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(54) Title: PARTITIONED ELASTOMERIC JOURNAL BEARING ASSEMBLIES, SYSTEMS AND METHODS

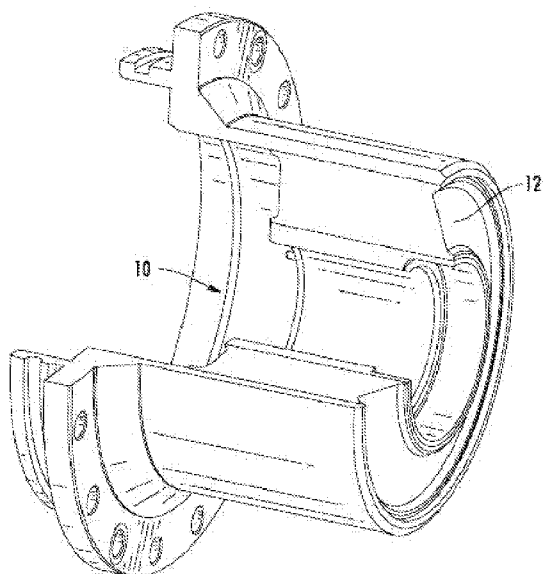


FIG. 1

(57) Abstract: Elastomeric journal bearing assemblies, systems, and methods are provided in which and at least one structural element is arranged between adjacent pairs of a plurality of elastomer sections arranged about a center axis. In such arrangements, the disclosed assemblies, systems, and methods redistribute stresses throughout the depth of elastomeric journal bearing more efficiently than conventional configurations.



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PARTITIONED ELASTOMERIC JOURNAL BEARING ASSEMBLIES, SYSTEMS AND METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application relates and claims priority to U.S. Provisional Patent Application Serial No. 61/768,865 filed February 25, 2013, the disclosure of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The subject matter disclosed herein relates generally to bearing assemblies used to control movement/vibration in a mechanical system or the like. More particularly, the subject matter disclosed herein relates to elastomeric journal bearing assemblies, systems and methods.

BACKGROUND

[0003] Fluid elastomeric dampers utilize elastomeric journal bearings with elastomer sections that are prone to separation of the elastomer due to direct tensile stress and localized bending. The direct tensile stress and localized bending typically occurs in thick elastomer sections and is induced by the increased elastomer section thickness required for the design motions. An exemplary elastomeric journal bearing is illustrated in Figure 1. In Figure 1, an elastomeric journal bearing, generally designated **10**, couples a shaft to a surrounding housing such that movement of the shaft relative to the housing is damped. Unitary elastomer section **12** having a substantially annular, cylindrical shape provides stiffness and damping. Such journal bearing designs have reduced useful service lives due to the direct tensile stress and localized bending of the thick elastomer sections. For example, Figures 2A and 2B illustrate the high principle stresses and strains that can develop within the elastomeric journal bearing during normal operation. As a result, it would be desirable for an elastomeric journal bearing design to alleviate the impact of these direct tensile stresses and areas of localized bending without compromising the effectiveness of the elastomeric journal bearing.

SUMMARY

[0004] In accordance with this disclosure, elastomeric journal bearing assemblies, systems, and methods are provided. In one aspect, an elastomeric journal bearing

assembly comprises a plurality of elastomer sections arranged about a center axis and at least one structural element arranged between an adjacent pair of the plurality of elastomer sections.

[0005] In another aspect, an elastomeric journal bearing system comprises a bearing housing, a shaft positioned within the bearing housing and movable with respect to the bearing housing, a plurality of elastomer sections arranged within the bearing housing about the shaft, and at least one structural element arranged between adjacent pairs of the plurality of elastomer sections.

[0006] In yet another aspect, a method for making an elastomeric journal bearing comprising arranging a plurality of elastomer sections within a bearing housing about a shaft that is positioned within the bearing housing and movable with respect to the bearing housing and arranging at least one structural element between adjacent pairs of the plurality of elastomer sections.

[0007] Although aspects of the subject matter disclosed herein has been stated hereinabove, and which is achieved in whole or in part by the presently disclosed subject matter, other aspects will become evident as the description proceeds when taken in connection with the accompanying drawings as best described hereinbelow.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 is a cut-away perspective view illustrating a conventional non-partitioned elastomeric journal bearing.

[0009] Figures 2A and 2B are finite-element analyses illustrating stress and strain distributions of a conventional non-partitioned elastomeric journal bearing under loaded conditions.

[0010] Figures 3A and 3B are cut-away perspective views illustrating a partitioned elastomeric journal bearing according to an embodiment of the presently disclosed subject matter.

[0011] Figures 4A and 4B are finite-element analyses illustrating stress and strain distributions of a partitioned elastomeric journal bearing according to an embodiment of the presently disclosed subject matter.

[0012] Figure 5 is a graph illustrating results from a fatigue comparison test between a conventional non-partitioned elastomeric journal bearing and a partitioned elastomeric journal bearing according to an embodiment of the presently disclosed subject matter.

[0013] Figure 6 is a cutaway end and side view illustrating a partitioned elastomeric journal bearing in an installed state according to an embodiment of the presently disclosed subject matter.

[0014] Figure 7A is a cross section view illustrating a partitioned elastomeric journal bearing compared to a classical non-partitioned journal bearing.

[0015] Figure 7B is a cross section view of a one elastomer section between a structural partition of a partitioned elastomeric journal bearing compared to a thick unitary elastomer section of classical non-partitioned journal bearing depicting localized bending in the elastomer section during motion.

DETAILED DESCRIPTION

[0016] The present subject matter discloses elastomeric journal bearing assemblies, systems and methods. In one aspect, the present subject matter provides an elastomeric journal bearing that incorporates structural partitions within the elastomer section. In one exemplary configuration illustrated in Figures 3A and 3B, an elastomeric journal bearing assembly, generally designated **100**, comprises a plurality of elastomer sections **110** having a combined size (e.g., length, thickness) that is substantially similar to the size of a unitary elastomer section that is commonly used in such systems (See, e.g., Figures 1, 7A and 7B).

[0017] Figure 7A illustrates a cross section of elastomeric journal bearing assembly **100** and non-partitioned journal bearing **102** compared side-by-side. In this comparison, elastomer sections **110** and structural elements **120** are illustrated on elastomeric journal bearing assembly **100**. Alternative, the classical non-partitioned journal bearing **102** has a thick, single elastomer section **112** as a unitary elastomer and does not have any structural partitions. As illustrated the combined elastomer sections **110** and structural elements **120** have a similar thickness as that of single elastomer section **112**. Single elastomer section **112** has high localized stresses while the combined elastomer sections **110** and structural elements **120** have reduced and distributed stresses as a result of including structural elements **120**.

[0018] Also illustrated in Figure 7B is the localized bending of an elastomer section **110** and structural elements **120** as compared to the localized bending of a single elastomer section **112**. Figure 7B illustrates shear force F_s acting upon elastomeric journal bearing assembly **100** and non-partitioned journal bearing **102**.

Both elastomeric journal bearing assembly **100** and non-partitioned journal bearing **102** each have an identical length **L** and width **W**. The thickness **t** and **t₁** are the thickness of elastomer section **110** and elastomer section **112**, respectively. Shear force **F_s** causes elastomer section **110** and structural elements **120** to displace by a displacement distance **δ_p**. Shear force **F_s** causes elastomer section **112** to displace by a displacement distance **δ₁**. The difference between the displacement distance **δ₁** compared to the displacement distance **δ_p** is substantially greater. However, the sum of all displacement distances **δ_p** in elastomeric journal bearing assembly **100** are equal to displacement distance **δ₁** for non-partitioned journal bearing **102**. The sum of all displacement distances **δ_p** in elastomeric journal bearing assembly **100** is equal to **δ_{p1} + δ_{p2} + ... δ_{pm}**, where displacement distance **δ_{p1}** is a first displacement distance **δ_p**, and **δ_{pm}** is the last displacement distance **δ_p**. As illustrated, elastomer section **112** has significant localized bending as compare to elastomer section **110**. Additionally, the displacement distance displacement distance **δ₁** is sufficient to induce a moment **M** in non-partitioned journal bearing **102**.

[0019] In the configuration illustrated in Figures 3A and 3B, elastomer sections **110** are substantially annular sections arranged concentrically between a housing **H** and a shaft **S** having a center axis **CA**. Although Figures 3A and 3B illustrate elastomer sections **110** as being divided into concentric annular sections, those having skill in the art will recognize that the principles discussed herein are not limited to annular/tubular geometries.

[0020] In some embodiments, at least one structural element **120** is arranged between adjacent pairs of the plurality of elastomer sections **110**. Referring again to Figures 3A and 3B, elastomer sections **110** and structural elements **120** are arranged together in a layered, alternating arrangement about the center axis **CA**. In some embodiments, structural elements **120** each comprise thin, rigid, non-elastomeric partition elements (e.g., metals, plastics, composites, or combinations thereof) arranged between two of concentric elastomer sections **110**. Structural elements **120** can be bonded to elastomer sections **110**, such as by arranging structural elements **120** between adjacent pairs of elastomer sections **110** during the molding and/or curing process. Alternatively, adhesives or other bonding agents can be used to couple structural elements **120** to elastomer sections **110**, or in yet further alternative implementations, elastomer sections **110** can be sized such that they are press-fit within and/or about associated structural elements **120**. In any

arrangement, structural elements **120** help to couple elastomer elements **110** together while still providing structural partitions between elastomer elements **110**.

[0021] In such arrangements, partitioned elastomer sections **110** are able to provide a variety of beneficial attributes to elastomeric journal bearing assembly **100**. In some embodiments, dividing the elastomer element of elastomeric journal bearing assembly **100** into a plurality of elastomer sections **110** and adding structural elements **120** between adjacent elastomer sections **110** reduces the direct tensile stress for a given strain in the elastomer. The configuration reduces surface tensile stresses on the elastomer, and it reduces elastomer section bending. Furthermore, where structural elements **120** comprise materials with comparatively high thermal conductivity (e.g., metal partitions), elastomeric journal bearing assembly **100** exhibits localized heat dissipation within the elastomer section, improved heat dissipation by conduction of heat through structural elements **120**, and heat transfer from one external surface to the opposite external surface.

[0022] Regarding stresses in the elastomer sections **110**, in some embodiments the interstitial addition of structural elements **120** (e.g., partitions) between elastomer sections **110** reduce the thickness-to-length ratio of each of elastomer sections **110**, which correspondingly reduces the cross-corner tension angle at each of elastomer sections **110**. Furthermore, the addition of structural elements **120** reduces the direct tensile stress in the elastomer of elastomer sections **110** that results from shear displacement of elastomer sections **110** (e.g., due to axial displacement of center shaft **S** with respect to housing **H**). In this way, the plurality of elastomer sections **110** are configured to more efficiently redistribute stresses throughout the depth of elastomeric journal bearing assembly **100**.

[0023] As illustrated in Figures 4A and 4B, the principle stresses developed within an exemplary configuration of elastomeric journal bearing assembly **100** during normal operation are relatively less concentrated than the stresses that are experienced in a conventional elastomeric journal bearing (See, e.g., Figures 2A and 2B). In the configuration illustrated, the maximum tensile stresses experienced in elastomeric journal bearing assembly **100** compared to conventional elastomeric journal bearing **10** with a unitary elastomer are reduced from over 500 psi to around 290 psi, for a reduced stress of about 42%, and the maximum strains are comparable between the two configurations. Preferably, the reduced tensile stress in this comparison is about 10% or greater, and about 60 % or greater for a

thickness to length ratio of less than equal to about 0.1. The reduction in tensile stress is related to the thickness and length of elastomer section **110**. Elastomer sections **110** with a significant thickness to length ratios (e.g., greater than 0.4) will have a greater cross-corner tension angle which increases the elastomer stress. In the configuration illustrated in Figures 4A and 4B elastomeric journal bearing assembly **100** does not substantively change the total assembly's maximum strain from that of conventional elastomeric journal bearing **10** having a unitary elastomer. In the comparison of the configurations for elastomeric journal bearing assembly **100** and conventional elastomeric journal bearing **10**, both have the same envelope and take up the same area.

[0024] Elastomeric journal bearing assembly **100** reduces direct tensile stress in the elastomer of elastomer sections **110** thereby resulting in an improvement in the fatigue life and damage propagation performance of elastomer sections **110**. For instance, Figure 5 illustrates the comparison of test data for a conventional non-partitioned journal bearing (e.g., elastomeric journal bearing **10**) and an elastomeric journal bearing assembly **100** that were subjected for to endurance testing for damper fatigue. Referring to Figure 5, the endurance testing shows a test life of 1,000 test hours for the conventional non-partitioned journal bearing when separation of the elastomer section occurred in the elastomer section. By comparison, a partitioned elastomeric journal bearing designed to incorporate on the elastomer section according to the presently disclosed subject matter (e.g., elastomeric journal bearing assembly **100**) shows a test life of greater than 1,800 test hours. Those of skill in the art will recognize that improving the elastomer fatigue performance as disclosed herein provides for an increase in the service life of the elastomer section.

[0025] Regarding the particular geometry of elastomeric journal bearing assembly **100**, in one configuration, the distribution of direct tensile stress and/or surface tensile stress is achieved by configuring elastomer sections **110** to have substantially the same radial thickness. In the configuration shown in Figure 3B, a first thickness t_1 of an innermost of elastomer sections **110** is substantially equivalent to a second thickness t_2 and a third thickness t_3 of the next two of elastomer sections **110**. In such a configuration, the total depth of elastomeric journal bearing assembly **100** is divided substantially evenly among the plurality of elastomer sections **110** to help distribute the stresses among elastomer sections **110**.

[0026] In alternate configurations, the geometry of each of elastomer sections **110** is specifically designed so that each of elastomer sections **110** defines a substantially similar total surface shear area. As illustrated in Figure 3B, elastomer sections **110** are configured to have a “stepped” geometry, wherein the innermost of the elastomer sections **110** has a first length d_1 , the next most inner of elastomeric sections **110** has a relatively shorter second length d_2 , and each successive section has a progressively shorter length. In other words, for at least two of the plurality of elastomer sections **110**, a first of elastomer section **110** positioned relatively nearer to center axis **CA** has a longer axial length than a second of elastomer section **110** positioned relatively farther from center axis **CA**. In this way, as the circumference of each successive elastomer section **110** increases, the axial length decreases (e.g., according to a substantially inverse proportional relationship) so that the total surface area of each of elastomer section **110** remains substantially consistent. This continues for as many n elastomer sections **110** as used. That is, the plurality of elastomer sections **110** each have different axial lengths where the n^{th} of the plurality of elastomer sections **110** positioned relatively nearer to the center axis **CA** has a longer axial length d_n than the axial length d_{n+1} of an $n^{\text{th}} + 1$ of the plurality of elastomer sections **110** positioned relatively farther from the center axis **CA**.

[0027] In some embodiments, the addition of structural elements **120** further acts to locally dissipate heat within elastomer sections, distribute heat within the elastomeric journal bearing assembly **100** as a whole, and transfer external heat through the portioned journal bearing **100** from one exposed structural surface to the opposing side. In the configurations illustrated in Figures 3A and 3B, structural elements **120** are configured to extend beyond the axial edges of at least one of an adjacent pair of elastomer sections **110**. This difference in lengths of structural elements **120** can be achieved by inserting structural elements **120** with each having an axial length that is longer than the largest axial length of elastomer sections **110**. Alternatively, the ends of structural elements **120** are configured to extend beyond the ends of adjacent elastomer sections **110** where the elastomeric journal bearing assembly **100** has the “stepped” configuration discussed above and illustrated in Figures 3A and 3B.

[0028] In one exemplary implementation shown in Figure 6, the axial length for a given one of structural elements **120** is equal to or greater than that of an adjacent one of elastomer sections **110** positioned relatively nearer to center axis **CA**.

Additionally, the axial length of the given one of structural elements **120** is greater than that of a second of the plurality of elastomer sections **110** positioned relatively farther from center axis **CA**. In this configuration, the edges of structural elements **120** extend beyond the edges of at least one of the adjacent elastomer sections **110** such that they are at least partially exposed to the surrounding environment. In this configuration, structural elements **120** are rigid shims extending into the internal and external environments and are capable of dissipating and/or transferring heat thereto. As used herein, dissipating heat includes the distribution and transference of heat by structural element **120** is capable of heat dissipation between at least two environments positioned adjacently to one another, and the heat dissipation is between either an internal and external environment or an external and external environment. Thus, structural element **120** is capable heat dissipation when at least two of the environments are an external environment positioned adjacent to one another and the heat dissipation is therebetween. Additionally, structural element **120** is capable heat dissipation when at least one of the environments is an external environment positioned adjacent to an internal environment and the heat dissipation is from the internal environment to the external environment.

[0029] In the exemplary configuration illustrated in Figure 6, the elastomeric journal bearing assembly **100** is provided between two different environments (e.g., in a system in which an enclosed, first fluid-filled cavity **A** is separated from a second environment **B** that is open to ambient air). In the arrangement illustrated, structural elements **120** comprise first exposed ends **121** that extend beyond the axial edges of at least one adjacent elastomer sections **110** into first fluid-filled cavity **A**, and/or structural elements **120** further comprise second exposed ends **122** that extend beyond the axial edges of at least one adjacent elastomer sections **110** into second environment **B**. In this way, the first and second exposed ends **121** and **122** are configured to help dissipate and/or transfer heat from one environment on one side of elastomeric journal bearing assembly **100** (e.g., from the fluid in first fluid-filled cavity **A**) to the second environment on the other side (e.g., to an open-air environment of second environment **B**). This enhanced heat transfer relieves thermal gradients along the length of the elastomeric journal bearing assembly **100** and further helps to reduce fatigue and increase the service life of the elastomeric journal bearing assembly **100**.

[0030] Methods to manufacture an elastomeric journal bearing assembly or assemblies such as those disclosed herein are also envisioned according to this disclosure.

[0031] The present subject matter can be embodied in other forms without departure from the spirit and essential characteristics thereof. The embodiments described therefore are to be considered in all respects as illustrative and not restrictive. Although the present subject matter has been described in terms of certain preferred embodiments, other embodiments that are apparent to those of ordinary skill in the art are also within the scope of the present subject matter.

CLAIMS

What is claimed is:

1. An elastomeric journal bearing assembly comprising:
a plurality of elastomer sections arranged about a center axis; and
at least one structural element arranged between an adjacent pair of the plurality of elastomer sections.
2. The elastomeric journal bearing assembly of claim 1, wherein each of the plurality of elastomer sections has a substantially similar thickness.
3. The elastomeric journal bearing assembly of claim 1, wherein the plurality of elastomer sections comprise substantially annular sections arranged concentrically about the center axis.
4. The elastomeric journal bearing assembly of claim 3, wherein at least two of the plurality of elastomer sections have different axial lengths, wherein a first of the plurality of elastomer sections positioned relatively nearer to the center axis has a longer axial length than a second of the plurality of elastomer sections positioned relatively farther from the center axis.
5. The elastomeric journal bearing assembly of claim 3, wherein of the plurality of elastomer sections each have different axial lengths, wherein a n^{th} of the plurality of elastomer sections positioned relatively nearer to the center axis has a longer axial length than an $n^{\text{th}} + 1$ of the plurality of elastomer sections positioned relatively farther from the center axis.
6. The elastomeric journal bearing assembly of claim 1, wherein each of the plurality of elastomer sections has a substantially similar total surface area.
7. The elastomeric journal bearing assembly of claim 1, wherein the plurality of elastomer sections are bonded to the at least one structural element.
8. The elastomeric journal bearing assembly of claim 1, wherein the at least one structural element comprises a non-elastomeric material.

9. The elastomeric journal bearing assembly of claim 1, wherein the at least one structural element comprises a metallic material.
10. The elastomeric journal bearing assembly of claim 9, wherein the at least one structural element comprises a metal sheet element.
11. The elastomeric journal bearing assembly of claim 1, wherein the at least one structural element extends beyond an axial edge of at least one of the adjacent pair of the plurality of elastomer sections.
12. The elastomeric journal bearing assembly of claim 11, wherein the at least one structural element has an axial length that is greater than an axial length of the at least one of the adjacent pair of the plurality of elastomer sections.
13. The elastomeric journal bearing assembly of claim 12, wherein each of the at least one structural element is arranged between two elastomer sections that are arranged concentrically about the center axis;
wherein an axial length of each of the at least one structural element is equal to or greater than an axial length of a first of the two elastomer sections positioned relatively nearer to the center axis; and
wherein the axial length of the at least one structural element is greater than an axial length of a second of the plurality of elastomer sections positioned relatively farther from the center axis.
14. The elastomeric journal bearing assembly of claim 1, wherein the structural element is a rigid shim extending into the internal and external environments.
15. The elastomeric journal bearing assembly of claim 14, wherein the structural element is capable of heat dissipation between at least two environments positioned adjacently to one another.
16. The elastomeric journal bearing assembly of claim 15, wherein at least two of the environments are an external environment positioned adjacent to one another and the heat dissipation is therebetween.
17. The elastomeric journal bearing assembly of claim 15, wherein at least one of the environments is an external environment positioned adjacent an internal

environment and the heat dissipation is from the internal environment to the external environment.

18. The elastomeric journal bearing assembly of claim 1, wherein the elastomeric journal bearing assembly provides for a reduction of tensile stress and localized bending of the elastomer sections.

19. The elastomeric journal bearing assembly of claim 19, wherein the reduction of tensile stress is about 10% over a elastomeric journal bearing having a unitary elastomer.

20. The elastomeric journal bearing assembly of claim 19, wherein the reduction of tensile stress is about 60% over a elastomeric journal bearing having a unitary elastomer with a thickness to length ratio of less than equal to 0.1.

21. The elastomeric journal bearing assembly of claim 20, wherein the reduction of tensile stress is about 42%.

22. The elastomeric journal bearing assembly of claim 19, further comprising a reduction in localized bending.

23. An elastomeric journal bearing system comprising:
a bearing housing;
a shaft positioned within the bearing housing and movable with respect to the bearing housing;
a plurality of elastomer sections arranged within the bearing housing about the shaft; and
at least one structural element arranged between adjacent pairs of the plurality of elastomer sections.

24. The elastomeric journal bearing system of claim 23, wherein the plurality of elastomer sections comprise substantially annular sections arranged concentrically about the shaft

25. The elastomeric journal bearing system of claim 24, wherein at least two of the plurality of elastomer sections have different axial lengths, wherein a first of the plurality of elastomer sections positioned relatively nearer to the shaft has a longer

axial length than a second of the plurality of elastomer sections positioned relatively farther from the shaft.

26. The elastomeric journal bearing system of claim 24, wherein an axial length of each of the at least one structural element is equal to or greater than an axial length of a first of the two elastomer sections positioned relatively nearer to the shaft; and
wherein the axial length of the at least one structural element is greater than an axial length of a second of the plurality of elastomer sections positioned relatively farther from the shaft.

27. A method for making an elastomeric journal bearing, the method comprising:
arranging a plurality of elastomer sections within a bearing housing about a shaft that is positioned within the bearing housing and movable with respect to the bearing housing; and
arranging at least one structural element between adjacent pairs of the plurality of elastomer sections.

28. The method of claim 27, wherein arranging the plurality of elastomer sections about the center axis comprises arranging substantially annular sections concentrically about the center axis.

29. The method of claim 27, wherein arranging the plurality of elastomer sections about the center axis comprises:
positioning a first of the plurality of elastomer sections relatively nearer to the center axis; and
positioning a second of the plurality of elastomer sections positioned relatively farther from the center axis;
wherein the first of the plurality of elastomer sections has a longer axial length than the second of the plurality of elastomer sections.

30. The method of claim 27, wherein arranging the at least one structural element between adjacent pairs of the plurality of elastomer sections comprises bonding the at least one structural element to the plurality of elastomer sections, wherein the structural element is capable of heat dissipation.

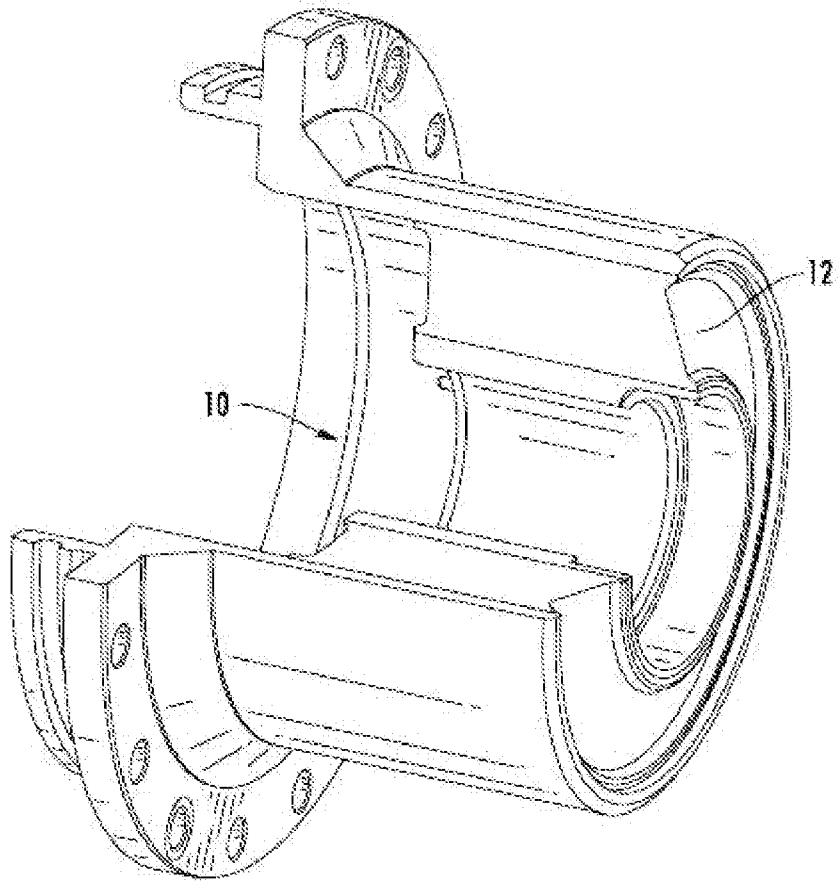


FIG. 1

B: COMPRESSION STATIC STRUCTURAL (ANSYS)
MAXIMUM PRINCIPLE STRESS
TYPE: MAXIMUM PRINCIPAL STRESS
UNIT: PSI

TIME: 1
4/19/2012 2:59 PM 256.15

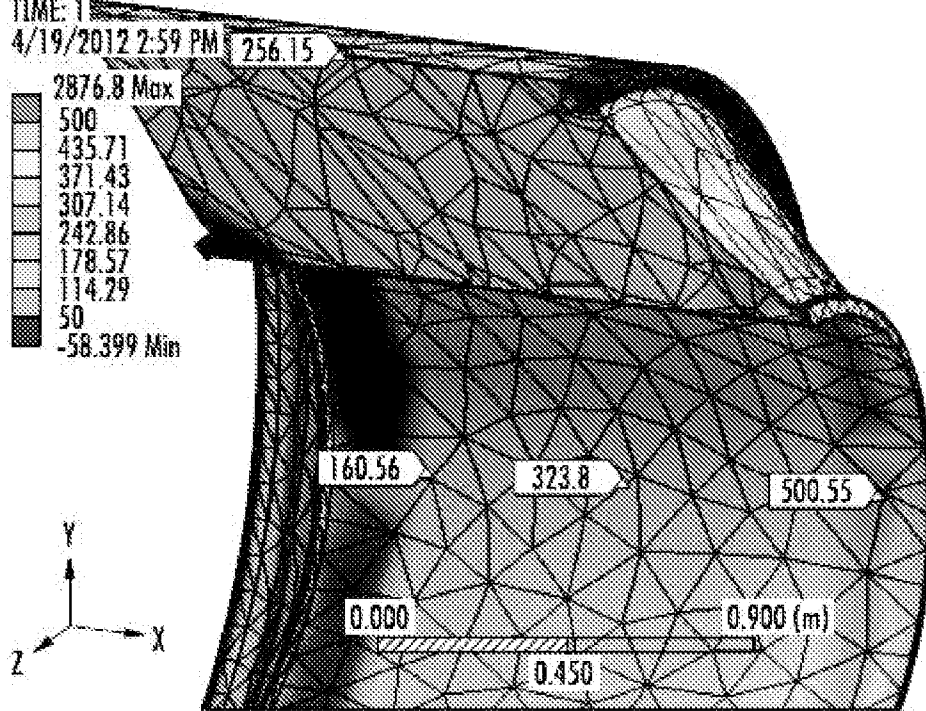
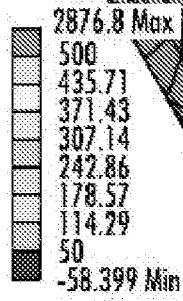


FIG. 2A

B: COMPRESSION STATIC STRUCTURAL (ANSYS)
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TYPE: MAXIMUM PRINCIPAL ELASTIC STRESS
UNIT: in/in
TIME: 1
5/4/2012 10:20 AM

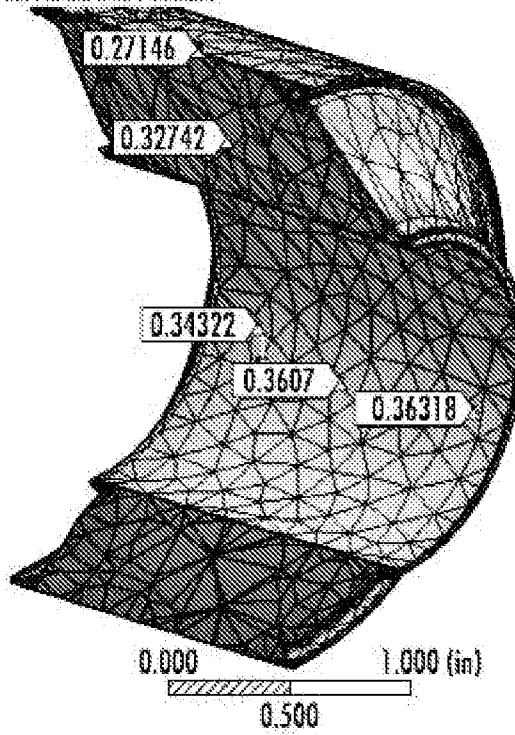
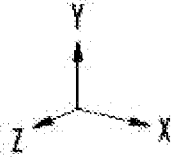
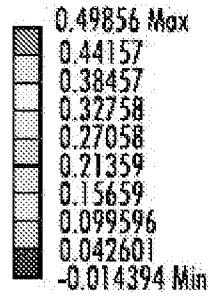


FIG. 2B

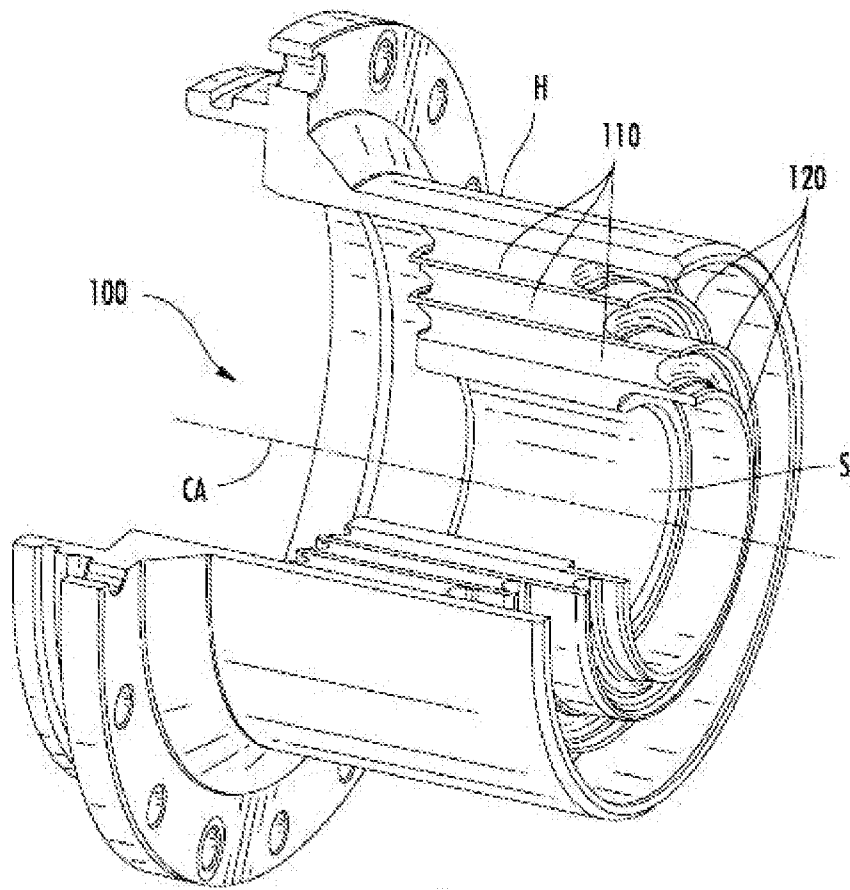


FIG. 3A

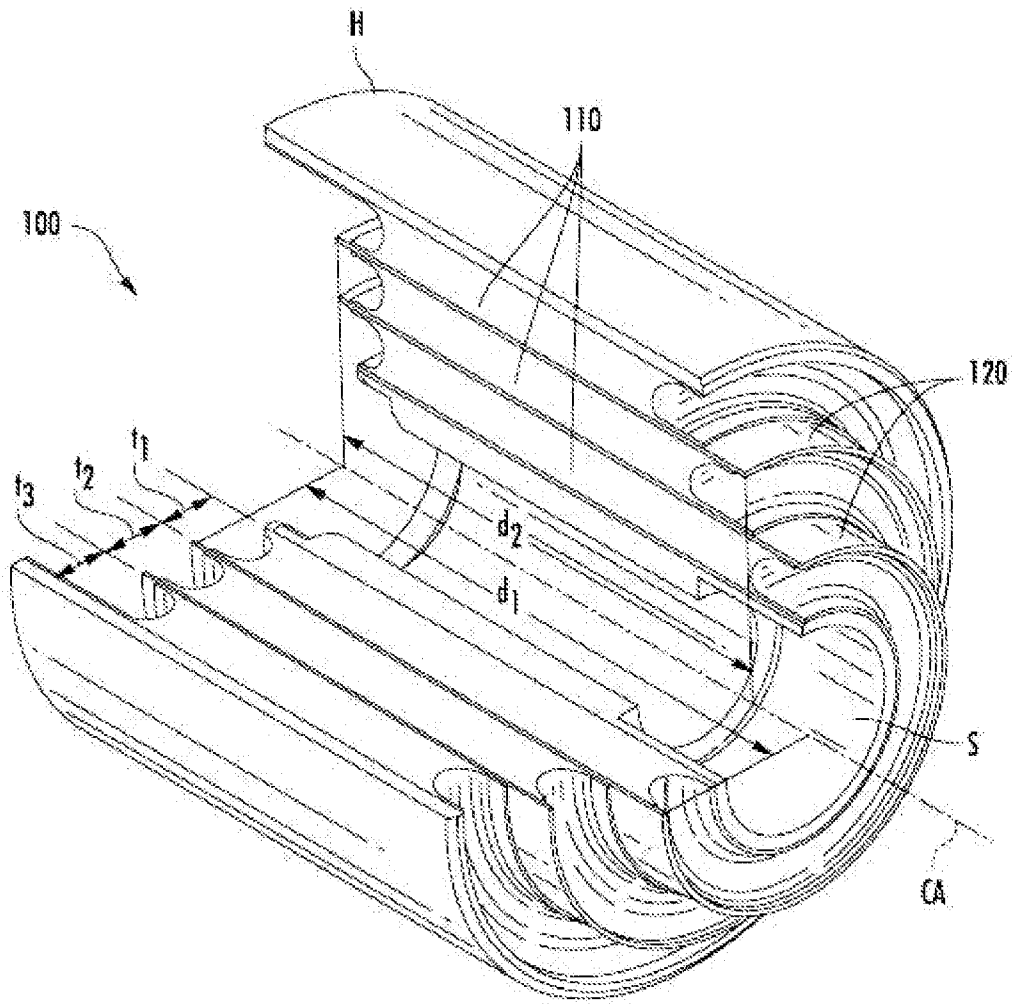


FIG. 3B

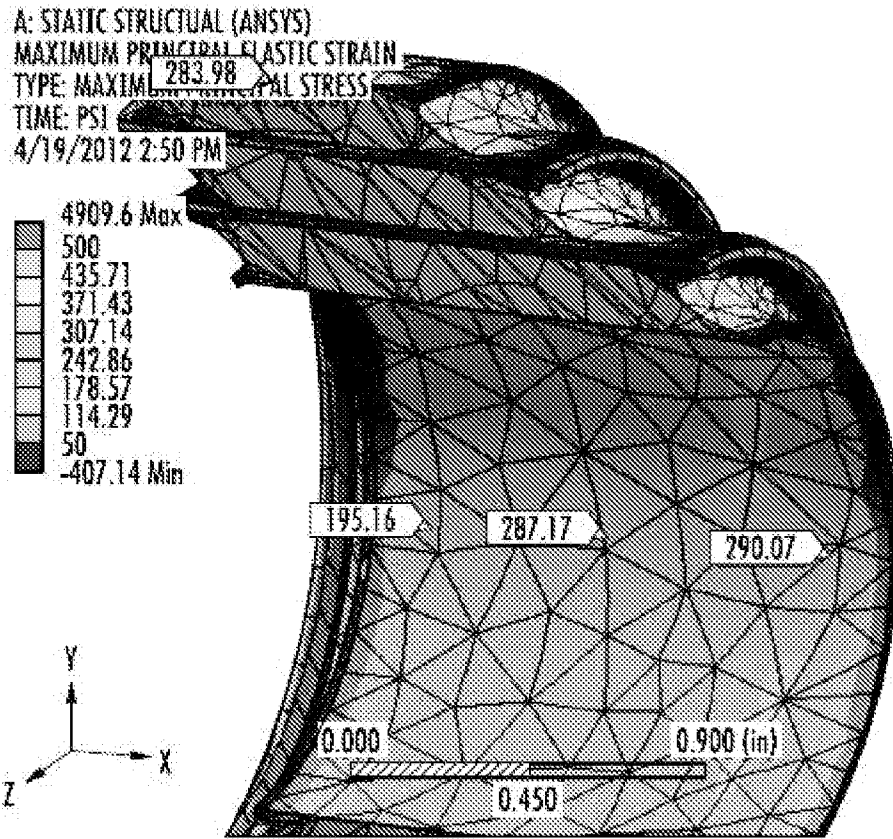


FIG. 4A

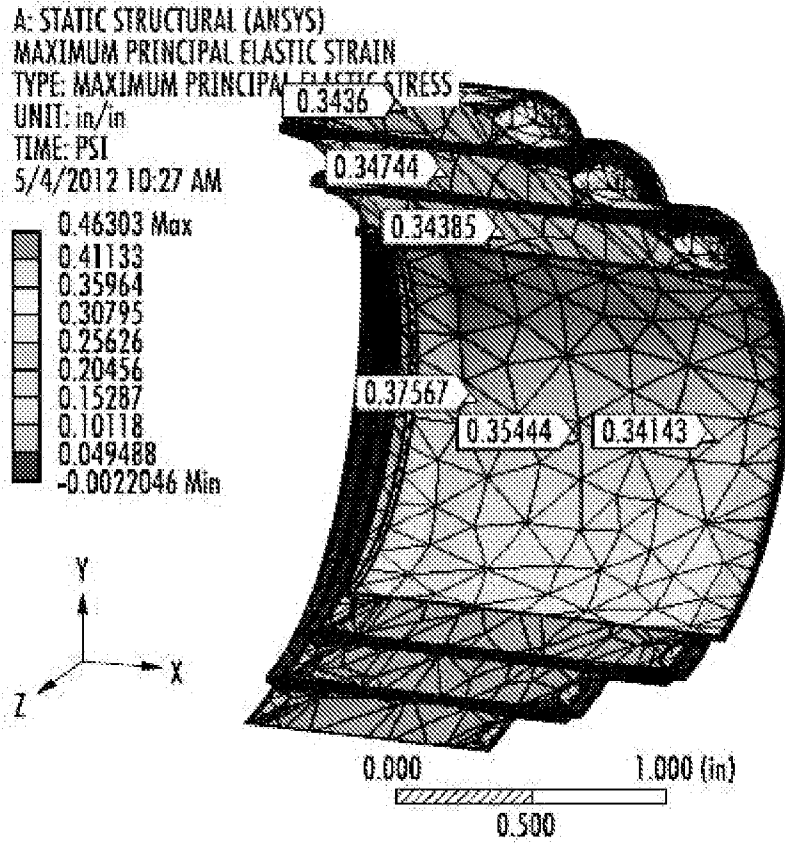


FIG 4B

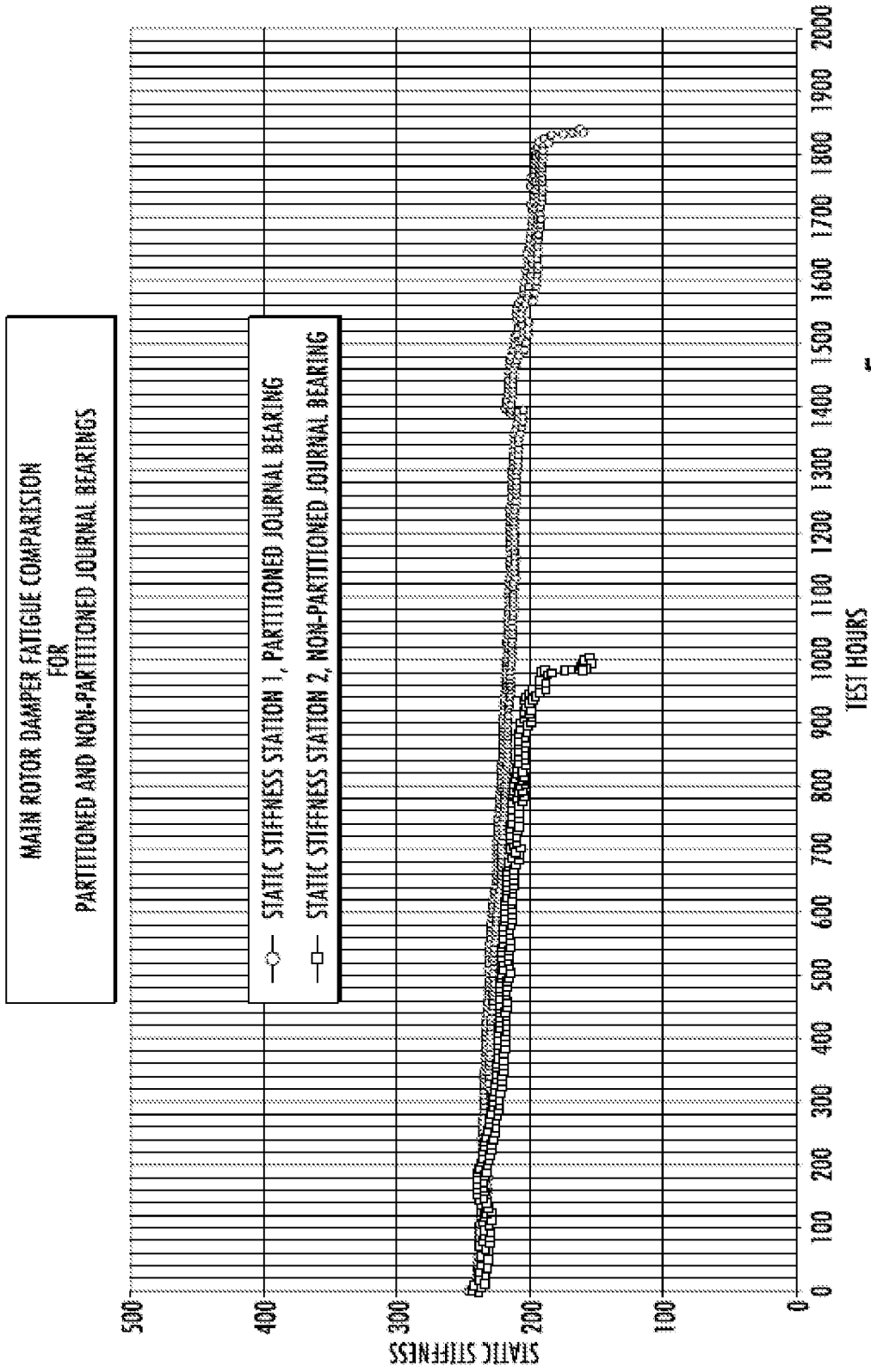


FIG 5

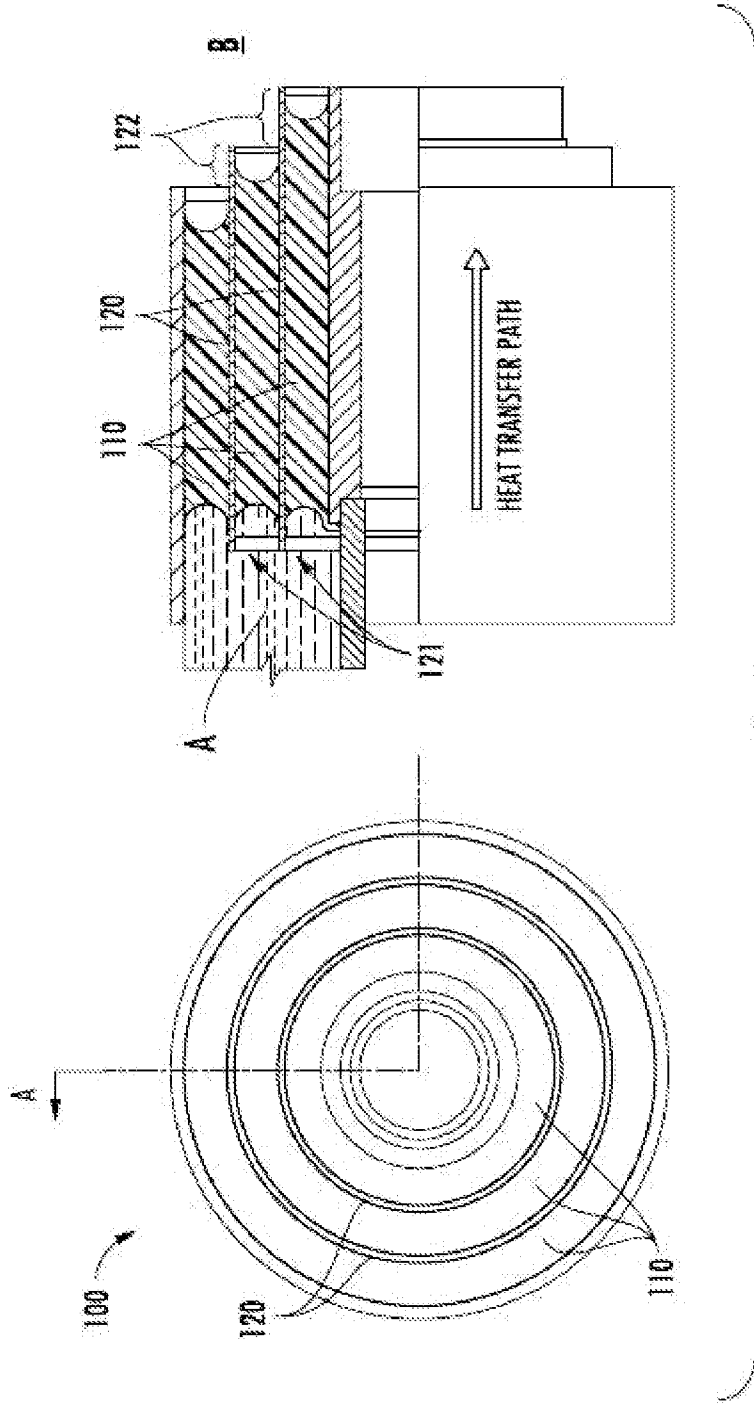


FIG 6

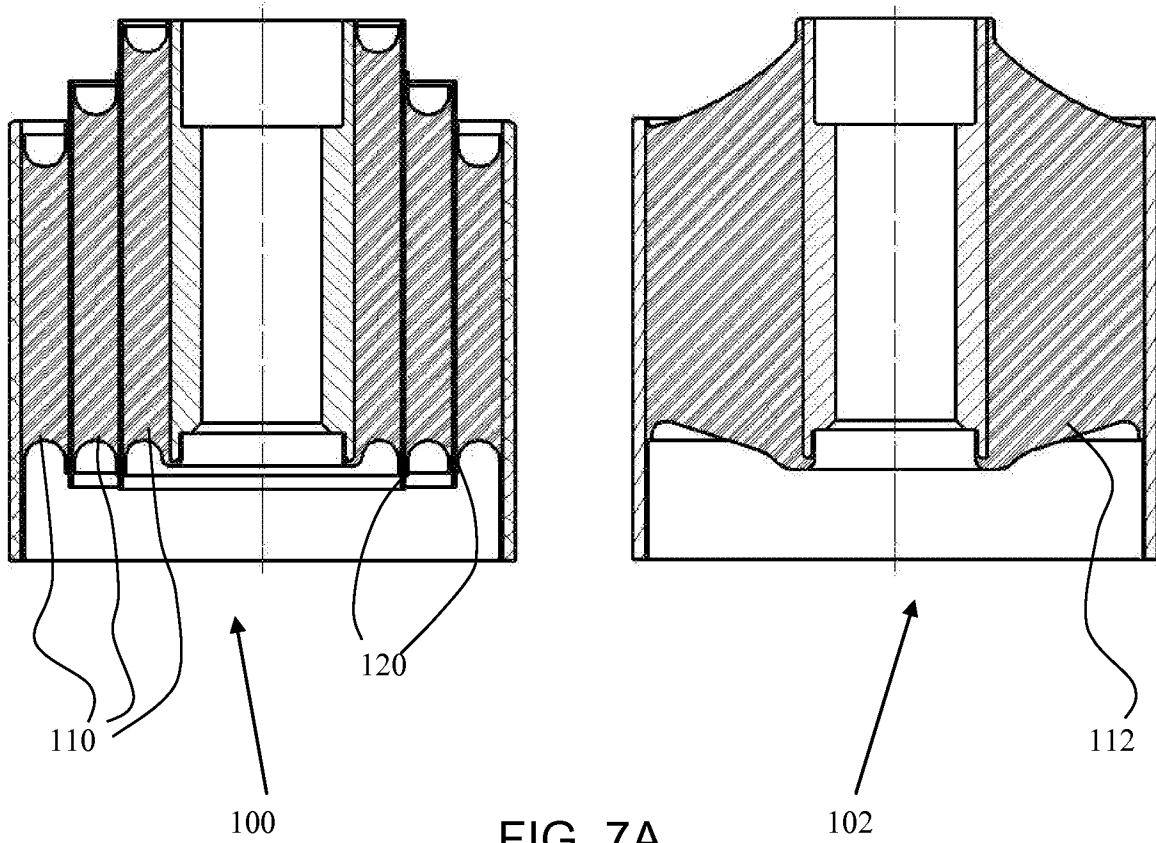


FIG. 7A

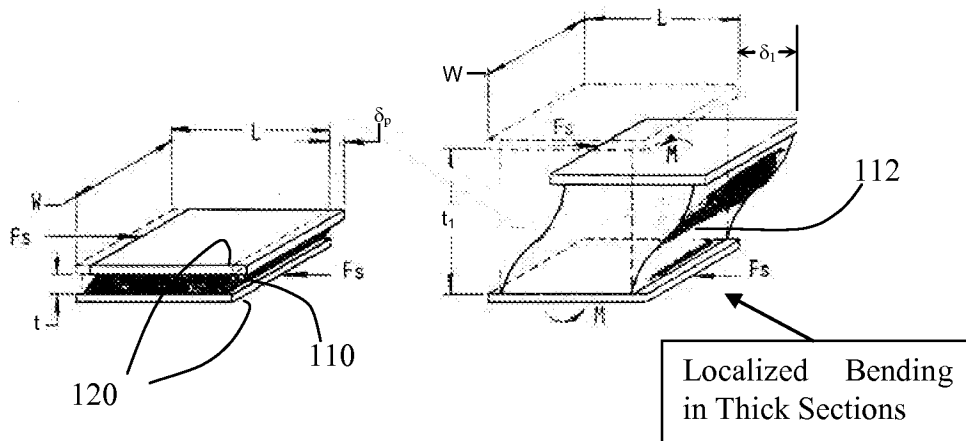


FIG. 7B

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/018273

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16F1/38
ADD.

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)
F16F

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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 804 481 A1 (MICHELIN AVS [FR]) 3 August 2001 (2001-08-03) figure 1 -----	1-22, 27-30
X	FR 2 818 717 A1 (EUROCOPTER FRANCE [FR]) 28 June 2002 (2002-06-28) figure 1 -----	23-26
X	FR 2 333 163 A1 (KLEBER COLOMBES [FR]) 24 June 1977 (1977-06-24) figure 1 -----	1
X	GB 2 018 940 A (WRIGHT BARRY CORP) 24 October 1979 (1979-10-24) figure -----	1
X	JP 2009 115156 A (TOYO TIRE & RUBBER CO) 28 May 2009 (2009-05-28) figure 1 -----	1

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search

16 May 2014

Date of mailing of the international search report

27/05/2014

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Beaumont, Arnaud

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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