



(51) International Patent Classification:
F16J 15/32 (2006.01)

(21) International Application Number:
PCT/IB2009/007900

(22) International Filing Date:
28 December 2009 (28.12.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/347,013 31 December 2008 (31.12.2008) US

(71) Applicant: **EATON CORPORATION** [US/US]; Eaton Center, 1111 Superior Ave., Cleveland, OH 44114-2584 (US).

(72) Inventor: **SHORT, John, F.**; 3 Maghan Circle, Smithfield, RI 02828 (US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,

CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: BRUSH SEAL FRONT PLATE AND ASSEMBLY

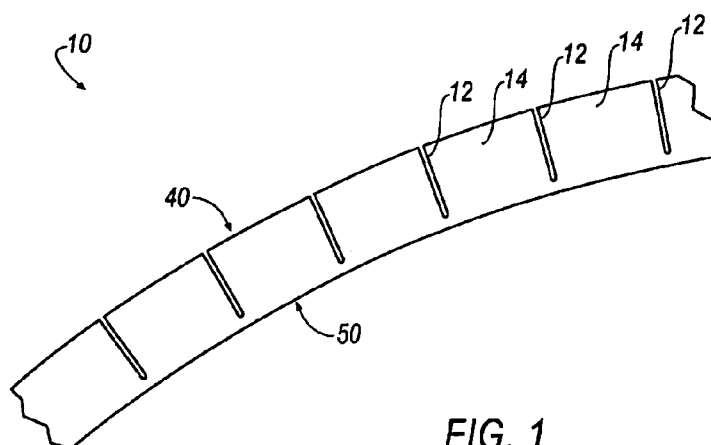


FIG. 1

(57) Abstract: A front plate (10) and brush seal assembly (20) for providing a seal between a high pressure area and a low pressure area. An embodiment of a front plate includes a front plate body (10). The front plate body (10) includes an inner peripheral edge (50) and an outer peripheral edge (40). A plurality of cuts or slots (12) are provided in the front plate body (10) and extend from the outer peripheral edge (40) of the front plate body (10) toward the inner peripheral edge (50) of the front plate body (10), such that the plurality of cuts or slots (12) do not extend to the inner peripheral edge (50), and the plurality of cuts or slots (12) define a plurality of fingers (14) in the front plate body (10). In an embodiment of a brush seal assembly (20), the assembly includes a retaining plate (30) that is connected to a front plate (10).



BRUSH SEAL FRONT PLATE AND ASSEMBLY

TECHNICAL FIELD

[0001] The present invention generally relates to shaft seals, such as those used in connection with gas turbine engines.

BACKGROUND

[0002] Brush seals have been employed as a means for sealing high pressure gas or fluid areas from low pressure gas or fluid areas. For example, brush seals may be used in connection with gas turbine engines. Brush seals commonly inhibit flow of gas or liquid along a shaft. Conventional brush seals typically include an annular retaining plate, an annular back plate, and a plurality of flexible bristles (or a bristle pack) that are secured between the retaining plate and back plate. When a brush seal is used to provide a seal with respect to a shaft, the tips of the bristles generally contact or run near the shaft to seal a system pressure from a discharge pressure.

[0003] Some conventional brush seals provide a recessed back plate and a flexible front plate that is concentric with the bristle pack. The front plate may be provided on the high pressure side of the bristle pack. A plurality of fingers may be provided to sandwich the bristle pack between the front plate and a rigid back plate. An example of a brush seal with a flexible front plate is disclosed in U.S. Patent No. 5,884,918 to Basu et al.

SUMMARY

[0004] A front plate and brush seal assembly for providing a seal between a high pressure area and a low pressure area. An embodiment of a front plate includes a front plate body. The front plate body includes an inner peripheral edge and an outer peripheral edge. A plurality of cuts or slots are provided in the front plate body and extend from the outer peripheral edge of the front plate body toward the inner peripheral edge of the front plate body, such that the plurality

of cuts or slots do not extend to the inner peripheral edge, and the plurality of cuts or slots define a plurality of fingers in the front plate body. In an embodiment of a brush seal assembly, the assembly includes a retaining plate that is connected to a front plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

[0006] FIG. 1 is partial front view of an embodiment of a front plate in accordance with teachings of the invention;

[0007] FIG. 2 is a partial front view of another embodiment of a front plate in accordance with teachings of the invention;

[0008] FIG. 3A is side cross sectional view of a front plate-retainer plate assembly according to an embodiment of the invention;

[0009] FIG. 3B is a front view of a portion of the assembly illustrated in FIG. 3A;

[00010] FIGS. 4, 5, and 6 are side cross sectional views of embodiments of front plate-retainer plate assemblies according to other embodiments of the invention;

[00011] FIG. 7 generally illustrates a partial front view of a double-groove embodiment of the invention with a plurality of slots provided in the associated land region; and

[00012] FIGS. 8, 9, and 10 are partial front views of embodiments of front plate-retainer plate assemblies according to yet other embodiments of the invention.

DETAILED DESCRIPTION

[00013] Reference will now be made in detail to embodiments of the present invention, examples of which are described herein and illustrated in the accompanying drawings. While the invention will be described in conjunction with embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is

intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims.

[00014] FIGS. 1 and 2 illustrate embodiments of front plates 10 shown in accordance with teachings of the present invention. FIG. 1 generally depicts a portion of a front plate 10 (also referred to as a “front plate body”) including slots 12 (or sometimes also referred to as “cuts”) – in this instance radial slots - that define a plurality of fingers 14. FIG. 2 also generally illustrates a front plate 10 that includes slots 12. However, the slots 12 included in the front plate 10 are angled and serve to define angled fingers 14 in the front plate 10.

[00015] In embodiments, for example as illustrated in FIGS. 1 and 2, slots 12 extend from an outer peripheral edge 40 of the front plate toward an inner peripheral edge 50. However, it is noted that the slots 12 shown in the illustrated embodiments do not extend up to (or through) the inner diameter, i.e., that is the slots 12 do not extend all the way up the inner peripheral edge 50. The slot-finger configurations may take on a variety of types and forms, including radial slots (*see, e.g.*, FIG. 1) and angled slots (*see, e.g.*, FIG. 2). Without limitation, in an embodiment the slots 12 are within the range of from about 3 mils to about 15 mils wide. However, the invention is not limited to a single configuration, and the numbers, sizes, and/or patterns of slots may vary.

[00016] In embodiments, to help maintain a desired amount of axial flexibility, the outer diameter of the flexible front plate 10 should be permitted to move or translate to some degree in the radial direction. This may be contrary to certain retention objectives associated with some prior seal configurations, which often prevent the front plate from shifting radially – for example, where tack or spot welding is employed to secure the front plate to a retaining plate. With embodiments of the invention, the front plate 10 is restrained at a portion adjacent or near the inner diameter (or inner peripheral edge). However, not all welding and similar restraining techniques are desirable as some techniques can introduce undesirable axial stiffness into the movement of the flexible front plate 10 by restricting radial movement of the front plate 10. With embodiments of the invention, features can be introduced that allow welding (e.g., spot welding) of the flexible front plate 10 to a retaining plate without unduly impacting axial stiffness.

[00017] In embodiments of the invention, the flexible front plate 10 will be retained at or about a portion near the outer diameter. For embodiments of the invention, the front plate 10 will be restrained in the circumferential direction, but some radial movement (e.g., substantially symmetrical radial movement at the front plate outer diameter) may be permitted. This manner of restraint or retention can be accomplished by employing various techniques.

[00018] For instance, in an embodiment, a feature or portion 16 of the front plate 10 may be “trapped,” or retained or restrained, in a corresponding or mating feature associated with a retainer, e.g., a retaining plate. FIGS. 3A and 3B generally illustrate an embodiment of an assembly 20 that includes a flexible front plate 10 and an associated retaining plate 30. In the illustrated embodiment, flexible front plate 10 includes a portion 16 (e.g., a lip) that may be trapped or restrained (e.g., in a sliding interface or arrangement) by or within a portion of a formation 32 (e.g., a groove or recess) associated with the retaining plate 30. In other embodiments, trapping or retention of a portion of the front plate 10, i.e., at or about the outer diameter portion thereof, can also be provided by placing the flexible front plate 10 in a groove machined in the retaining plate 30. With such configurations, the flexible front plate 10 can be captured or retained between a bristle pack and a retaining plate.

[00019] In another embodiment, a welding-type technique, e.g., spot welding – can be employed at specific or select locations toward the end of the flexible front plate 10 closer in proximity to the outer diameter of the front plate 10. For such embodiments, it is generally desirable to weld portions of the front plate 10 at only a few locations (e.g., locations 40 generally illustrated in FIGS. 4 and 5) so as not to substantially or unduly increase the axial stiffness of the front plate 10.

[00020] FIGS. 5 and 6 generally illustrate another embodiment of the assembly 20. In this embodiment, a plurality of grooves – which may comprise a double-groove – may be provided (e.g., machined) in a retaining plate 30. Flexible front plate 10 may be welded (e.g., spot welded) at specific locations (such as generally illustrated as locations 50 in FIG. 6) that correspond to portions of a land region 60 (see, e.g., FIG. 7) that are provided between the grooves in the retaining plate 30.

[00021] In embodiments of the assembly that employ a double-groove, a portion of a land region (or “beam”) can effectively be provided that can, itself, deflect in the radial direction. If desired, to further weaken the beam kerfs or slots can be provided in the land region. For example and without limitation, as generally illustrated in FIG. 7, a plurality of slots can be cut at select angles in the land regions.

[00022] FIG. 8 generally illustrates an embodiment of the invention in which cuts or kerfs 12 are provided in a flexible front plate 10. In the illustrated embodiment, the cuts or kerfs 12 are not straight, but are turned or angled before breaking continuing on to the outer diameter **OD** of the front plate 10. This type of configuration can provide a cantilever-type beam in connection with a front plate 10. In an embodiment one or more weld locations (e.g., spot weld locations) 80, or other forms of connecting techniques, may be utilized to connect front plate 10 to retaining plate 30. The one or more weld locations 80 may be provided in a cantilever beam section (generally designated as section 90 in FIG. 8) of front plate 10. Such a configuration can permit some flexibility of the front plate 10 in the radial direction when axial deflection of the front plate 10 occurs.

[00023] A further non-limiting example of a connection configuration between a flexible front plate 10 and a retaining plate 30 is shown in FIG. 9. As generally illustrated, a separate or independent cantilever beam section 90 may be provided (e.g., cut) in the flexible front plate 10. In such an embodiment, the cantilever beam section 90 is not part of the cuts or slots 12 between the defined fingers 14. In an embodiment, and as generally shown in FIG. 9, one or more weld locations 80 may be provided to weld (or connect) the flexible front plate 10 to the retainer plate 30. This can offer a measure of radial motion flexibility with respect to the front plate 10.

[00024] With further reference to FIGS. 8 and 9, a distance **D** is generally illustrated. The distance **D** generally represents a distance from the innermost radial portion of a cut or slot 12 and the inner diameter **ID** of the flexible front plate 10. By way of example, and without limitation as to the embodiments illustrated in FIGS. 8 and 9, distance **D** may range from about 0.025 inches to about 0.075 inches.

[00025] FIG. 10 illustrates yet another embodiment of a connection configuration between a flexible front plate 10 and a retaining plate 30. In the illustrated embodiment, a separate end-

supported beam 100 is provided in a defined finger 14 of the flexible front plate 10 near the outer diameter **OD** of the finger 14. For example, without limitation, the end-supported beam 100 may be provided within about 0.025 inches to about 0.100 inches from the outer diameter **OD**. In the illustrated embodiment, a single weld location 80 is provided at or about a midpoint of the beam section 90 (which is provided between the end-supported beam 100 and the outer diameter **OD** of the finger 14).

[00026] It is noted that while some exemplary connection or weld locations (such as those identified as elements 80) are illustrated in connection with several depicted embodiments, the weld locations can be provided in connection with every finger location, or instead only at a few locations. Also while multiple weld locations 80 may be shown, if desired, welding may instead be provided in as little as one location to hold the front plate 10 and the retaining plate 30 in position. Moreover, various combinations of connection configurations and methods may be employed. For instance, a front plate could be captured within a groove in the retaining plate, and a single spot weld could be used to weld portions of the two components together.

[00027] The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and various modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to explain the principles of the invention and its practical application, to thereby enable others skilled in the art to utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto and their equivalents.

CLAIMS

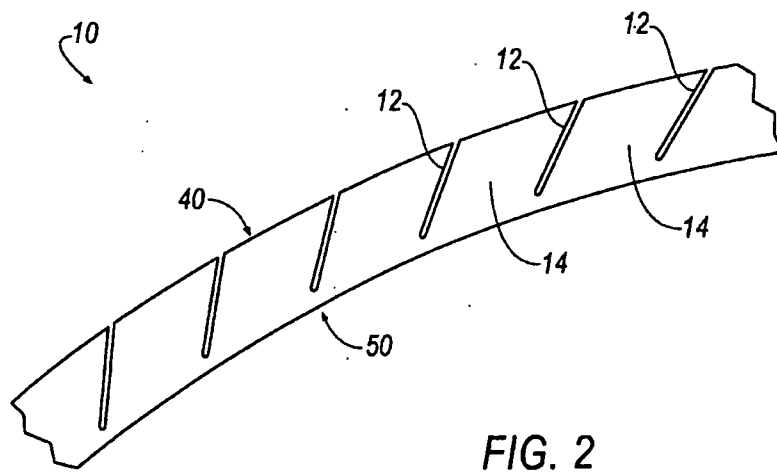
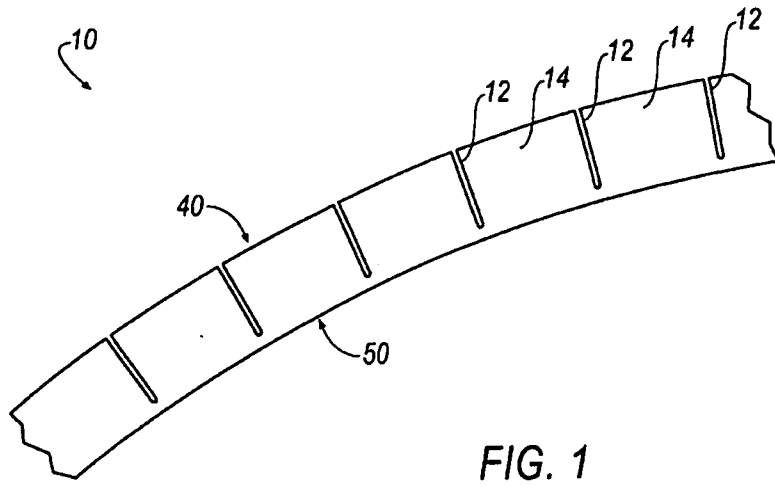
What is claimed is:

1. A front plate (10) for a brush seal configured to seal a high pressure area from a low pressure area, the front plate (10) comprising:
 - a front plate body (10), the front plate body including an inner peripheral edge (50) and an outer peripheral edge (40);
 - a plurality of cuts or slots (12) extending from the outer peripheral edge (40) of the front plate body (10) toward the inner peripheral edge (50) of the front plate body;
 - wherein the plurality of cuts or slots (12) do not extend to the inner peripheral edge (50), and the plurality of cuts or slots (12) define a plurality of fingers (14) in the front plate body (10).
2. The front plate (10) of claim 1, wherein the front plate is annular.
3. The front plate (10) of claim 1, wherein the cuts or slots (12) are substantially radial.
4. The front plate (10) of claim 1, wherein the cuts or slots (12) are angled.
5. The front plate (10) of claim 1, wherein the cuts or slots (12) have a width that is within the range of about 3 mils to about 15 mils.
6. The front plate (10) of claim 1, wherein the distance from the innermost radial portion of a cut or slot (12) and the inner peripheral edge (50) of the front plate body (10) is within the range of from about 0.025 inches to about 0.075 inches.
7. The front plate (10) of claim 1, wherein an outer diameter (OD) of the front plate is configured to move or translate in the radial direction (D).
8. The front plate (10) of claim 1, wherein the front plate is restrained to a retaining plate (30) at a portion (16) adjacent or near the inner diameter (ID) or inner peripheral edge (50).

9. The front plate (10) of claim 1, including a means for restraining the front plate (10) in the circumferential direction, wherein some radial movement at the front plate outer diameter (OD) is permitted.
10. The front plate (10) of claim 1, wherein the front plate (10) includes a feature or portion (16) that is configured to be trapped or restrained in a corresponding or mating feature of a retaining plate (30).
11. The front plate (10) of claim 10, wherein the feature or portion (16) comprises a lip (16).
12. The front plate (10) of claim 11, wherein the lip (16) is configured to be trapped or restrained within a portion or formation (32) associated with a retaining plate (30).
13. The front plate (10) of claim 1, wherein the front plate is configured to be captured or retained between a bristle pack and a retaining plate (30).
14. A brush seal assembly (20) comprising:
 - a flexible front plate (10); the flexible front plate including an inner peripheral edge (50), an outer peripheral edge (40), and a plurality of cuts or slots (12) extending from the outer peripheral edge (40) toward the inner peripheral edge (50), the plurality of cuts or slots (12) do not extend to the inner peripheral edge (50), and the plurality of cuts or slots (12) define a plurality of fingers (14) in the front plate (10); and
 - a retaining plate (30);
 - wherein the flexible front plate (10) is connected to the retaining plate (30) and the front plate is restrained at a portion of the front plate adjacent or near the inner peripheral edge (50).
15. The brush seal assembly (20) of claim 14, wherein the front plate (10) and the retaining plate (30) are generally annular.

16. The brush seal assembly (20) of claim 14, the assembly including a plurality of bristles provided adjacent to the flexible front plate (30).
17. The brush seal assembly (20) of claim 16, wherein the lateral flexibility of each finger (14) is greater than the lateral flexibility of a section of the bristles adjacent the fingers (14) of the front plate (10).
18. The brush seal assembly (20) of claim 14, wherein one or more locations of the front plate in proximity of the outer diameter (OD) of the front plate are connected to a retaining plate (30).
19. The brush seal assembly (20) of claim 18, wherein front plate (10) is welded to the retaining plate (30) at the one or more locations.
20. The brush seal assembly (20) of claim 14, wherein at least two grooves (32) are provided in a retaining plate (30) and the at least two grooves (32) form a land (60) that corresponds to a portion of the front plate (10) at or about the outer diameter (OD) of the front plate.
21. The brush seal assembly (20) of claim 20, wherein the front plate (10) is welded to the retaining plate (30) at one or more locations (80) in the land (60) formed between at the at least two grooves (32).
22. The brush seal assembly (20) of claim 14, wherein the front plate (10) includes one or more cuts or kerfs (12) that include an turned or angled segment before continuing on to the outer diameter (OD) of the front plate.
23. The brush seal assembly (20) of claim 14, wherein the flexible front plate (10) includes a cantilever beam section (90) separate or independent from the cuts or slots (12) between defined fingers (14).

24. The brush seal assembly (20) of claim 14, wherein, a separate end-supported beam (100) is provided in a defined finger (14) of the flexible front plate (10) near the outer diameter of the finger (14).
25. The brush seal assembly (20) of claim 24, wherein a weld location (80) for connecting the front plate (10) to the retaining plate (30) is provided at or about a midpoint of the beam (60) between the end-supported beam (100) and the outer diameter of the finger (14).
26. The brush seal assembly (20) of claim 14, wherein a portion (16) of the front plate (10) engages or is retained by a means for retaining provided in the retaining plate (30), and at least one weld is provided to weld a portion (16) of the front plate (10) and a portion (16) of the retaining plate(30).



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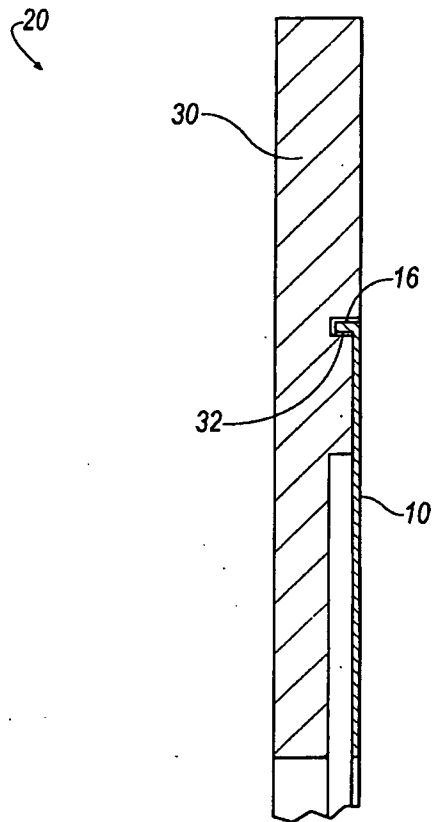


FIG. 3A

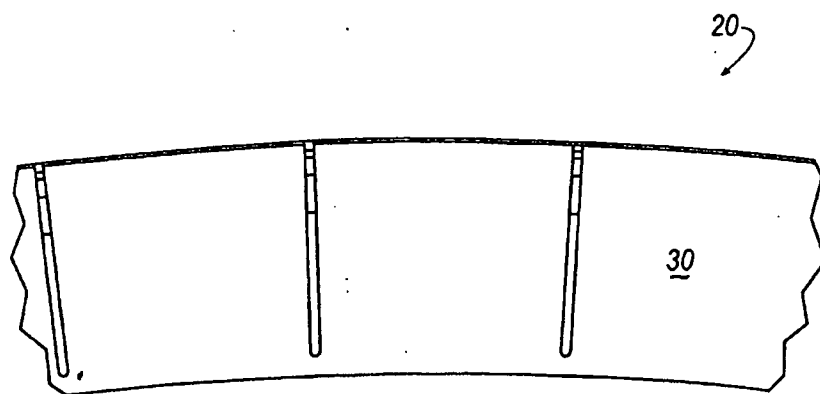


FIG. 3B

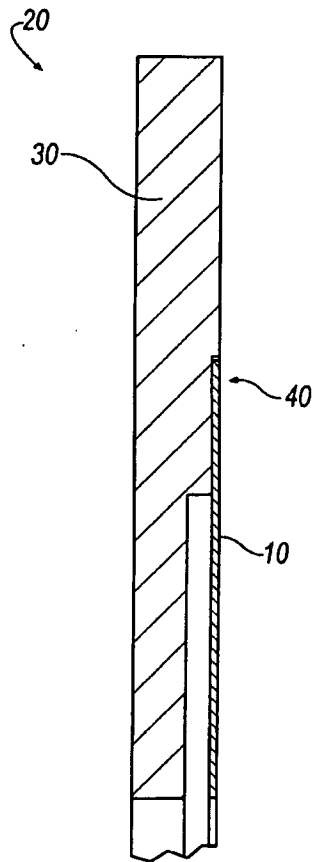


FIG. 4

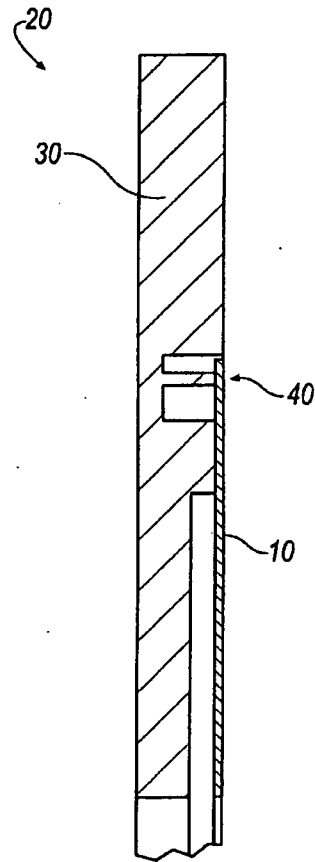


FIG. 5

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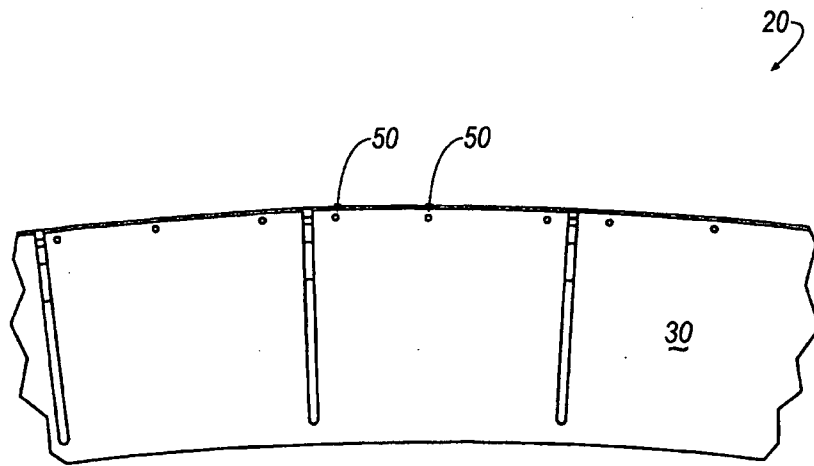


FIG. 6

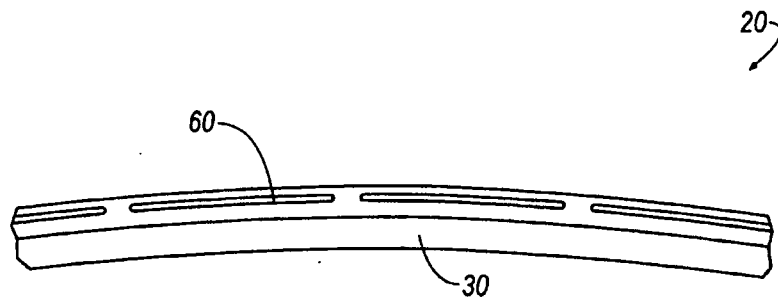


FIG. 7

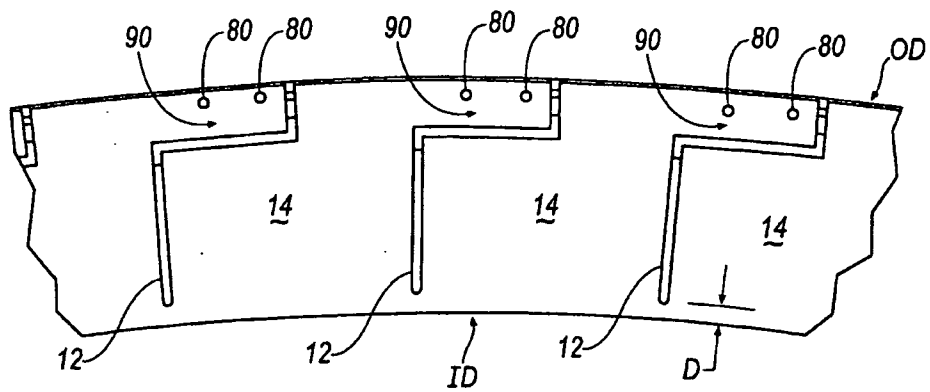


FIG. 8

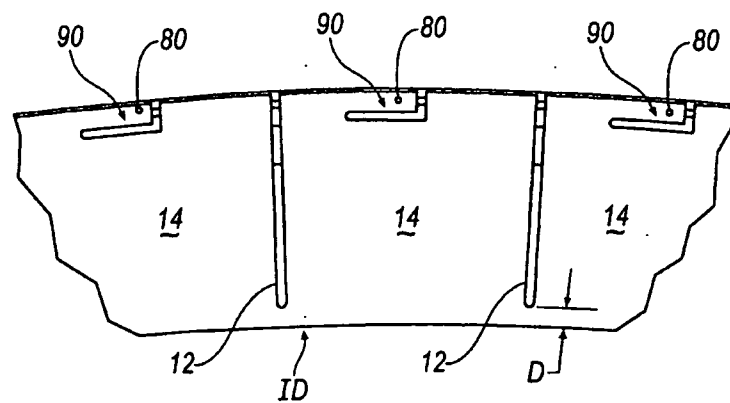


FIG. 9

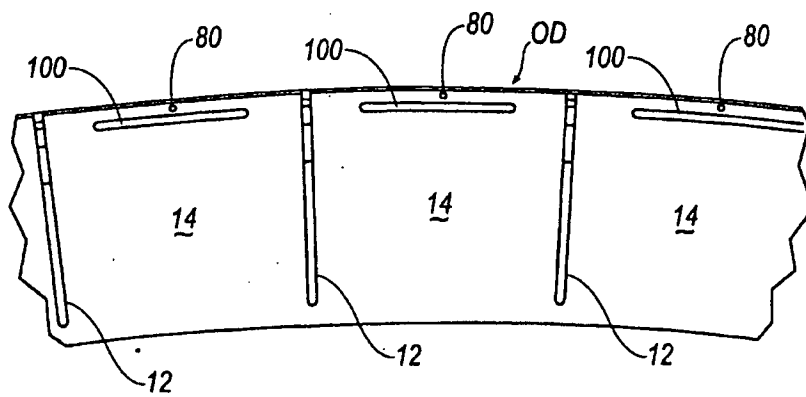


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2009/007900

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16J15/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F16J F01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 893 632 A2 (GEN ELECTRIC [US]) 27 January 1999 (1999-01-27) column 3, line 18 - column 5, line 32 -----	1-6, 8, 10, 14-16, 18-19, 26
X	US 5 884 918 A (BASU PRITHWISH [US] ET AL) 23 March 1999 (1999-03-23) cited in the application	1-10, 13-17, 22, 26
Y	column 5, line 45 - column 6, line 49; figures 6-8 -----	11-12
X	US 5 568 931 A (TSENG WU-YANG [US] ET AL) 29 October 1996 (1996-10-29)	1-3, 5-6, 8, 10, 13-17, 26
Y	column 4, line 16 - column 6, line 9 -----	11-12
A	-/--	4, 7, 9, 22

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

18 March 2010

Date of mailing of the international search report

25/03/2010

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Díaz Antuña, Elena

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2009/007900

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	column 4, line 20 - line 43; figures 1-6	4
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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