESSEUR D'UNE TURBOMACHINE A FLUX AXIAL

(54) Title: ABRADABLE COMPOSITION AND SEAL OF AN AXIAL-FLOW TURBOMACHINE COMPRESSOR CASING



(57) Abrégé/Abstract:
A composition for an abradable seal of a turbomachine includes an aluminium base, nickel powder, polyester powder. The abradable seal may be for an outer casing of a low-pressure compressor of an axial-flow turbomachine, the abradable seal surrounds an annular row of rotor blades. The seal includes a rounded support covered with a layer of abradable material having a metallic phase mainly made of aluminium and with nickel in a lesser proportion. The abradable material additionally includes from 25% to 55% of additive, such as polyester, methyl methacrylate, hexagonal boron nitride, calcium fluoride. The support is segmented, and forms an organic matrix composite outer casing of the compressor. A process for producing an abradable seal includes plasma spraying an Al-Ni-polyester powder.

Abstract

A composition for an abradable seal of a turbomachine includes an aluminium base, nickel powder, polyester powder. The abradable seal may be for an outer casing of a low-pressure compressor of an axial-flow turbomachine, the abradable seal surrounds an annular row of rotor blades. The seal includes a rounded support covered with a layer of abradable material having a metallic phase mainly made of aluminium and with nickel in a lesser proportion. The abradable material additionally includes from 25% to 55% of additive, such as polyester, methyl methacrylate, hexagonal boron nitride, calcium fluoride. The support is segmented, and forms an organic matrix composite outer casing of the compressor. A process for producing an abradable seal includes plasma spraying an Al-Ni-polyester powder.

Description

ABRADABLE COMPOSITION AND SEAL OF AN AXIAL-FLOW TURBOMACHINE COMPRESSOR CASING

Technical field

[0001] The present disclosure relates to the field of axial-flow turbomachine seals made of abradable material. More specifically, the disclosure tackles the subject of seals made of aluminium-based abradable material for an axial-flow turbomachine compressor for aircraft.

Prior art

[0002] An abradable material is known for ensuring dynamic sealing in a turbomachine, in particular in a compressor of the axial-flow turbomachine. Such material is applied as a layer to an outer casing and is capable of eroding in the event of contact with the tips of rotor blades without damaging them. The mechanical integrity is preserved despite speeds of rotation of greater than 8000 rpm, and a relative speed between a blade tip and its seal substantially equal to the speed of sound. Such a material is also used for ensuring sealing under inner shrouds, or on a drive shaft bearing.

[0003] In this way, it is possible to design a compressor while reducing the operating clearance between the tips of rotor blades and the inner surface of the casing. The optimization may also take into account the expansion, the centrifugal force; and certain operating risks such as ingestions and pumping phenomena. An abradable material that forms a casing coating generally comprises aluminium, silica, polyester.

[0004] Document EP 1 010 861 A2 discloses a composition of a layer of abradable material for an axial-flow turbomachine compressor. The composition comprises a mixture of aluminium powder and silica powder, the aluminium being in the majority. In addition, the powder has a polymer powder with methyl methacrylate. This composition is applied by plasma spraying onto a wall of an axial-flow turbomachine compressor, the wall receiving beforehand a bonding layer with a majority amount of nickel, and aluminium in a lesser proportion. This composition makes it possible to produce an abradable seal with a requirement of corrosion resistance; however this corrosion resistance still warrants being improved in order to optimize the resistance and the efficiency of the turbomachine.

Summary

Technical problem

[0005] The embodiment of the disclosure aims to solve at least one of the problems posed by the prior art. More specifically, one embodiment of the disclosure aims to improve the corrosion resistance of an axial-flow turbomachine seal made of abradable material. Another embodiment of the disclosure aims to optimize both the durability of the abradable material, the friable nature of the abradable material and the sealing provided by the abradable material.

Technical solution

[0006] The disclosure relates to a seal for an axial-flow turbomachine, in particular for a compressor, optionally a low-pressure compressor, of an axial-flow turbomachine; the seal comprising: a rounded support; at least one coating made of abradable material with a metallic phase mainly or predominantly comprising aluminium, in particular aluminium powder; the metallic phase additionally comprising nickel, in particular nickel powder; the abradable coating being applied to the rounded support, and being intended to cooperate by abrasion with a rotor element of the axial-flow turbomachine.

[0007] Another subject of the disclosure is a composition for an abradable coating of a seal of an axial-flow turbomachine, in particular for application to a rounded support by plasma spraying, the composition comprising: metal, in particular a metallic powder, with mainly aluminium; an organic or mineral filler, in particular as powder; noteworthy in that the metal additionally comprises nickel, in particular nickel powder.

[0008] According to one embodiment of the disclosure, the metal comprises, by weight, between 20% and 45%, preferably between 35% and 45% of nickel, in particular of nickel powder.

[0009] According to another embodiment of the disclosure, the metal comprises, by weight, between 55% and 80% of aluminium, in particular of aluminium powder.

[0010] According to another embodiment of the disclosure, the composition comprises, by weight, between 5% and 50% of filler, preferably between 15% and 25% of filler; optionally the filler is a polymer such as polyester or methyl methacrylate; or hexagonal boron nitride; or calcium fluoride; optionally as powder(s).

[0011] According to another embodiment of the disclosure, the combination of aluminium and nickel represents more than 80% of the weight of the metal of the composition, preferably more than 90%, more preferably more than 95%.

[0012] Another subject of the disclosure is a seal of an axial-flow turbomachine, in particular of a compressor of an axial-flow turbomachine, the seal comprising: a rounded support; at least one coating made of abradable material covering the rounded support, and which is intended to cooperate by abrasion with a rotor element of the axial-flow turbomachine; noteworthy in that the composition of the abradable coating is in accordance with the disclosure.

[0013] According to another embodiment of the disclosure, in the abradable coating, the metal forms a matrix which is combined with the filler; optionally, in the abradable coating, the volume occupied by the metallic matrix is the majority volume.

[0014] According to another embodiment of the disclosure, the rounded support is an outer shroud, the abradable coating being on the inside of the outer shroud; or the rounded support is an outer casing, the abradable coating being positioned on the inside of the outer casing.

[0015] According to another embodiment of the disclosure, the support is made of an organic matrix composite material with carbon fibres and/or glass fibres, said fibres being arranged as a stack of optionally woven fibrous plies.

[0016] According to another embodiment of the disclosure, the support comprises attachment means, such as orifices and/or at least one annular attachment tab, said means being positioned upstream and/or downstream of the abradable coating.

[0017] According to another embodiment of the disclosure, the support has an annular groove with an upstream edge and a downstream edge, the abradable coating covering the annular groove from the upstream edge to the downstream edge.

[0018] According to another embodiment of the disclosure, the abradable coating forms a layer having a thickness of greater than 0.30 mm, preferably greater than 2.00 mm, more preferably greater than 5.00 mm.

[0019] According to another embodiment of the disclosure, the coating forms a uniform layer over its thickness and/or over its main area.

[0020] According to another embodiment of the disclosure, the rounded support forms a circle or a portion of a circle. The expression “portion of a circle” may be understood to mean an angular portion of a circle.

[0021] According to another embodiment of the disclosure, the abradable coating has a compactness of greater than 80%, preferably of greater than 95%, more preferably of greater than 99%.

[0022] According to another embodiment of the disclosure, in the metal of the abradable coating, the volume of aluminium is the majority volume.

[0023] According to another embodiment of the disclosure, the abradable coating forms a leaktight barrier so as to protect the support from chemical attacks of the turbomachine.

[0024] According to another embodiment of the disclosure, the seal comprises an interlayer positioned between the support and the abradable coating; preferably the interlayer is a metal strip.

[0025] Another subject of the disclosure is a process for producing an abradable seal of an axial-flow turbomachine, in particular of a compressor of an axial-flow turbomachine, the seal comprising a rounded support and an abradable coating applied to the support, the process comprising the following steps: (a) provision or manufacture of a rounded support; (d) application of an abradable composition to the rounded support, the composition comprising metallic powder that mainly comprises aluminium powder; noteworthy in that during the application step (d), the metallic powder additionally comprises nickel powder; optionally the composition is in accordance with the disclosure.

[0026] According to another embodiment of the disclosure, during the application step (d), the composition is applied by plasma spraying to the support; preferably the composition additionally comprises an organic powder such as a polymer, or a mineral powder.

[0027] Another subject of the disclosure is a turbomachine comprising an abradable seal produced according to a process, noteworthy in that the abradable seal is in accordance with the disclosure, and/or the process is in accordance with the disclosure.

[0028] According to another embodiment of the disclosure, the turbomachine comprises a low-pressure compressor with at least one row of rotor blades, the seal being a seal of the low-pressure compressor which surrounds the at least one row of rotor blades.

[0029] According to another embodiment of the disclosure, the turbomachine comprises at least one annular row of stator blades with platforms attached to the support, the abradable coating being in contact with the platforms of blades; preferably the abradable coating forms a leaktight barrier that protects the support starting from, axially, the platforms. Such a seal provides two-fold sealing; namely dynamic sealing and static sealing.

[0030] According to another embodiment of the disclosure, the support is an inner shroud connected to the inner ends of a row of stator blades, the abradable coating being applied to the inside of the inner shroud.

[0031] According to another embodiment of the disclosure, the compressor comprises heating elements capable of heating the abradable material coating, and/or the compressor comprises flow bleed ports.

[0032] According to another embodiment of the disclosure, the inner surface of the abradable seal guides an annular flow, generally an axial annular flow, of the turbomachine.

[0033] Generally, the embodiments of each subject of the disclosure are also applicable to the other subjects of the disclosure.

[0034] The performance offered by the disclosure limits releases of the filler, such as polymer, into the turbomachine so as not to disrupt the combustion therein. The release of particles that obstruct the ducts and the mechanisms, or that abrade the latter, is restricted. These characteristics of the disclosure fall within a context of improving safety.

[0035] The disclosure is particularly relevant within the context of a low-pressure compressor since the air which enters therein may be at -50°C, and at +170°C at the compressor outlet. The composition proposed is suitable for low temperatures as well as for intermediate temperatures, for the temperature variations of the primary flow as a function of the flight phases of an aircraft over a range of more than 200°C. The disclosure additionally makes it possible to preserve the thermal resistance of the abradable material.

[0036] The Al-Ni-polyester composition offers a certain resistance to corrosion, in particular faced with a salt spray as tests have proven. The resistance may be observed over a wide range of temperatures, for example from -50°C to more than 150°C. This resistance also respects the sealing over time without prematurely degrading the rotor blades. These characteristics of the disclosure space out the maintenance operations of the turbomachine which enables a substantial saving to be made.

Brief description of the drawings

[0037] Figure 1 represents an axial-flow turbomachine according to the disclosure.

[0038] Figure 2 is a diagram of a turbomachine compressor according to the disclosure.

[0039] Figure 3 outlines a turbomachine abradable seal according to the disclosure.

[0040] Figure 4 illustrates a flowchart of a process for producing a turbomachine abradable seal according to the disclosure.

Description of the embodiments

[0041] In the description which follows, the terms interior or inner and exterior or outer refer to a positioning relative to the axis of rotation of an axial-flow turbomachine. The axial direction corresponds to the direction along the axis of rotation of the turbomachine.

[0042] Figure 1 represents an axial-flow turbomachine in a simplified manner. In this specific case it is a turbofan. The turbofan 2 comprises a first compression stage, referred to as low-pressure compressor 4, a second compression stage, referred to as high-pressure compressor 6, a combustion chamber 8 and one or more turbine stages 10. In operation, the mechanical power of the turbine 10 transmitted by the central shaft to the rotor 12 moves the two compressors 4 and 6. The latter comprise several rows of rotor blades combined with rows of stator blades. The rotation of the rotor about its axis of rotation 14 thus makes it possible to generate an air stream and to gradually compress the latter up to the inlet of the combustion chamber 8. Gear reduction means may increase the speed of rotation transmitted to the compressors.

[0043] An inlet fan commonly denoted by fan or blower 16 is coupled to the rotor 12 and generates an air flow which is split into a primary flow 18 that passes through the aforementioned various stages of the turbomachine, and a secondary flow 20 that passes through an annular duct (partially represented) along the machine in order to then rejoin the primary flow at the outlet of the turbine. The secondary flow may be accelerated so as to generate a thrust reaction. The primary flow 18 and secondary flow 20 are annular flows; they are channelled by the casing of the turbomachine. For this purpose, the casing has cylindrical walls or shrouds which may be inner and outer walls or shrouds.

[0044] Figure 2 is a cross-sectional view of a compressor of an axial-flow turbomachine such as that from Figure 1. The compressor may be a low-pressure compressor 4. A portion of the blower 16 and the splitter 22 for separating the primary flow 18 and the secondary flow 20 can be seen therein. The rotor 12 comprises several rows of rotor blades 24, in this particular case three.

[0045] The low-pressure compressor 4 comprises several straighteners, in this particular case four, which each contain a row of stator blades 26. The straighteners are combined with the blower 16 or with a row of rotor blades 24 in order to straighten the air flow, so as to convert the speed of the flow into static pressure. The stator blades 26 extend essentially radially from an outer casing 28 of the compressor, and may be attached thereto with the aid of a bolt 30 that radially extends the platforms 32 of stator blades 26.

[0046] The outer casing 28 may comprise an annular wall 34 and annular attachment flanges 36 that axially delimit the wall 34. The outer casing 28 may be formed of two half-shells. The wall 34 forms a sleeve and has an ogive shape, and its rotational profile is curved and mainly extends axially; its radius varies. The wall 34 serves as support for attachment to the attachment platforms 32 of the stator blades 26, and as support for the application of coatings of abradable materials 38 that ensure dynamic sealing; so as to form abradable seals 39 around the rotor blades 24. The abradable coatings 38 form uniform annular layers, such as circular strips, the thicknesses of which are greater than 2.00 mm. Dynamic sealing is understood to be a limitation of the flow between the abradable material and a rotor blade that turns during the operation of the turbomachine.

[0047] The annular attachment flanges 36 extend radially outwards. The annular flanges 36 upstream and downstream of the casing 28 make it possible to attach the compressor 4 to the intermediate blower casing 40, but also enable the attachment of the splitter 22. The attachment flanges 36 may comprise axial attachment orifices (not represented), and tubular seatings. The abradable coatings 38 may be positioned axially between the annular attachment flanges 36.

[0048] The casing 28, in particular its wall 34, may be made from an organic matrix composite material. The composite material may comprise an epoxy resin and a preform with a stack of three-dimensionally woven carbon fibrous plies. Alternatively, the casing may be made of metal, such as a titanium or aluminium alloy. According to an alternative of the disclosure, the casing may be formed from several outer shrouds, added and attached axially to one another; for example using radial annular flanges.

[0049] The rows of stator blades 26 may support inner shrouds 42 connected to the inner ends of the stator blades 26. The inner surfaces of the inner shrouds 42 may support layers of abradable materials 44 so as to form seals 45 around annular strips of the rotor 12, or lips, to combat recirculations under the inner shrouds 42.

[0050] The term “coating” may be understood to mean the skin of the structure of the seal (39; 45), over which the air flows and which is subjected to aerodynamic forces. The coating may form the outer or inner surface of the seal (39; 45).

[0051] Figure 3 represents an abradable seal 39 of a compressor such as that from Figure 2. Represented therein is a wall 34 of a casing 28, or support 28, an abradable coating 38 which is applied thereto, and a tip of a rotor blade 24 between two stator blades 26.

[0052] The abradable coating 38 extends from one platform 32 of a blade 26 to the next, which belongs to a neighbouring row positioned upstream or downstream. The abradable coating 38 is flush with the inner surfaces of the platforms 32. The platforms 32 of stator blades 26 form circular shoulders 46 that axially delimit the abradable coatings 38. Alternatively, the wall has radial annular grooves formed in its thickness, which are filled in by the abradable coatings, over the entire depths thereof. The abradable coatings cover the entire inner surface of the wall between the platforms of the stator blades. The combination of the platforms 32 and the abradable coatings 38 forms a generally leaktight barrier all along the casing 28, or at least the wall 34; optionally except for grooves between the platforms 32 of one and the same annular row.

[0053] The abradable coating 38 may be applied directly on its support 34. Or else, the seal 39 may comprise an interlayer between the support and the abradable coating. The interlayer may be a strip, such as a sheet of steel, or a sheet of nickel. The strip may be perforated and/or cut.

[0054] The abradable coating 38 has an inner surface in contact with the primary flow 18. Its surface guides and delimits the primary flow 18 during the compression thereof. The abradable coating 38 may comprise at least two mixed phases, namely a metallic phase and optionally a filler phase, such as a mineral phase and/or an organic filler, so as to form a composite. The materials of the abradable coating may be granular, or some may be granular and others may fill in the spaces between the grains thereof.

[0055] The metallic phase of the abradable coating 38 mainly comprises aluminium. The metallic phase of the coating is based on aluminium. That is to say that among the metals of the abradable material, the one having the largest weight is aluminium. The predominance of aluminium optimizes the weight of the seal 39. The metallic phase of the abradable coating 38 also comprises nickel, in a proportion by weight lower than that of the aluminium. The metallic phase may comprise between 20% and 45% nickel; and between 55% and 80% aluminium. In addition, the metallic phase may optionally comprise iron, copper, zinc, manganese, magnesium, impurities; these components each representing between 1% and 0.1% of the weight of the metallic phase.

[0056] The filler of the abradable coating 38 may comprise polymer, such as polyester or methyl methacrylate. The filler may also comprise hexagonal boron nitride or calcium fluoride. The weight of the filler may represent between 5% and 50%, preferably between 15% and 25%, optionally 20% of the weight of the coating 38. The metallic phase may represent the majority of the volume of the abradable coating; thus the metallic phase may form therein a matrix that receives the filler or additive. Optionally, the abradable coating may be formed of grains of metal powders, the intergranular spaces of which are filled in by the filler. The empty space in the abradable coating is less than 1%, preferably less than 0.1%.

[0057] Figure 4 represents a flowchart of a process for producing an abradable seal of an axial-flow turbomachine as presented in Figure 3. The seal may be used on a compressor, in particular a low-pressure compressor.

[0058] The process comprises the following steps, optionally carried out in the following order:

(a)- provision 100 of a rounded support, such as a compressor outer casing,

(b)- provision 102 of stator blades with platforms;

(c)- attachment 104 of the blades by their platforms to the rounded support forming annular rows;

(d)- application 106 of an abradable composition to the rounded support between the annular rows of platforms so as to cover the support between the rows of blade platforms;

(e)- assembly 108 of the support around a rotor of the turbomachine, for example an annular row of rotor blades.

[0059] At the start of the step (d) of application 106, the composition has a metallic phase with mainly aluminium, for example in powder form. The metallic phase may also comprise nickel and a filler; both as powders. The composition of the powder may correspond to the chemical composition of the abradable coating presented above. At the end of the step (d) of application 106, at least one or each compound of the composition remains in powder form, or at least one of the compounds has melted, or every compound has melted.

[0060] Optionally, some grains or every type of grain are essentially solid, and their own voids represent less than 5% of their material, preferably less than 1%, more preferably less than 0.20%. Each grain may have a homogeneous material. Optionally, one type of grain is hollow, for example the aluminium or nickel grains.

[0061] During the step (d) of application 106, the composition may be applied to the support by plasma spraying. Such a technique is well known to a person skilled in the art, and it may be carried out in a manner similar to that disclosed in document EP 1 010 861 A2. The filler powder may be introduced into the plasma jet downstream of the metallic powders. Other techniques can be envisaged. Alternatively, the composition may be applied to the support by sintering, optionally with prolonged heating. In this alternative, certain grains may keep their initial shapes.

[0062] The steps: (b) provision 102 of stator blades; (c) attachment 104 of the blades; (e) assembly 108 of the support; are entirely optional according to the disclosure. Indeed, the abradable composition may be applied to a support free of blades and their platforms. In this case, the step (d) of application 106 may be carried out in a groove formed in the thickness of a shroud.

CLAIMS

1. A turbomachine comprising:
a rotor;
a rounded support with an inner annular surface;
at least one coating made of abradable material covering the inner annular surface of the rounded support for cooperating by abrasion with the rotor;
wherein a composition of the abradable coating includes:
a metal phase with aluminum and nickel, the metal phase comprising, by weight, at least 50% of aluminum and between 20% and 45% of nickel; and
a filler.

2. The turbomachine according to claim 1, wherein in the abradable coating, the metal phase forms a metallic matrix which is combined with the filler.

3. The turbomachine according to claim 2, wherein the metallic matrix occupies a majority of a volume of the abradable coating.

4. The turbomachine according to any one of claims 1 to 3, wherein the rounded support is an outer shroud, the abradable coating being on the inside of the outer shroud.

5. The turbomachine according to any one of claims 1 to 4, wherein the rounded support is an outer casing, the abradable coating being positioned inside of the outer casing.

6. The turbomachine according to any one of claims 1 to 5, wherein the rounded support is made of an organic matrix composite material with carbon

fibres, the carbon fibres being arranged as a stack, the abradable coating comprising an interface in contact with the organic matrix composite material.

7. The turbomachine according to any one of claims 1 to 6, wherein the rounded support comprises attachment portions, the attachment portions being positioned upstream and downstream of the abradable coating.

8. The turbomachine according to any one of claims 1 to 7, wherein the rounded support has an upstream edge and a downstream edge, the abradable coating covering the rounded support from the upstream edge to the downstream edge.

9. The turbomachine according to any one of claims 1 to 8, the turbomachine comprising a low-pressure compressor with at least one row of rotor blades, the abradable coating being a seal of the low-pressure compressor, which surrounds the at least one row of rotor blades.

10. The turbomachine according to any one of claims 1 to 9, the turbomachine comprising at least one annular row of stator blades with platforms attached to the rounded support, the abradable coating being in contact with the platforms of blades.

11. The turbomachine according to claim 10, wherein the abradable coating forms a leak-tight barrier that protects the rounded support between the platforms.

12. A turbomachine comprising:
a rotor;

a rounded support with an inner annular surface supporting stator vanes with fixation platforms;
at least one coating made of abradable material covering the inner annular surface of the rounded support for cooperating by abrasion with the rotor;
wherein a composition of the abradable coating includes:
a metal phase with aluminum and nickel, the metal phase comprising, by weight, at least 50% of aluminum and between 20% and 45% of nickel; and
a filler.

13. The turbomachine according to claim 12, wherein the metal phase comprises, by weight, between 55% and 80% of aluminum.

14. The turbomachine according to claim 12, wherein the abradable coating comprises, by weight, between 5% and 50% of filler.

15. The turbomachine according to claim 12 or 14, wherein the filler is mineral filler.

16. The turbomachine according to any one of claims 12, 14, and 15, wherein the filler comprises at least one material selected from a group consisting of hexagonal boron nitride, and calcium fluoride.

17. The turbomachine according to any one of claims 12, 14-16 wherein the filler is a polymer selected from the group consisting of polyester, methyl methacrylate.

18. A turbomachine comprising:
a rotor;
a rounded support with an inner annular surface;

at least one coating made of abradable material covering the inner annular surface of the rounded support for cooperating by abrasion with the rotor;
an interlayer comprising a metal strip between the inner annular surface and the coating,
wherein a composition of the abradable coating includes:
a metal phase with aluminum and nickel, the metal phase comprising, by weight, at least 50% of aluminum and at least 20% of nickel; and
a filler, the aluminum and the nickel being in contact with the metal strip.

19. The turbomachine according to claim 18, wherein the metal strip is made of a metal sheet selected from a group consisting of steel sheet and nickel sheet.

FIG 1

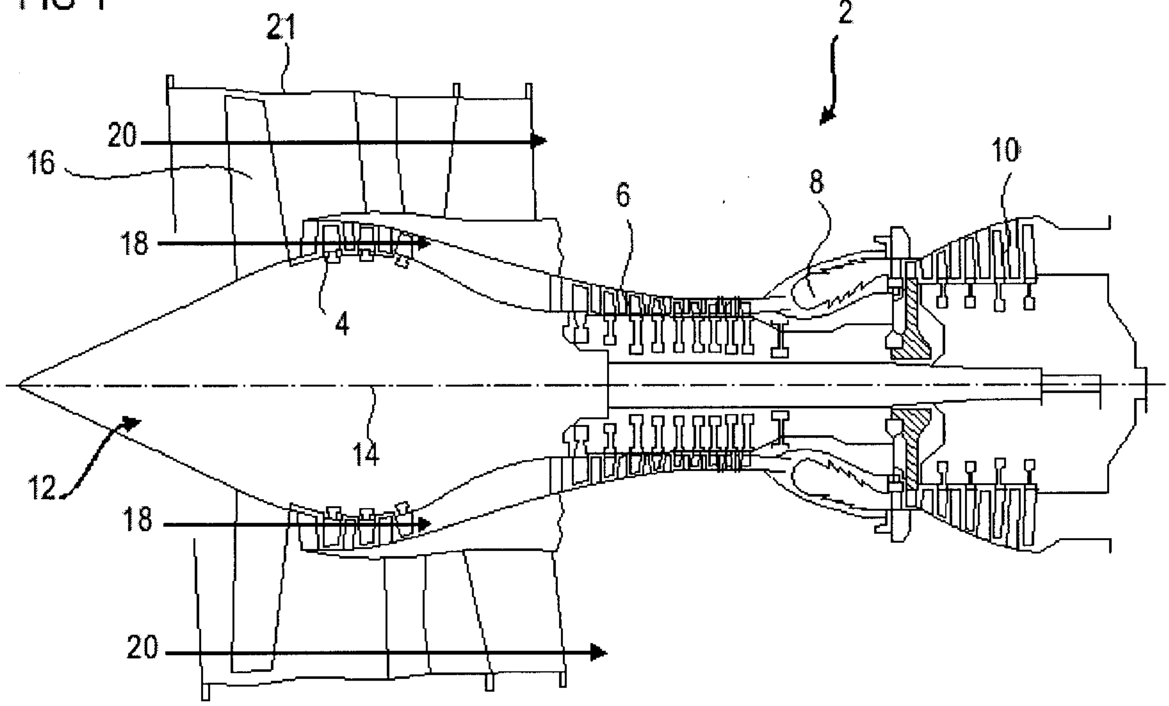

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FIG 2

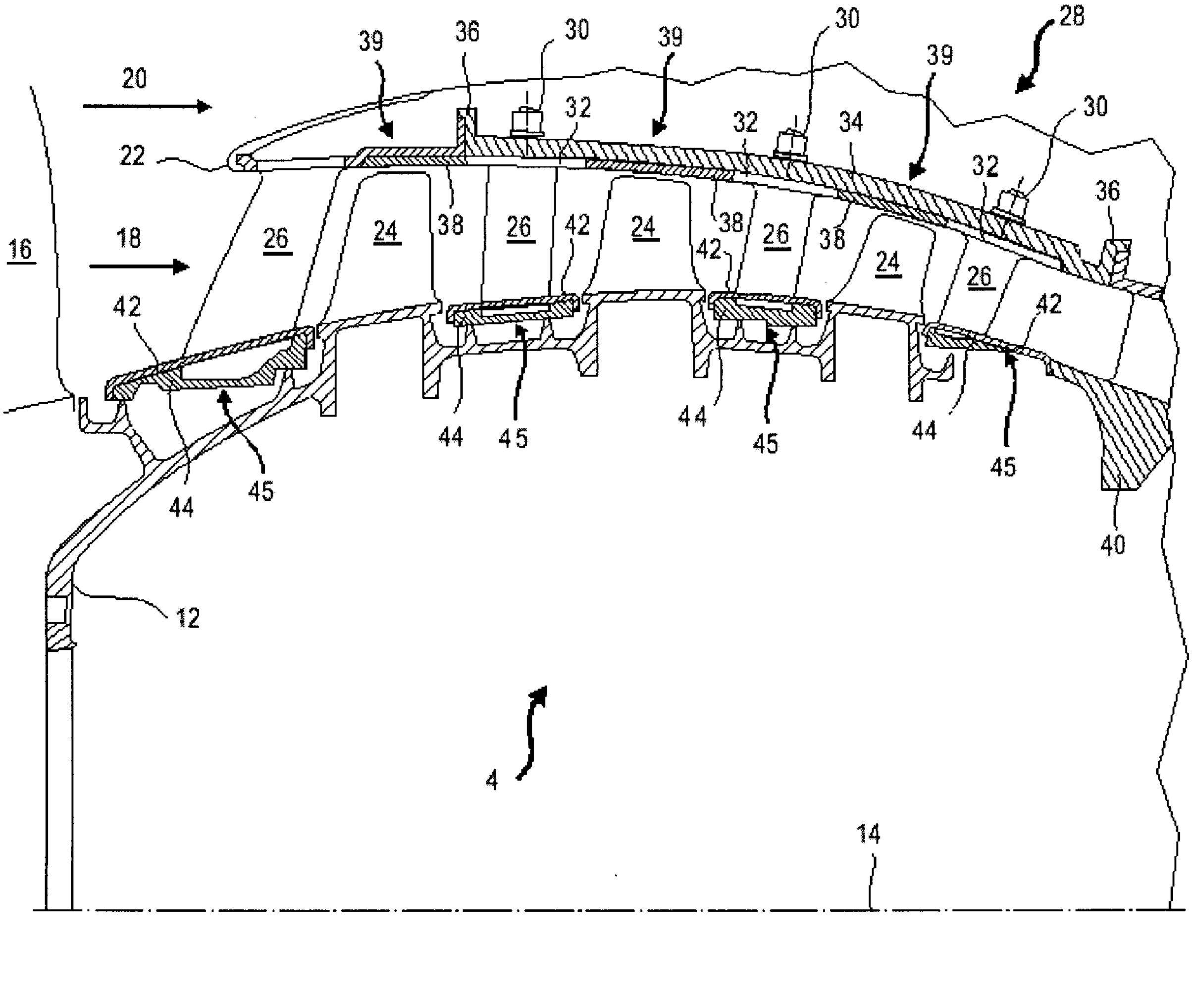
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FIG 3

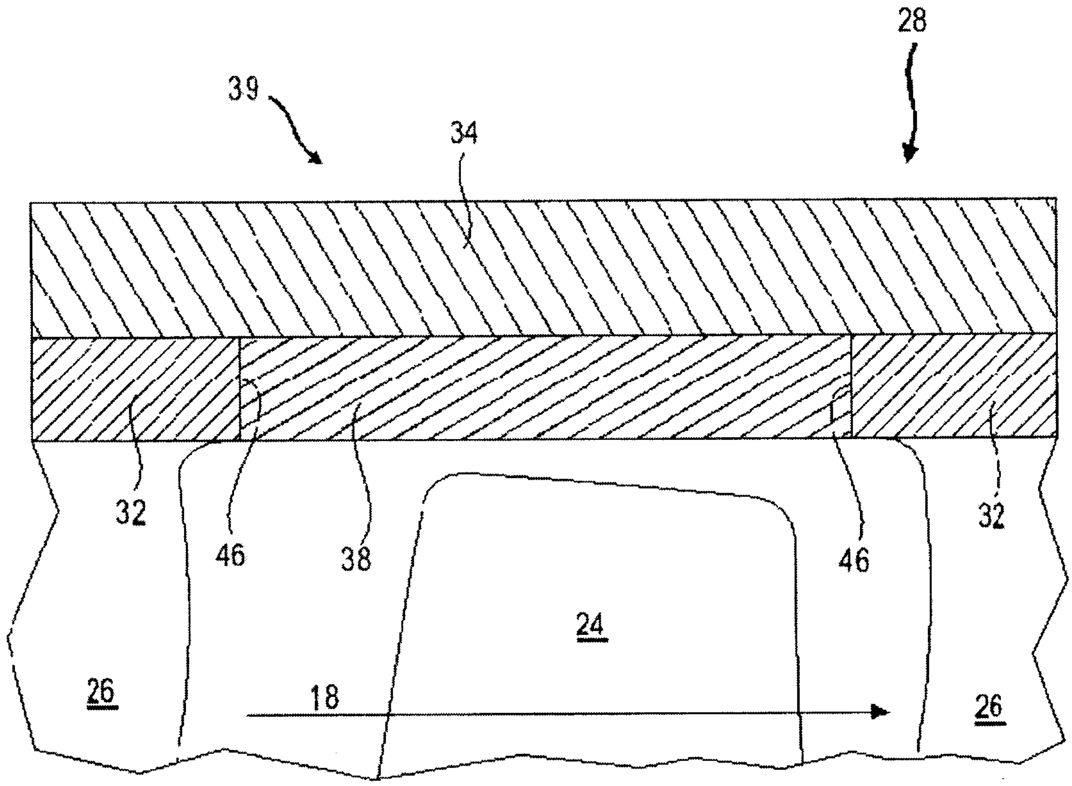
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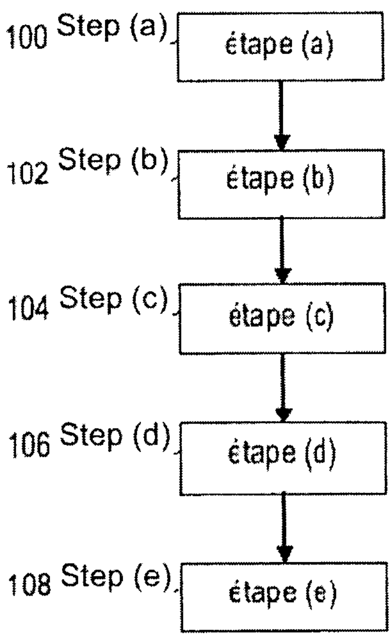
Fig. 4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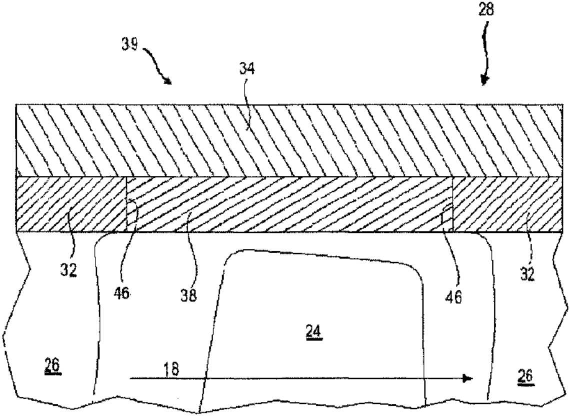
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