

(19)



Europäisches Patentamt
European Patent Office
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(11)

EP 1 645 725 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

12.04.2006 Bulletin 2006/15

(51) Int Cl.:

F01D 9/04 (2006.01)

F01D 11/08 (2006.01)

F01D 25/24 (2006.01)

(21) Application number: **05254609.0**

(22) Date of filing: **25.07.2005**

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR**

Designated Extension States:

AL BA HR MK YU

(30) Priority: **08.10.2004 US 962310**

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(54) Turbine engine shroud segment

(57) A turbine engine shroud segment comprises a body (12) including an outer surface (16) away from which an integral attachment system projects. The attachment system comprises a plurality of at least two axially (40) spaced apart circumferentially (38) extending

rows (28,30) of discrete projection hook segments (26) to interrupt a potential hoop stress path through the attachment system. Each projection hook segment (26) includes a segment support surface (36) aligned circumferentially (38) and radially (42) with other segment support surfaces (36) in a row (28/30).

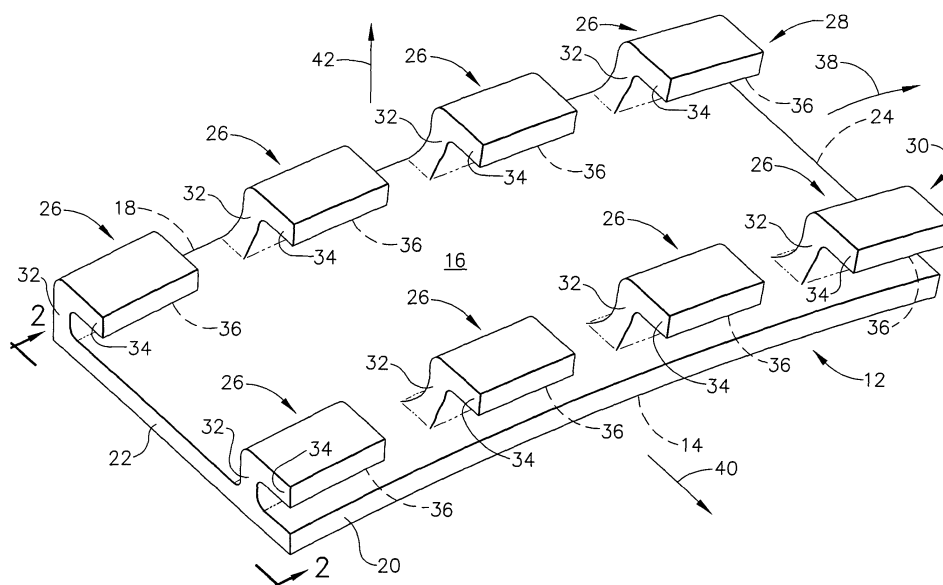


FIG. 1

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Description

[0001] This invention relates generally to turbine engine shroud segments including a surface exposed to elevated temperature engine gas flow. More particularly, it relates to air cooled gas turbine engine shroud segments, for example used in the turbine section of a gas turbine engine, and made of a low ductility material.

[0002] A turbine engine shroud segment is a stationary engine component separate and distinct from a component that includes an airfoil, for example a nozzle segment or a stationary blading member. In a gas turbine engine, a plurality of stationary shroud segments is assembled circumferentially about an axial flow engine axis and radially about and spaced apart from rotating blading members, for example about rotating turbine blades. Together, such shroud segments define a part of the radial flowpath boundary over the blades. As has been described in various forms in the gas turbine engine art, it is desirable to maintain the operating clearance between the tips of the rotating blades and the cooperating, juxtaposed spaced-apart surface of the stationary shroud segments as close as possible to enhance engine operating efficiency. Typical examples of U.S. Patents relating to turbine engine shrouds, shroud segments and such shroud clearance include 5,071,313 - Nichols; 5,074,748 - Hagle; 5,127,793 - Walker et al.; 5,562,408 - Proctor et al.; and 6,702,550 B2 - Darkins, Jr. et al.

[0003] In its function as a flowpath component, the shroud segment must be capable of meeting the design life requirements selected for use in a designed engine operating temperature and pressure environment. To enable current materials to operate effectively as a shroud segment in the strenuous temperature and pressure conditions as exist in the turbine section flowpath of modern gas turbine engines, it has been a practice to provide cooling air to an outer portion of the shroud segment. However as is well known in the art, for example as described in some of the above identified patents, provision of such cooling air is at the expense of engine efficiency. Therefore, it is desired to conserve use of cooling air by minimizing leakage into the flowpath of the engine of cooling air not intended to be introduced into the flowpath. For example, some forms of shroud segments include cooling passages intentionally to pass cooling air into the engine flow stream. However, cooling air leakage about edges of a shroud segment can reduce designed efficiency by wasting cooling airflow.

[0004] It has been observed that one source of such segment edge leakage can result from shroud segment deformation such as deflection or distortion, generally referred to as "chording". Chording results from a thermal differential or gradient between a higher temperature radially inner shroud surface and a lower temperature, air cooled shroud outer shroud surface. At least the radially inner or flowpath surface of a shroud and its segments are arced circumferentially to define a flowpath annular surface about the rotating tips of the blades. The thermal

gradient between the inner and outer faces of the shroud, resulting from cooling air impingement on the outer surface, causes the arc of the shroud segments to chord or tend to straighten out circumferentially. As a result of chording, the circumferential end portions of the inner surface of the shroud segment tend to move radially outwardly in respect to the middle portion of the segment. If allowed to occur, this type of action can increase the tip clearance required to prevent a rub between the blade and the shroud. As a shroud straightens from its original curvature, the shroud ends pull away from the intended flowpath and effectively increase the clearance of the blade. Therefore, for more efficient engine operation, it is desirable to restrain chording or seal the gap resulting from chording.

[0005] As is well known in the gas turbine engine art, other segment distortion or distortion forces can occur, for example in a high pressure turbine. Such forces are generated by pressure differences acting on a shroud segment as a result of a relatively high cooling air pressure on a radially outer portion of a shroud segment, opposite a lower flow stream pressure which reduces further passing downstream through a turbine. In certain shroud segment attachment systems that include shroud segment supports integral with the shroud segment and generally in the shape of circumferential rings or hoops, tensile stresses resulting from such thermal gradients can develop in a circumferential path through a support. Such tensile stresses in ring-like structures frequently are referred to as hoop stresses.

[0006] Metallic type materials currently and typically used as shroud segments and their supports have mechanical properties including strength and ductility sufficiently high to enable the shroud segments to be restrained against such deflection, distortion or excessive hoop stresses resulting from thermal gradients and other forces. Examples of such restraint include the well known side rail type of structure, or the C-clip type of sealing structure, for example described in the above identified Walker et al patent. That kind of restraint and sealing results in application of a compressive force at least to one end of the shroud to inhibit chording or other distortion. Other known shroud segment restraints or attachment systems can result in significant hoop stress development in an integral attachment system.

[0007] Current gas turbine engine development has suggested, for use in higher temperature applications such as shroud segments and other components, certain materials having a higher temperature capability than the metallic type materials currently in use. However such materials, forms of which are referred to commercially as a ceramic matrix composite (CMC), have mechanical properties that must be considered during design and application of an article such as a shroud segment. For example, as discussed below, CMC type materials have relatively low tensile ductility or low strain to failure when compared with metallic materials. Also, CMC type materials have a coefficient of thermal expansion (CTE) in the

range of about 1.5 - 5 microinch/inch/°F, significantly different from commercial metal alloys used as restraining supports or hangers for shrouds of CMC type materials. Such metal alloys typically have a CTE in the range of about 7 - 10 microinch/inch/°F. Therefore, if a CMC type of shroud segment is restrained and cooled on one surface during operation, forces or stresses can be developed in CMC type segment sufficient to cause failure of the segment or its integral attachment system.

[0008] Generally, commercially available CMC materials include a ceramic type fiber for example SiC, forms of which are coated with a compliant material such as BN. The fibers are carried in a ceramic type matrix, one form of which is SiC. Typically, CMC type materials have a room temperature tensile ductility of no greater than about 1%, herein used to define and mean a low tensile ductility material. Generally CMC type materials have a room temperature tensile ductility in the range of about 0.4 - 0.7%. This is compared with metallic shroud and/or supporting structure or hanger materials having a room temperature tensile ductility of at least about 5%, for example in the range of about 5 - 15%.

[0009] Shroud segments made from CMC type materials, although having certain higher temperature capabilities than those of a metallic type material, cannot tolerate the above described and currently used type of compressive force or similar restraint force against chording. Neither can they withstand a stress rising type of feature, for example one provided at a relatively small bent or filleted surface area, without sustaining damage or fracture typically experienced by ceramic type materials. Furthermore, manufacture of articles from CMC materials limits the bending of the SiC fibers about such a relatively tight fillet to avoid fracture of the relatively brittle ceramic type fibers in the ceramic matrix.

[0010] In some applications and embodiments using CMC materials as a shroud segment, high pressure loading on a shroud segment integral attachment system, coupled with radial temperature gradients, can develop hoop stress amounts in a substantially continuous path through such attachment system that can result in failure of the attachment system. Provision of a shroud segment of such a low ductility material, that includes a shroud segment attachment system that interrupts such a hoop stress path through the system, would enable advantageous use of the higher temperature capability of CMC material for that purpose.

[0011] The present invention provides a shroud segment for use in a turbine engine, for example in a gas turbine engine turbine shroud assembly, comprising a body including a body inner surface and a body outer surface spaced apart from the body inner surface. The body extends between spaced-apart body first and second axial edge portions and spaced-apart body first and second circumferential edge portions. The shroud segment includes an attachment system comprising projection hooks, for carrying the shroud segment, integral with and projecting away from the body outer surface. Each

projection hook comprises a hook arm extending away from the body outer surface and a hook end portion extending axially and including a segment support surface of selected support surface shape facing toward the body outer surface.

[0012] According to embodiments of the present invention, to interrupt or cut a potential hoop stress path through the attachment system of integral projection hooks and to reduce hoop stress induced by a radial temperature gradient in the projection hooks of the attachment system, there is provided a plurality of individual, discrete projection hook segments. Such projection hook segments are in at least two axially spaced-apart circumferentially extending rows defining the attachment system. Each row comprises a plurality of the discrete projection hook segments spaced-apart circumferentially along the body outer surface at least partially between the first and second circumferential edge portions. Each hook end portion of each projection hook segment in a row faces an axial edge portion, and each segment support surface of each projection hook is aligned circumferentially and radially with other segment support surfaces in a row.

[0013] The invention will now be described in greater detail, by way of example, with reference to the drawings, in which:-

Figure 1 is a diagrammatic, perspective view of an embodiment of a shroud segment according to the present invention, including two rows of projection hook segments.

Figure 2 is a diagrammatic view from a circumferential end of the shroud segment of Figure 1, viewed along lines 2-2.

Figure 3 is a diagrammatic view, similar to Figure 2, from a circumferential end of another form of shroud segment including three rows of projection hook segments.

Figure 4 is a diagrammatic, perspective, partially fragmentary view of still another embodiment of a shroud segment according to the present invention, including two rows of projection hook segments.

Figure 5 is a diagrammatic, fragmentary view of a shroud segment similar to that in Figure 1 viewed from axially aft of the shroud segment assembled in a turbine engine circumferentially about the axis of the engine.

[0014] The present invention will be described in connection with an axial flow gas turbine engine for example of the general type shown and described in the above identified Proctor et al patent. Such an engine comprises, in serial flow communication generally from forward to aft, one or more compressors, a combustion section, and

one or more turbine sections disposed axisymmetrically about a longitudinal engine axis. Accordingly, as used herein, phrases using the term "axially", for example "axially forward" and "axially aft", refer to relative positions or general directions in respect to the engine axis; phrases using forms of the term "circumferential" refer to circumferential position or direction generally about the engine axis; and phrases using forms of the term "radial", for example "radially inner" and "radially outer", refer to relative radial position or direction generally from the engine axis.

[0015] Figure 1 is a diagrammatic perspective view of an embodiment of a turbine engine shroud segment according to the present invention. Such embodiment includes an attachment system that enables carrying of a shroud segment, made of the above described low ductility materials such as a CMC, in a turbine engine shroud assembly without application or development of excessive pressure or force to the shroud segment, including excessive hoop stresses. A shroud segment shown generally at 10 includes a shroud segment body, shown generally at 12, having a body radially inner surface 14 and a body radially outer surface 16 spaced apart from radially inner surface 14. Body 12 extends between spaced apart first and second axial edge portions, respectively 18 and 20, and first and second circumferential edge portions, respectively 22 and 24.

[0016] Shroud segment 10 includes a plurality of individual, discrete projection hook segments, shown generally at 26, integral with and extending generally away from body radially outer surface 16. For carrying shroud segment 10, projection hook segments 26 comprise a shroud segment attachment system that severs a potential hoop stress path through such system. In such attachment system, projection hook segments 26 are spaced-apart and aligned circumferentially along body outer surface 16 in a plurality of axially spaced-apart, circumferentially extending rows of projection hook segments. In Figure 1, such rows comprising the integral attachment system are shown generally at 28 and 30.

[0017] In the drawings, each projection hook segment 26 comprises a hook segment arm 32 extending away from body outer surface 16 and a hook segment end portion 34 extending generally axially toward an axial edge portion 18 or 20. Hook segment end portion 34 includes a segment support surface 36 facing toward body outer surface 16 and of a selected support surface shape, for example planar or arcuate. In Figure 1, segment support surfaces 36 of projection hook segments 26 in a circumferential row, for example in row 28 and in row 30, are aligned circumferentially and radially one with another in the row. Segment support surface 36 is shown more clearly in Figures 2, 3 and 5. In Figure 1, all hook segment end portions 34 face toward segment body second axial edge portion 20.

[0018] As used in connection with the present invention, the terms "toward" or "away from" in respect to a surface direction means generally and predominantly in

the direction with respect to such surface or member. In the drawings, orientation of shroud segment 10 and its attachment system comprising a plurality of circumferential rows of projection hook segments are shown in respect to a turbine engine by arrows 38, 40 and 42 representing, respectively, the engine circumferential, axial, and radial directions.

[0019] Figure 2 is another diagrammatic view of the embodiment of Figure 1, along lines 2-2, toward circumferential edge portion 22 of shroud segment 10 of Figure 1. Figure 2 shows projection hook segments 26 in circumferential row 28 and in circumferential row 30 spaced-apart in axial direction 40 with their segment support surfaces 36 aligned respectively in circumferential direction 38 and radial direction 42. In Figure 2, segment support surfaces are shown to have a planar selected support surface shape.

[0020] Figure 3 is a diagrammatic view, similar to Figure 2 and based on a shroud segment as described in connection with Figure 1, toward a circumferential edge portion 22 of another embodiment of a shroud segment according to the present invention. In the embodiment of Figure 3, a plurality of projection hook segments 26 is circumferentially spaced-apart in three circumferentially extending rows represented by 28, 44 and 30, respectively spaced-apart in axial direction 40 aft along body radially outer surface 16. As described in connection with Figures 1 and 2, projection hook segments 26 in a circumferential row are spaced-apart in circumferential direction 38, with their segment support surfaces aligned in circumferential direction 38 and in radial direction 42. In Figure 3, all hook end portions 34 face toward second axial edge portion 20.

[0021] Figure 4 is a diagrammatic, perspective, partially fragmentary view of still another embodiment according to the present invention, including two axially spaced-apart, circumferentially extending rows, first row 28 and second row 46, of circumferentially spaced-apart projection hook segments 26. In this embodiment, hook end portions 34 of projection hook segments 26 in circumferential first row 28 face toward second axial edge portion 20 while hook end portions 34 of projection hook segments 26 in circumferential second row 46 face toward first axial edge portion 18. As described above in connection with other embodiments, segment support surfaces 36 in a row are aligned one with another in circumferential direction 38 and in radial direction 42.

[0022] The diagrammatic, fragmentary view of Figure 5 is of a shroud segment, similar to that in Figure 1 and viewed aft of shroud segment 10 from axial direction 40, assembled circumferentially adjacent other shroud segments (not shown) as is typical in a turbine engine shroud assembly, circumferentially about engine axis 48. In the embodiment of Figure 5, the shape of segment support surfaces 36 of each projection hook 26 in a circumferential row is selected to be an arc along a circle, shown in phantom as 50, with radius 52 about engine axis 48.

[0023] The present invention provides a shroud seg-

ment including an integral attachment system that interrupts a potentially damaging, substantially continuous hoop stress path through the attachment system, enabling use in a turbine engine of a shroud segment made of a low ductility material.

Claims

1. A shroud segment (10), for use in a turbine engine, comprising a body (12) including a body inner surface (14) and a body outer surface (16) spaced apart from the body inner surface (14), the body (12) extending between spaced apart body first (18) and second (20) axial edge portions and spaced apart body first (22) and second (24) circumferential edge portions, the shroud segment (10) including a plurality of spaced apart projection hooks, for carrying the shroud segment (10), integral with and projecting away from the body outer surface (16), each projection hook comprising a hook arm (32) extending away from the body outer surface (16) and a hook end portion (34) extending axially (40) and including a segment support surface (36) of selected support surface shape facing toward the body outer surface (16), wherein the plurality of projection hooks comprises:

at least two axially (40) spaced apart circumferentially (38) extending rows (28,30) of discrete projection hook segments (26), each row (28,30) comprising a plurality of the discrete hook segments (26) spaced apart circumferentially (38) along the body outer surface (16) at least partially between the first (22) and second (24) circumferential edge portions with each hook end portion (34) of each projection hook segment (26) in a row (28,30) facing toward an axial edge portion (18/20); and, each segment support surface (36) of each projection hook segment (26) is aligned circumferentially (38) and radially (42) with other segment support surfaces (36) in a row (28/30).

2. The shroud segment (10) of claim 1 in which the shroud segment (10) is made of a low ductility material having a low tensile ductility, measured at room temperature to be no greater than about 1 %.
3. The shroud segment (10) of claim 1 in which the selected support surface shape is an arc (50) of a circle about an axis (48) of the turbine engine.
4. The shroud segment (10) of claim 1 in which the selected support surface shape is planar.
5. The shroud segment (10) of claim 1 in which each hook end portion (34) of each of the discrete projec-

tion hook segments (26) faces toward the same axial edge portion (18/20).

6. The shroud segment (10) of claim 5 in which the plurality of projection hooks comprises two axially spaced apart circumferentially (38) extending rows (28,30) of discrete projection hook segments (26).
7. The shroud segment (10) of claim 5 in which the plurality of projection hooks comprises three axially (40) spaced apart circumferentially (38) extending rows (28,30,44) of discrete projection hook segments (26).
8. The shroud segment (10) of claim 1 in which:
the plurality of projection hooks comprises at least two axially (40) spaced apart circumferentially (38) extending rows (28,46) of discrete projection hook segments (26);
each hook end portion (34) of a first row (28) of discrete projection hook segments (26) facing the second axial edge portion (20); and,
each hook end portion of a second row (46) of discrete projection hook segments (26) facing the first axial edge portion (18).

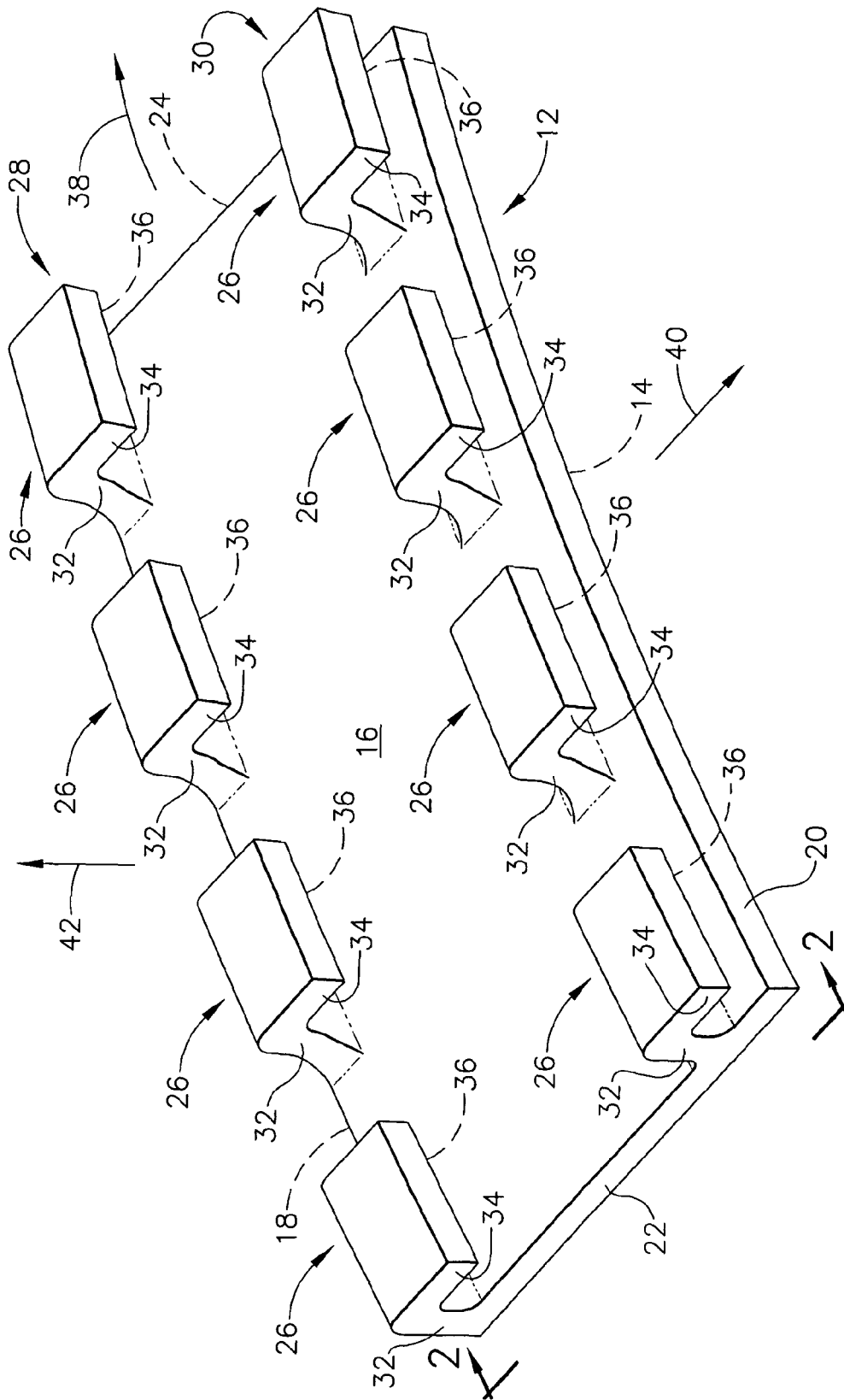


FIG. 1

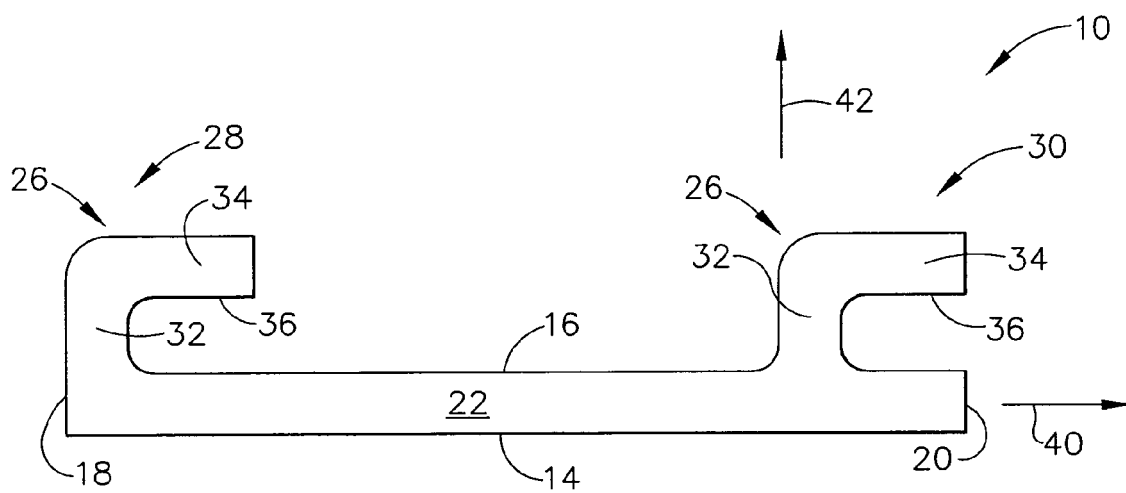


FIG. 2

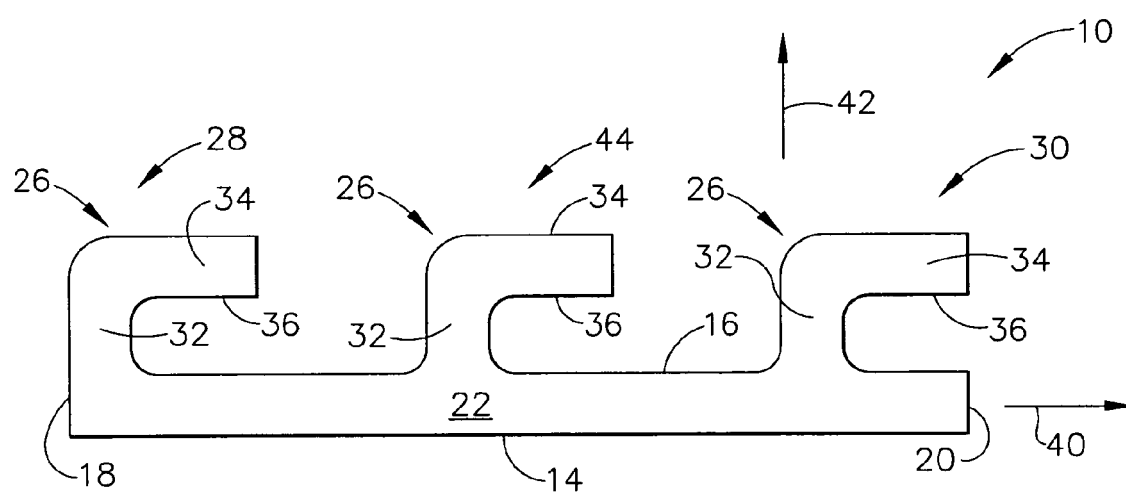


FIG. 3

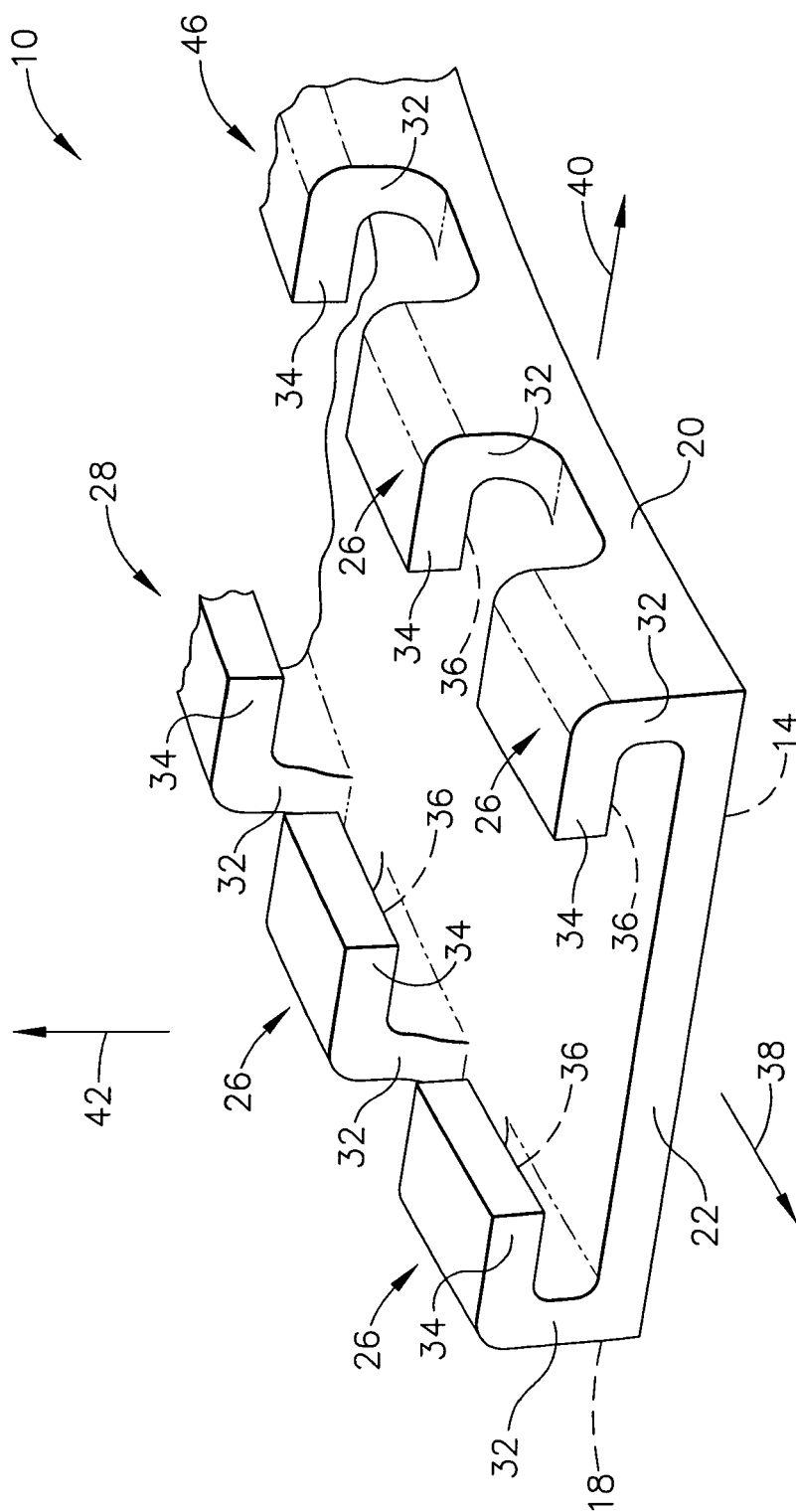


FIG. 4

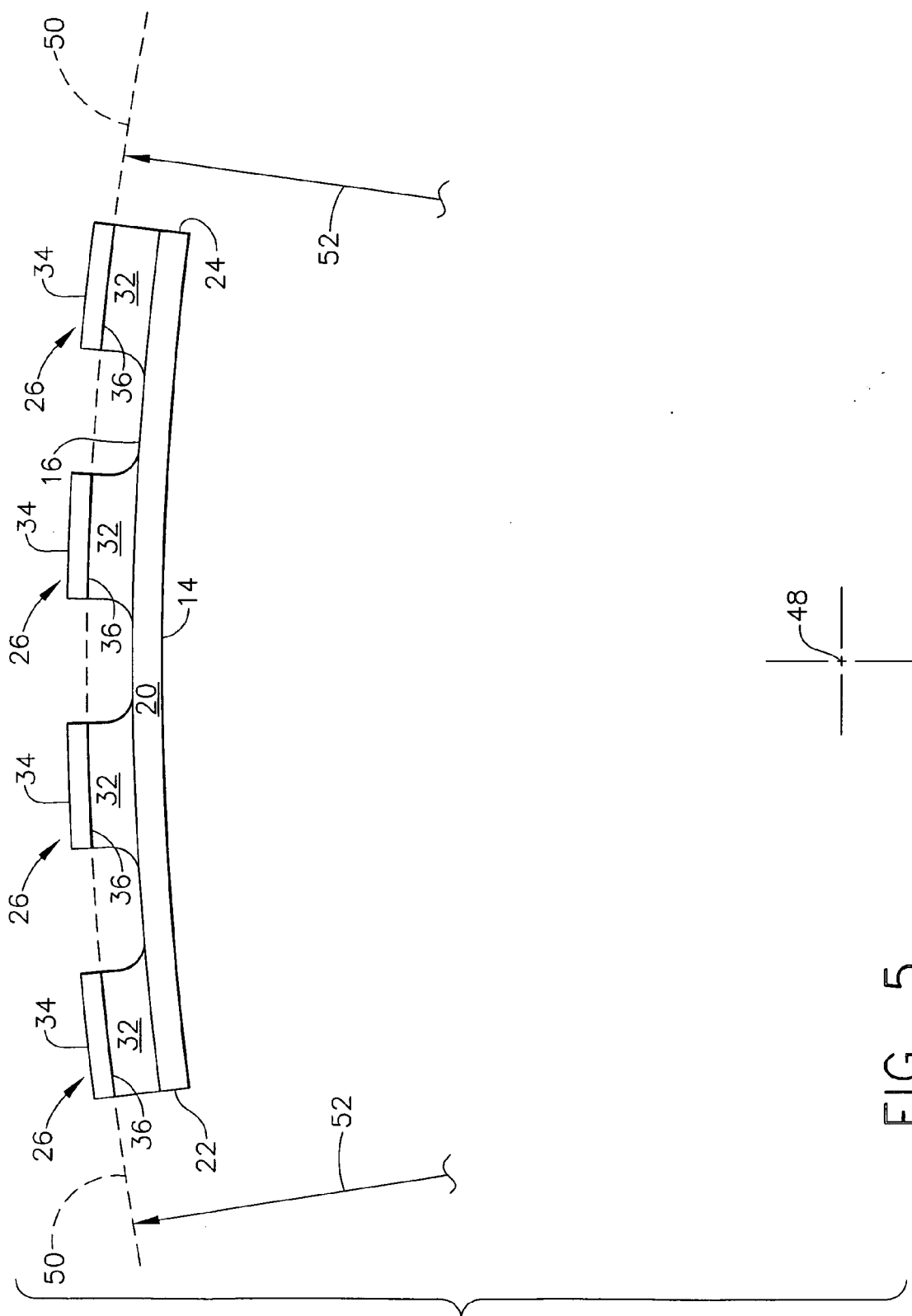


FIG. 5



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 05 25 4609

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 1 178 182 A (MITSUBISHI HEAVY INDUSTRIES, LTD) 6 February 2002 (2002-02-06) * the whole document *	1,4,6	F01D9/04 F01D11/08 F01D25/24
Y	----- US 2004/062639 A1 (GLYNN CHRISTOPHER CHARLES ET AL) 1 April 2004 (2004-04-01) * paragraphs [0006], [0024]; figure 2 *	2,3,5,7,8	
Y	----- US 6 726 391 B1 (KREIS ERHARD ET AL) 27 April 2004 (2004-04-27) * abstract; figure 6 *	2,3	
Y	----- US 6 602 050 B1 (SCHEURLIN MICHAEL ET AL) 5 August 2003 (2003-08-05) * paragraph [0015]; figures 1-3 *	5,7	
Y	----- US 6 602 050 B1 (SCHEURLIN MICHAEL ET AL) 5 August 2003 (2003-08-05) * paragraph [0015]; figures 1-3 *	8	
A	----- EP 0 959 229 A (GENERAL ELECTRIC COMPANY) 24 November 1999 (1999-11-24) * columns 5,6; figures 3,8,9 *	1,5-7	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 3 February 2006	Examiner Chatziapostolou, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 05 25 4609

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03-02-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1178182 A	06-02-2002	CA 2372984 A1	13-09-2001
		WO 0166914 A1	13-09-2001
		JP 3632003 B2	23-03-2005
		US 6508623 B1	21-01-2003

US 2004062639 A1	01-04-2004	NONE	

US 6726391 B1	27-04-2004	DE 19938443 A1	15-02-2001
		EP 1076184 A2	14-02-2001

US 6602050 B1	05-08-2003	CA 2366357 A1	28-09-2000
		DE 50003360 D1	25-09-2003
		WO 0057033 A1	28-09-2000
		JP 2002540337 T	26-11-2002

EP 0959229 A	24-11-1999	JP 2000054804 A	22-02-2000
		US 6059525 A	09-05-2000
