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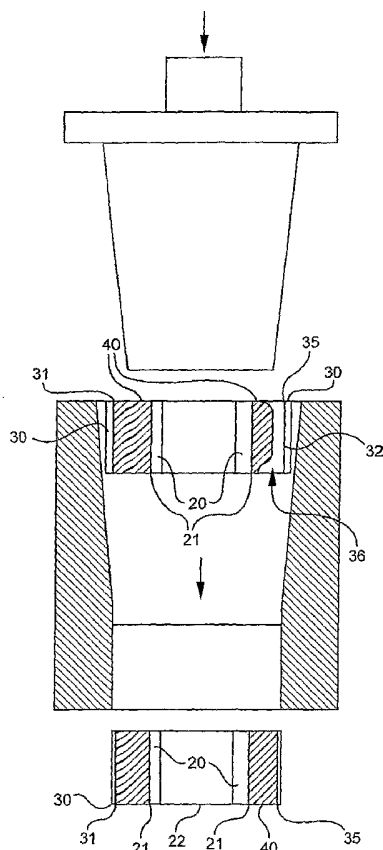
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(54) Title: MULTIPLE RADIAL SPRING RATE PIVOT BUSHING AND METHOD OF MAKING THE SAME



(57) Abstract: A vehicle hood pivot bushing and methods of making a hood pivot bushings with multiple spring rates. The method of making the multiple radial spring rate pivot bushing includes providing a nonelastomeric inner member (20) having an outer circumference bonding surface (21) and a bore (22) with a center bore axis. The method includes providing an elastomer (40) and a bushing mold for receiving the nonelastomeric inner member (20) and the nonelastomeric outer member (30) with the nonelastomeric inner member held in the nonelastomeric outer member axial bore, and molding the nonelastomeric inner member to the nonelastomeric outer member with the elastomer, with the elastomer bonding to the inner member outer circumference bonding surface while inhibiting a bonding of the elastomer to an elastomeric void section (35) of the outer member inner circumference bonding surface. The method includes deforming the nonelastomeric outer ductile member in towards the nonelastomeric inner member wherein the elastomeric void section of the nonelastomeric outer ductile member contacts the elastomer.



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MULTIPLE RADIAL SPRING RATE PIVOT BUSHING AND METHOD OF MAKING

Cross Reference

This application claims the benefit of, and incorporates by reference, United States Provisional Patent Application Number 60/621,175 filed on October 22, 2004.

Field of the Invention

The present invention relates to hood pivot bushings and methods of making hood pivot bushings with multiple spring rates. More particularly the invention relates to vehicle hood pivot bushings and methods of making vehicular hood pivot bushings with multiple radial spring rates.

Background of the Invention

There is a need for an economical method of making hood pivot bushings with multiple spring rates. There is a need for a pivot bushing with multiple radial spring rates. There is a need for an economically feasible method of making pivot bushings with multiple spring rates.

SUMMARY OF THE INVENTION

The invention includes a method of making a multiple radial spring rate pivot bushing. The method includes providing a nonelastomeric inner member having an outer circumference bonding surface and a bore with a center bore axis, preferably with the center bore axis offset from a center axis of the inner member outer circumference. The method includes providing a nonelastomeric outer ductile member having an inner

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circumference bonding surface and a center bore with a center bore axis, with the center bore axis preferably centered with a center axis of the outer member inner circumference. The method includes providing an elastomer. The method includes providing a bushing mold for receiving the nonelastomeric inner member and the nonelastomeric outer member with the nonelastomeric inner member held in the nonelastomeric outer member axial bore. The method includes molding the nonelastomeric inner member to the nonelastomeric outer member with the elastomer, with the elastomer bonding to the inner member outer circumference bonding surface while inhibiting a bonding of the elastomer to an elastomeric void section of the outer member inner circumference bonding surface. The method includes deforming the nonelastomeric outer ductile member in towards the nonelastomeric inner member wherein the elastomeric void section of the nonelastomeric outer ductile member contacts the elastomer.

The invention includes a method of making a pivot bushing. The method includes providing a nonelastomeric inner member having an outer circumference bonding surface. The method includes providing a nonelastomeric outer member having an inner circumference bonding surface. The method includes providing an elastomer. The method includes bonding the nonelastomeric inner member to the nonelastomeric outer member with the elastomer bonding to the inner member outer circumference bonding surface while inhibiting a bonding of the elastomer to an elastomeric void section of the outer member inner circumference bonding surface in order to define an elastomeric void. The method includes deforming the nonelastomeric outer ductile member in towards the nonelastomeric inner member wherein the elastomeric void section of the nonelastomeric outer ductile member contacts the elastomer.

The invention includes a method of making a bushing. The method includes providing a nonelastomeric outer member having an inner circumference bonding surface and a center bore. Preferably the outer member center bore contains an elastomer and a

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nonelastomeric inner member having an outer circumference bonding surface with the elastomer bonded to the inner member outer circumference bonding surface and to the outer member inner bonding surface with an elastomeric void defined by the elastomer between the inner member and the outer member. The method includes deforming the nonelastomeric outer member in towards the nonelastomeric inner member wherein the elastomeric void is reduced and the nonelastomeric outer member is brought into contact with the elastomer with the elastomer between the inner member and the outer member.

The invention includes a vehicle hood multiple radial spring rate pivot bushing. The bushing includes a nonelastomeric inner member having an inner member outer circumference bonding surface and an inner member bore with an inner member center bore axis, the inner member center bore axis offset from an outer circumference center axis of the inner member outer circumference bonding surface. The invention includes an elastomer bonded to the inner member outer circumference bonding surface, and a ductile nonelastomeric outer member having an inner circumference bonding surface and an outer member center bore with an outer member center bore axis, the outer member center bore axis centered with an inner circumference center axis of the outer member inner circumference bonding surface. The ductile nonelastomeric outer member inner circumference bonding surface has an elastomeric void section. The ductile nonelastomeric outer member contains the elastomer and the inner member with the elastomer bonded to the outer member inner circumference bonding surface except at the elastomeric void section, the ductile nonelastomeric outer member having a deformed reduced diameter wherein the ductile nonelastomeric outer member elastomeric void section contacts the elastomer.

The invention includes a bushing preform. The bushing preform includes a nonelastomeric inner member having an inner member outer circumference bonding surface and an inner member bore with an inner member center bore axis, the inner member center bore axis offset from an outer circumference center axis of the inner member outer circumference bonding surface. The bushing preform includes an elastomer bonded to the inner member outer circumference bonding surface. The bushing

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preform includes a ductile nonelastomeric outer member having an inner circumference bonding surface and an outer member center bore with an outer member center bore axis, the outer member center bore axis centered with an inner circumference center axis of the outer member inner circumference bonding surface. The ductile nonelastomeric outer member contains the elastomer and the inner member with the elastomer bonded to the outer member inner circumference bonding surface, the contained elastomer defining an elastomeric void between the inner member and the outer member, wherein the elastomeric void is removed by deforming the ductile nonelastomeric outer member of the bushing preform to a reduced bushing diameter to provide a multiple spring rate bushing.

It is to be understood that both the foregoing general description and the following detailed description are exemplary of the invention, and are intended to provide an overview or framework for understanding the nature and character of the invention as it is claimed. The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate various embodiments of the invention, and together with the description serve to explain the principals and operation of the invention.

Brief Description of the Drawings

FIG. 1 shows a method of making a bushing with a mold.

FIG. 2 illustrates a bushing preform and a method of making a bushing.

FIG. 3 illustrates bushing performs, bushings, and methods of making bushings.

FIG. 4 illustrates a method of making a bushing.

FIG. 5 illustrates a bushing.

FIG. 6 illustrates an installed bushing.

FIG. 7 illustrates an installed bushing.

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Detailed Description of the Preferred Embodiments

Additional features and advantages of the invention will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the invention as described herein, including the detailed description which follows, the claims, as well as the appended drawings.

Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings.

The invention provides a method of making a multiple radial spring rate pivot bushing. The method includes providing a nonelastomeric inner member having an outer circumference cylindrical shell bonding surface and a bore with a center bore axis, the center bore axis offset from a center axis of the inner member outer circumference. The method includes providing a nonelastomeric nonresilient outer ductile member having an inner circumference cylindrical shell bonding surface and a center bore with a center bore axis, the center bore axis centered with a center axis of the outer member inner circumference. The method includes providing an elastomer, and providing a bushing mold for receiving the nonelastomeric inner member and the nonelastomeric outer member with the nonelastomeric inner member held in the nonelastomeric outer member axial bore, and molding the nonelastomeric inner member to the nonelastomeric outer member with the elastomer, with the elastomer bonding to the inner member outer circumference bonding surface while inhibiting a bonding of the elastomer to an elastomeric void section of the outer member inner circumference bonding surface in order to form and define an elastomeric void. The method includes deforming the nonelastomeric outer ductile member in towards the nonelastomeric inner member wherein the elastomeric void section of the nonelastomeric outer ductile member contacts the elastomer, preferably with the nonelastomeric inner member center bore axis centered with the nonelastomeric outer ductile member center bore axis. Preferably the offcentered inner member bore becomes centered with the outer member. In an embodiment

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deforming includes contacting the elastomer with the elastomeric void section of the outer member while inhibiting substantial compression of the elastomer by the elastomeric void section of the outer member. In an embodiment deforming and contacting includes compressing the elastomer between the elastomeric void section of outer member and the inner member outer bonding surface.

The FIGS. illustrate methods of making multiple radial spring rate pivot bushings. As shown in FIG. 1 the method includes providing a nonelastomeric inner member 20 having an outer circumference cylindrical shell bonding surface 21 and a bore 22 with a center bore axis 23, the center bore axis preferably offset from the center axis of the inner member outer circumference 21. The method includes providing a nonelastomeric nonresilient outer ductile member 30 having an inner circumference cylindrical shell bonding surface 31 and a center bore 32 with a center bore axis 33, the center bore axis centered with the center axis of the outer member inner circumference 31. The method includes providing an elastomer 40, and providing a bushing mold 50 for receiving the nonelastomeric inner member 20 and the nonelastomeric outer member 30 with the nonelastomeric inner member held in the nonelastomeric outer member axial bore 32, and molding the nonelastomeric inner member 20 to the nonelastomeric outer member 30 with the elastomer 40, with the elastomer bonding to the inner member outer circumference bonding surface 21 while inhibiting a bonding of the elastomer to an elastomeric void section 35 of the outer member inner circumference bonding surface 31 in order to form and define an elastomeric void 36, such as with mold 50 extending into and occupying the elastomeric void space 36. As shown in FIG. 4 the method includes deforming the nonelastomeric outer ductile member 30 in towards the nonelastomeric inner member 20 wherein the elastomeric void section 35 of the nonelastomeric outer ductile member contacts the elastomer 40, preferably with the nonelastomeric inner member center bore axis centered with the nonelastomeric outer ductile member center bore axis. As shown in FIG 3-4, preferably the bushing performs as bonded with the elastomer to the inner member 20 and the outer member 30, are deformed by swaging to deform the outer member 30 radially inward towards the inner member 20. In preferred embodiments the performs are swagged so that the elastomer 40 adjacent the elastomeric

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void space 36 touches the outer member inside circumference at the elastomeric void section 35, preferably while inhibiting compression of that elastomer by the outer member inside circumference at the elastomeric void section 35. Preferably the offcentered inner member bore becomes centered with the outer member.

In an embodiment deforming includes contact of the elastomer 40 by the elastomeric void section 35 of the outer member while inhibiting substantial compression of the elastomer by the elastomeric void section 35 of the outer member. In an embodiment deforming and contacting includes compressing the elastomer 40 between the elastomeric void section 35 of the outer member and the inner member outer bonding surface. In an embodiment, molding the nonelastomeric inner member 20 to the nonelastomeric outer member 30 with the elastomer 40, preferably includes inhibiting bonding of the elastomer 40 to a first elastomeric void section 35 and to a second elastomeric void section 35 such as shown in the lower half of FIG. 3. Preferably the second elastomeric void section 35 is separate and distal from the first elastomeric void section 35, preferably with the second section 35 oriented in opposition to the first section 35. In a preferred embodiment each elastomeric void section 35 is about twenty five percent of the outer member inner circumference bonding surface 31. Preferably molding the nonelastomeric inner member 20 to the nonelastomeric outer member 30 with the elastomer 40, includes inhibiting bonding of the elastomer 40 to an elastomeric void section 35 comprising at least twenty five percent of the outer member inner circumference bonding surface. Preferably molding the nonelastomeric inner member to the nonelastomeric outer member with the elastomer, includes inhibiting bonding of the elastomer from twenty five to seventy five percent of the outer member inner circumference bonding surface 31, more preferably about fifty percent ($50 \pm 10\%$). Preferably with one elastomeric void, the void section 35 is about fifty percent of the outer member inner circumference bonding surface 31, and with two elastomeric voids, each void section is about twenty five percent. In an embodiment deforming the nonelastomeric outer ductile member in towards the nonelastomeric inner member includes compressing the elastomer 40 between the inner member outer surface 21 and the elastomeric void section 35 of the nonelastomeric outer ductile member inner

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surface. Preferably compressing the elastomer 40 between the inner member outer surface 21 and the elastomeric void section 35 of the nonelastomeric outer ductile member inner surface, includes compressing the elastomer with a compression strain in the range of one to fifty percent, more preferably with a compression strain in the range of fifteen to twenty percent.

The invention includes a method of making a multiple radial spring rate pivot bushing. The method includes providing a nonelastomeric inner member 20 having an outer circumference cylindrical shell bonding surface 21 and a bore 22 with a center bore axis 23, with the center bore axis 23 offset from the center axis of the inner member outer circumference 21. The method includes providing a nonelastomeric outer ductile member 30 having an inner circumference cylindrical shell bonding surface 31 having a center bore 32 and a center bore axis 33 preferably centered with the center axis of the outer member inner circumference 31. The method includes providing an elastomer 40 and bonding the nonelastomeric inner member to the nonelastomeric outer member with the elastomer 40 bonding to the inner member outer circumference bonding surface 21 while inhibiting a bonding of the elastomer 40 to an elastomeric void section 35 of the outer member inner circumference 31 in order to define an elastomeric void 36. The method includes deforming the nonelastomeric outer ductile member 30 in towards the nonelastomeric inner member 20 wherein the elastomeric void section 35 of the nonelastomeric outer ductile member contacts the elastomer 40 and the nonelastomeric inner member center bore axis 23 is preferably centered with the nonelastomeric outer ductile member center bore axis 33, preferably with the offcentered inner member bore becoming centered. Preferably in an embodiment just contact is made between the elastomer and the elastomeric void section of the outer member and not compression of elastomer by elastomeric void section of the outer member. Preferably in an embodiment contacting includes compressing the elastomer 40 between the elastomeric void section 35 of outer member and inner member outer bonding surface 21. Preferably molding the nonelastomeric inner member to the nonelastomeric outer member with the elastomer, includes inhibiting the bonding of the elastomer 40 to a first elastomeric void section 35

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and to a second elastomeric void section 35, preferably with the second elastomeric void section 35 separate and distal from the first elastomeric void section 35. Preferably the second elastomeric void section 35 is oriented in opposition to the first elastomeric void section 35. Preferably with two elastomeric void sections, each section is about twenty five percent of the outer member inner circumference bonding surface. Preferably molding the nonelastomeric inner member to the nonelastomeric outer member with the elastomer, includes inhibiting bonding of the elastomer to an elastomeric void section comprising at least twenty five percent of the outer member inner circumference bonding surface. Preferably molding the nonelastomeric inner member to the nonelastomeric outer member with the elastomer, includes inhibiting bonding of the elastomer from twenty five to seventy five percent of the outer member inner circumference bonding surface, more preferably about fifty percent ($50 \pm 10\%$). Preferably with one elastomeric void, the elastomeric void section is about fifty percent of the outer member inner circumference. Preferably with two elastomeric voids, each void section is about twenty five percent of the outer member inner circumference. Preferably deforming the nonelastomeric outer ductile member in towards the nonelastomeric inner member includes compressing the elastomer between the inner member outer surface and the elastomeric void section of the nonelastomeric outer ductile member inner surface. Preferably compressing the elastomer between the inner member outer surface and the elastomeric void section of the nonelastomeric outer ductile member inner surface, includes compressing the elastomer with a compression strain in the range of one to fifty percent, more preferably with a compression strain in the range of fifteen to twenty percent.

The invention includes a method of making a multiple radial spring rate pivot bushing. The method includes providing a nonelastomeric outer ductile member 30 having an inner circumference, an inner circumference cylindrical shell bonding surface and a center bore with a center bore axis. Preferably the center bore center bore axis is centered with the center axis of the outer member inner circumference. The outer member center bore 32 contains an elastomer 40 and a nonelastomeric inner member 20 having an outer circumference cylindrical shell bonding surface and a bore with a center bore axis.

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Preferably the inner member center bore axis is offset from the center axis of the inner member outer circumference. The elastomer 40 is bonded to the inner member outer circumference bonding surface and to the outer member inner bonding surface with an elastomeric void 36 defined by the elastomer 40 between the inner member and the outer member. The method includes deforming the nonelastomeric outer ductile member 30 radially in towards the nonelastomeric inner member 20 wherein the elastomeric void space 36 is reduced and the nonelastomeric outer ductile member 30 is brought into contact with the elastomer 40 between the inner member 20 and the outer member 30. Preferably the nonelastomeric inner member 20 center bore axis is centered with the nonelastomeric outer ductile member 30 center bore axis, preferably with the offcentered inner member bore becoming centered by the deforming of the outer ductile member 30. In an embodiment deforming includes contacting of the elastomer 40 by the elastomeric void section 35 of the outer member while inhibiting substantial compression of the elastomer 40 by the elastomeric void section 35 of the outer member. In an embodiment deforming and contacting includes compressing the elastomer 40 between the elastomeric void section 35 of outer member and the inner member outer bonding surface 21. Preferably the elastomer 40 defines a first elastomeric void 36 and a second elastomeric void 36, with the second elastomeric void section separate and distal from the first elastomeric void section. Preferably the second elastomeric void section 35 is oriented in opposition to the first elastomeric void section 35, most preferably with each section about twenty five percent ($25\% \pm 5\%$) of the outer member inner circumference bonding surface. Preferably the elastomeric void 36 includes an elastomeric void section 35 comprising at least twenty five percent of the outer member 30 inner circumference surface. Preferably the elastomeric void 36 includes an elastomeric void section 35 comprising from twenty five to seventy five percent of the outer member inner circumference bonding surface, more preferably about fifty percent ($50\% \pm 10\%$), preferably with only one void the void section is about fifty percent ($50\% \pm 10\%$), and with two voids, each void section is about twenty five percent ($25\% \pm 5\%$). Preferably deforming the nonelastomeric outer ductile member 30 in towards the nonelastomeric inner member 20 includes compressing the elastomer 40 between the inner member outer surface and the nonelastomeric outer ductile member inner surface. Preferably

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compressing the elastomer 40 between the inner member outer surface 21 and the nonelastomeric outer ductile member inner surface 31, includes compressing the elastomer 40 with a compression strain in the range of one to fifty percent, more preferably a compression strain in the range of fifteen to twenty percent.

The invention includes a multiple radial spring rate pivot bushing. The bushing includes nonelastomeric inner member 20 having an outer circumference cylindrical shell bonding surface 21 and a bore 22 with a center bore axis 23, preferably with the center bore axis 23 offset from a center axis of the inner member outer circumference 21. The bushing includes elastomer 40 bonded to the inner member outer circumference bonding surface 21, and ductile nonelastomeric nonresilient outer member 30 having an inner circumference cylindrical shell bonding surface 31 and center bore 32 with a center bore axis 33, preferably with the center bore axis centered with a center axis of the outer member inner circumference. The ductile nonelastomeric outer member inner circumference cylindrical shell bonding surface 31 has elastomeric void section 35, with the ductile nonelastomeric outer member 30 containing the elastomer 40 and the inner member 20 with the elastomer 40 bonded to the outer member inner circumference cylindrical shell bonding surface 31 except at the elastomeric void section 35. The ductile nonelastomeric outer member 30 has a deformed radially inward reduced diameter wherein the elastomeric void section 35 of the nonelastomeric outer ductile member 30 contacts the elastomer 40 and preferably the nonelastomeric inner member center bore axis 23 is centered with the nonelastomeric outer ductile member center bore axis 33. In an embodiment there is just contact and not compression of the elastomer 40 by the elastomeric void section 35 of outer member. In an embodiment the elastomer 40 is compressed between the elastomeric void section 35 of outer member and inner member outer bonding surface 21.

The invention includes a multiple radial spring rate pivot bushing preform. The bushing preform includes the nonelastomeric inner member 20 having an outer

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circumference cylindrical shell bonding surface 21 and bore 22 with a center bore axis 23, with the center bore axis 23 offset from a center axis of the inner member outer circumference cylindrical shell surface 21. The bushing preform includes elastomer 40 bonded to the inner member outer circumference bonding surface 21, and the ductile nonelastomeric nonresilient outer member 30 having the inner circumference cylindrical shell bonding surface 31 and center bore 32 with center bore axis 33. Preferably the center bore axis 33 is centered with a center axis of the outer member inner circumference 31. The ductile nonelastomeric outer member contains the elastomer 40 and the inner member 20 with elastomer 40 bonded to the outer member inner circumference cylindrical shell bonding surface 31. The contained elastomer 40 defines an elastomeric void 36 between the inner member 20 and the outer member 30, wherein the elastomeric void 36 is removed by radially inwardly deforming the ductile nonelastomeric outer member 30 of the preform to a reduced diameter to provide a multiple radial spring rate pivot bushing, preferably with the nonelastomeric inner member center bore axis 23 centered with the nonelastomeric outer ductile member center bore axis 33. Preferably the offcentered inner member bore 22 of the preform becomes centered in the resulting bushing.

The invention provides a vehicle hood pivot bushing that incorporates multiple radial spring rates that are dependent upon the bushing orientation. The invention provides a hood pivot bushing that has two distinct radial and axial spring rates. The invention provides various radial spring rates that allow varying degrees of deflection that are dependent upon bushing orientation. The invention provides a vehicle hood bushing that provides compliance that accommodates vehicle frame articulation resulting from road inputs during vehicle use. The bushing preferably incorporates a ductile nonelastomeric cylindrical outer member 30 (O.M.[Outer Member], preferably a cylindrical ductile steel outer member) and a nonelastomeric inner member 20 (I.M.[Inner Member], preferably a brass inner member), preferably with an off-set inside diameter bore. The elastomer 40 is bonded to a portion of the O.M.'s inside surface (preferably about half of the O.M.'s inside surface) and relatively all of the I.M.'s outside surface. The opposite elastomer section (oppositely orientated relative to the

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elastomer bonded to the portion of the O.M.'s inside surface) has a cored area elastomeric void 36 between the elastomer itself and the O.M.'s inside surface. Upon swaging (radially reducing the bushing O.D. [Outside Diameter] and deforming the ductile O.M.'s O.D.) the cored area elastomeric void 36 closes up thereby causing the elastomer 40 to contact the O.M. I.D. [Inside Diameter]. When radially loaded in the direction of the core the elastomer compresses and the opposite elastomer section is tensioned thereby providing the relatively stiffer spring rate; when radially loaded in the opposite direction the formerly tensioned elastomer is compressed while the cored area elastomeric void portion disengages from the O.M. inner circumference surface providing the relatively softer spring rate.

It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit and scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

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CLAIMS

1. A method of making a multiple radial spring rate pivot bushing, said method comprising:
 - providing a nonelastomeric inner member having an outer circumference bonding surface and a bore with a center bore axis, said center bore axis offset from a center axis of said inner member outer circumference,
 - providing a nonelastomeric outer ductile member having an inner circumference bonding surface and a center bore with a center bore axis, said center bore axis centered with a center axis of said outer member inner circumference,
 - providing an elastomer,
 - providing a bushing mold for receiving said nonelastomeric inner member and said nonelastomeric outer member with said nonelastomeric inner member held in said nonelastomeric outer member axial bore,
 - molding said nonelastomeric inner member to said nonelastomeric outer member with said elastomer, with said elastomer bonding to said inner member outer circumference bonding surface while inhibiting a bonding of said elastomer to an elastomeric void section of said outer member inner circumference bonding surface,
 - deforming said nonelastomeric outer ductile member in towards said nonelastomeric inner member wherein said elastomeric void section of said nonelastomeric outer ductile member contacts said elastomer .
2. A method as claimed in claim 1, wherein molding said nonelastomeric inner member to said nonelastomeric outer member with said elastomer, includes inhibiting bonding of said elastomer to a first elastomeric void section and to a second elastomeric void section.
3. A method as claimed in claim 1, wherein molding said nonelastomeric inner member to said nonelastomeric outer member with said elastomer, includes inhibiting bonding of

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said elastomer to an elastomeric void section comprising at least twenty five percent of said outer member inner circumference bonding surface.

4. A method as claimed in claim 1, wherein molding said nonelastomeric inner member to said nonelastomeric outer member with said elastomer, includes inhibiting bonding of said elastomer from twenty five to seventy five percent of said outer member inner circumference bonding surface.

5. A method as claimed in claim 1, wherein deforming said nonelastomeric outer ductile member in towards said nonelastomeric inner member includes compressing the elastomer between said inner member outer surface and said elastomeric void section of said nonelastomeric outer ductile member inner surface.

6. A method as claimed in claim 5, wherein compressing the elastomer between said inner member outer surface and said elastomeric void section of said nonelastomeric outer ductile member inner surface, includes compressing the elastomer with a compression strain in the range of one to fifty percent.

7. A method of making a pivot bushing, said method comprising:
providing a nonelastomeric inner member having an outer circumference bonding surface,
providing a nonelastomeric outer member having an inner circumference bonding surface,
providing an elastomer,
bonding said nonelastomeric inner member to said nonelastomeric outer member with said elastomer bonding to said inner member outer circumference bonding surface while inhibiting a bonding of said elastomer to an elastomeric void section of said outer member inner circumference bonding surface in order to define an elastomeric void,
deforming said nonelastomeric outer ductile member in towards said nonelastomeric inner member wherein said elastomeric void section of said nonelastomeric outer ductile member contacts said elastomer.

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8. A method as claimed in claim 7, wherein molding said nonelastomeric inner member to said nonelastomeric outer member with said elastomer, includes inhibiting bonding of said elastomer to a first elastomeric void section and to a second elastomeric void section.

9. A method as claimed in claim 7, wherein molding said nonelastomeric inner member to said nonelastomeric outer member with said elastomer, includes inhibiting bonding of said elastomer to an elastomeric void section comprising at least twenty five percent of said outer member inner circumference bonding surface.

10. A method as claimed in claim 7, wherein molding said nonelastomeric inner member to said nonelastomeric outer member with said elastomer, includes inhibiting bonding of said elastomer from twenty five to seventy five percent of said outer member inner circumference bonding surface.

11. A method as claimed in claim 7, wherein deforming said nonelastomeric outer ductile member in towards said nonelastomeric inner member includes compressing the elastomer between said inner member outer surface and said elastomeric void section of said nonelastomeric outer ductile member inner surface.

12. A method as claimed in claim 11, wherein compressing the elastomer between said inner member outer surface and said elastomeric void section of said nonelastomeric outer ductile member inner surface, includes compressing the elastomer with a compression strain in the range of one to fifty percent.

13. A method of making a bushing, said method comprising:
providing a nonelastomeric outer member having an inner circumference bonding surface and a center bore, said outer member center bore containing an elastomer and a nonelastomeric inner member having an outer circumference bonding surface with the

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elastomer bonded to said inner member outer circumference bonding surface and to said outer member inner bonding surface with an elastomeric void defined by said elastomer between said inner member and said outer member, deforming said nonelastomeric outer member in towards said nonelastomeric inner member wherein said elastomeric void is reduced and said nonelastomeric outer member is brought into contact with said elastomer with said elastomer between said inner member and said outer member.

14. A method as claimed in claim 13, wherein said elastomer defines a first elastomeric void and a second elastomeric void.

15. A method as claimed in claim 13, wherein said elastomeric void includes an elastomeric void section comprising at least twenty five percent of said outer member inner circumference bonding surface.

16. A method as claimed in claim 13, wherein said elastomeric void includes an elastomeric void section comprising from twenty five to seventy five percent of said outer member inner circumference bonding surface.

17. A method as claimed in claim 13, wherein deforming said nonelastomeric outer member in towards said nonelastomeric inner member includes compressing the elastomer between said inner member outer surface and said nonelastomeric outer member inner surface.

18. A method as claimed in claim 17, wherein compressing the elastomer between said inner member outer surface and said nonelastomeric outer member inner surface, includes compressing the elastomer with a compression strain in the range of one to fifty percent.

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19. A multiple radial spring rate pivot bushing, said bushing comprising a nonelastomeric inner member having an inner member outer circumference bonding surface and an inner member bore with an inner member center bore axis, said inner member center bore axis offset from an outer circumference center axis of said inner member outer circumference bonding surface, an elastomer bonded to the inner member outer circumference bonding surface, and a ductile nonelastomeric outer member having an inner circumference bonding surface and an outer member center bore with an outer member center bore axis, said outer member center bore axis centered with an inner circumference center axis of said outer member inner circumference bonding surface, said ductile nonelastomeric outer member inner circumference bonding surface having an elastomeric void section, said ductile nonelastomeric outer member containing said elastomer and said inner member with said elastomer bonded to said outer member inner circumference bonding surface except at said elastomeric void section, said ductile nonelastomeric outer member having a deformed reduced diameter wherein said ductile nonelastomeric outer member elastomeric void section contacts said elastomer .

20. A bushing preform, said bushing preform comprising a nonelastomeric inner member having an inner member outer circumference bonding surface and an inner member bore with an inner member center bore axis, said inner member center bore axis offset from an outer circumference center axis of said inner member outer circumference bonding surface,
 an elastomer bonded to the inner member outer circumference bonding surface,
 and a ductile nonelastomeric outer member having an inner circumference bonding surface and an outer member center bore with an outer member center bore axis, said outer member center bore axis centered with an inner circumference center axis of said outer member inner circumference bonding surface,
 said ductile nonelastomeric outer member containing said elastomer and said inner member with said elastomer bonded to said outer member inner circumference bonding surface, said contained elastomer defining an elastomeric void between said inner member and said outer member, wherein said elastomeric void is removed by deforming

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the ductile nonelastomeric outer member of the bushing preform to a reduced bushing diameter to provide a multiple spring rate bushing .

FIG. 1

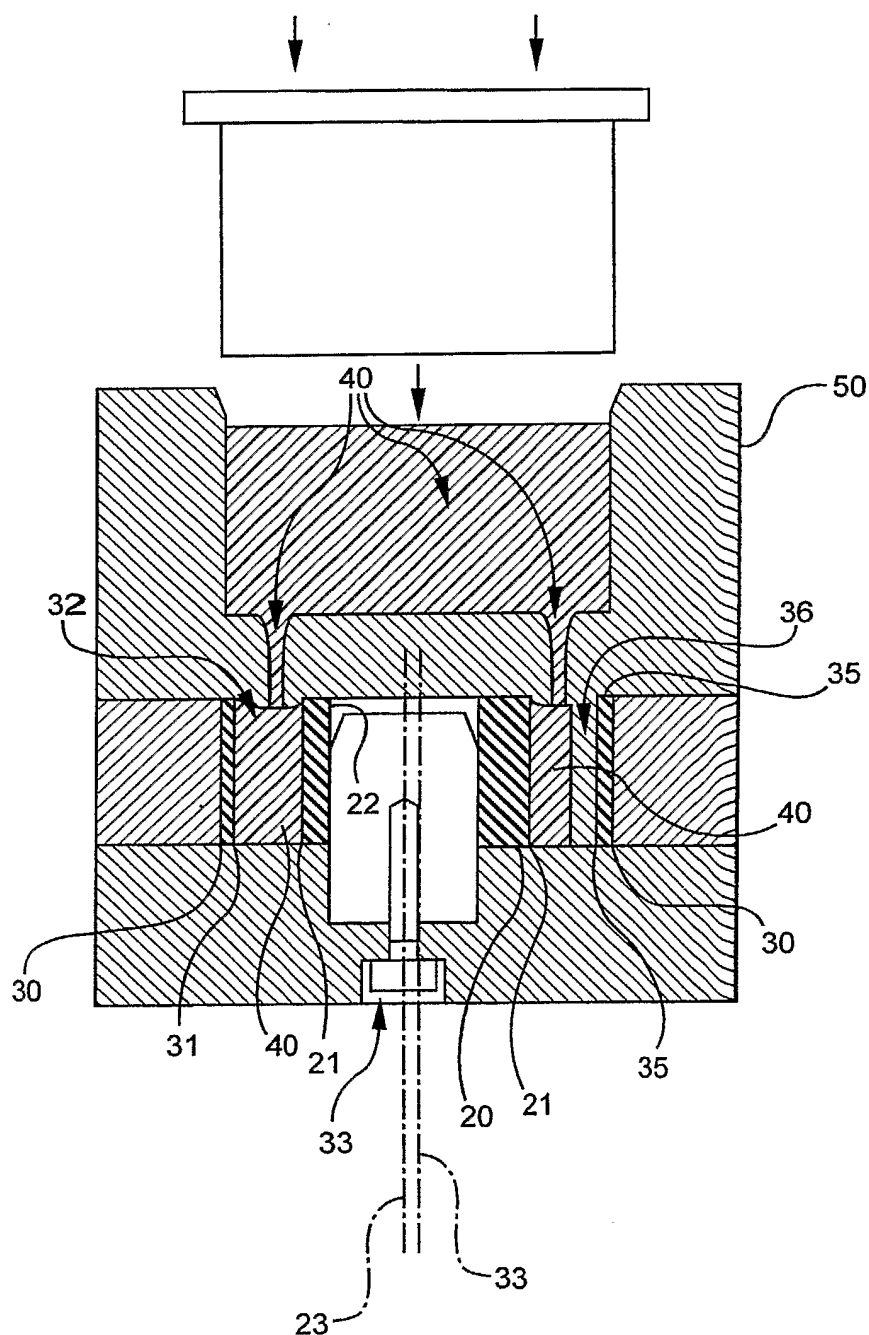


FIG. 2

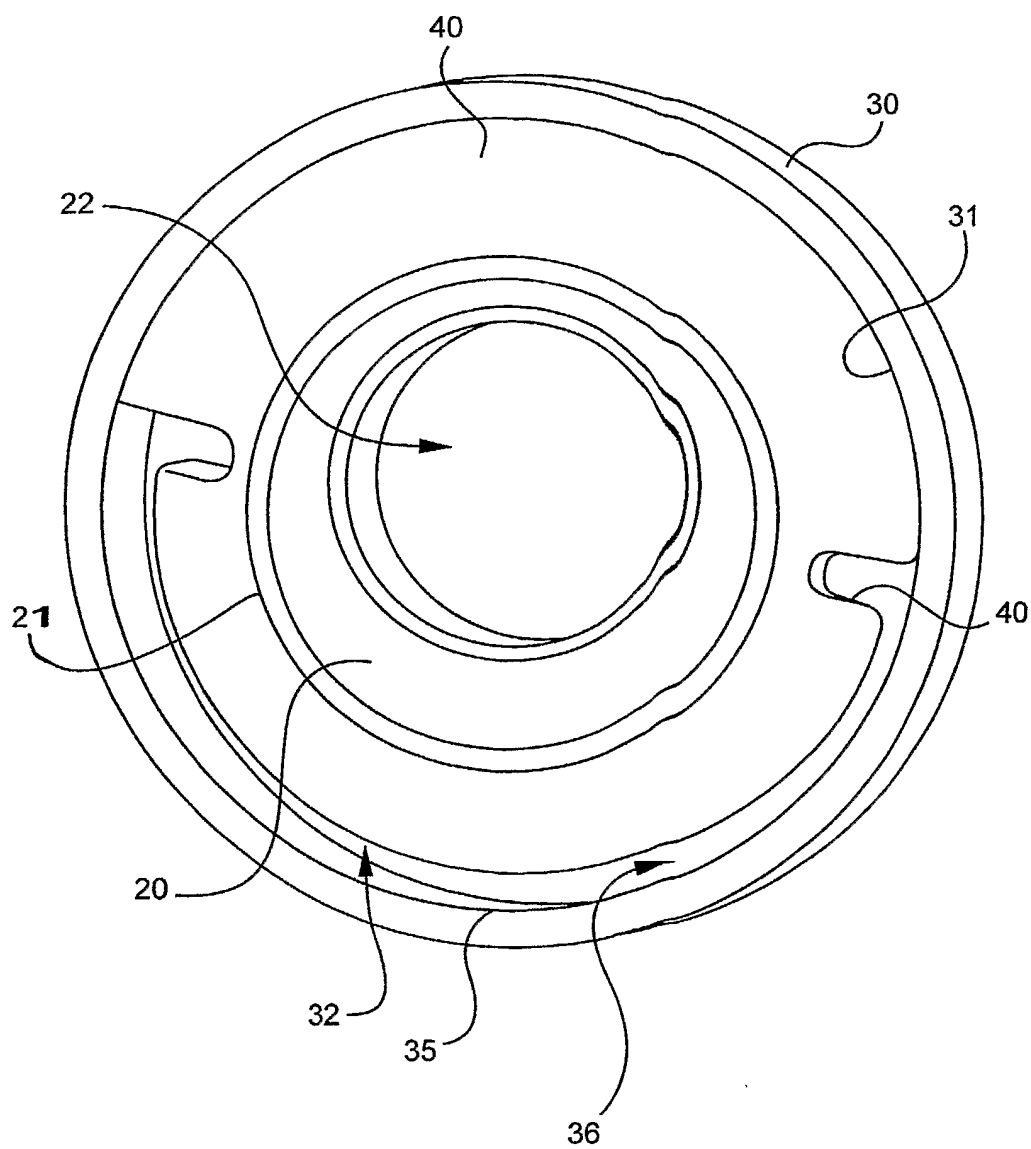


FIG. 3A

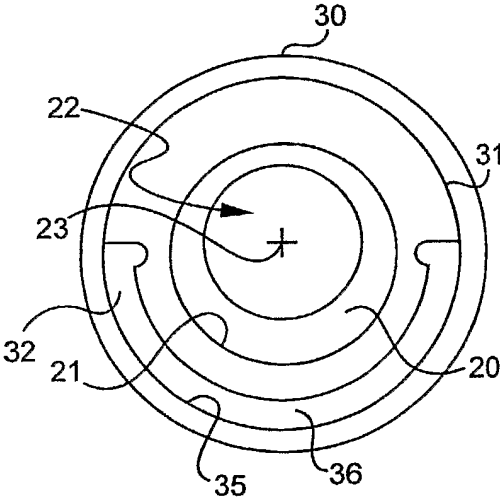


FIG. 3B

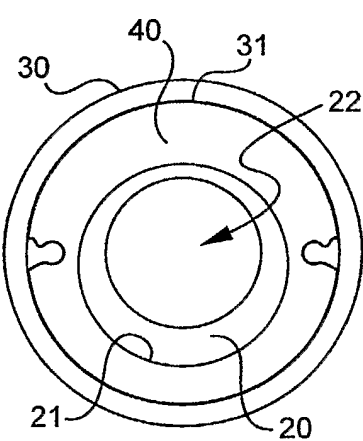


FIG. 3C

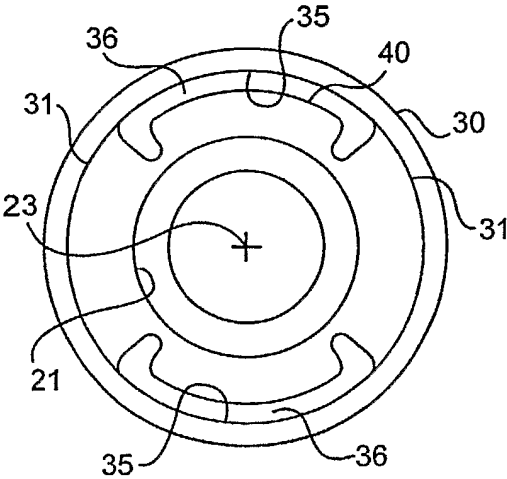
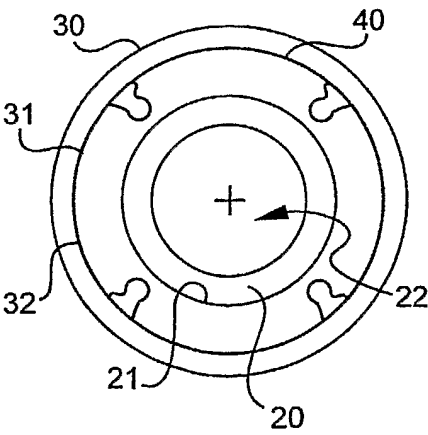


FIG. 3D



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FIG. 4

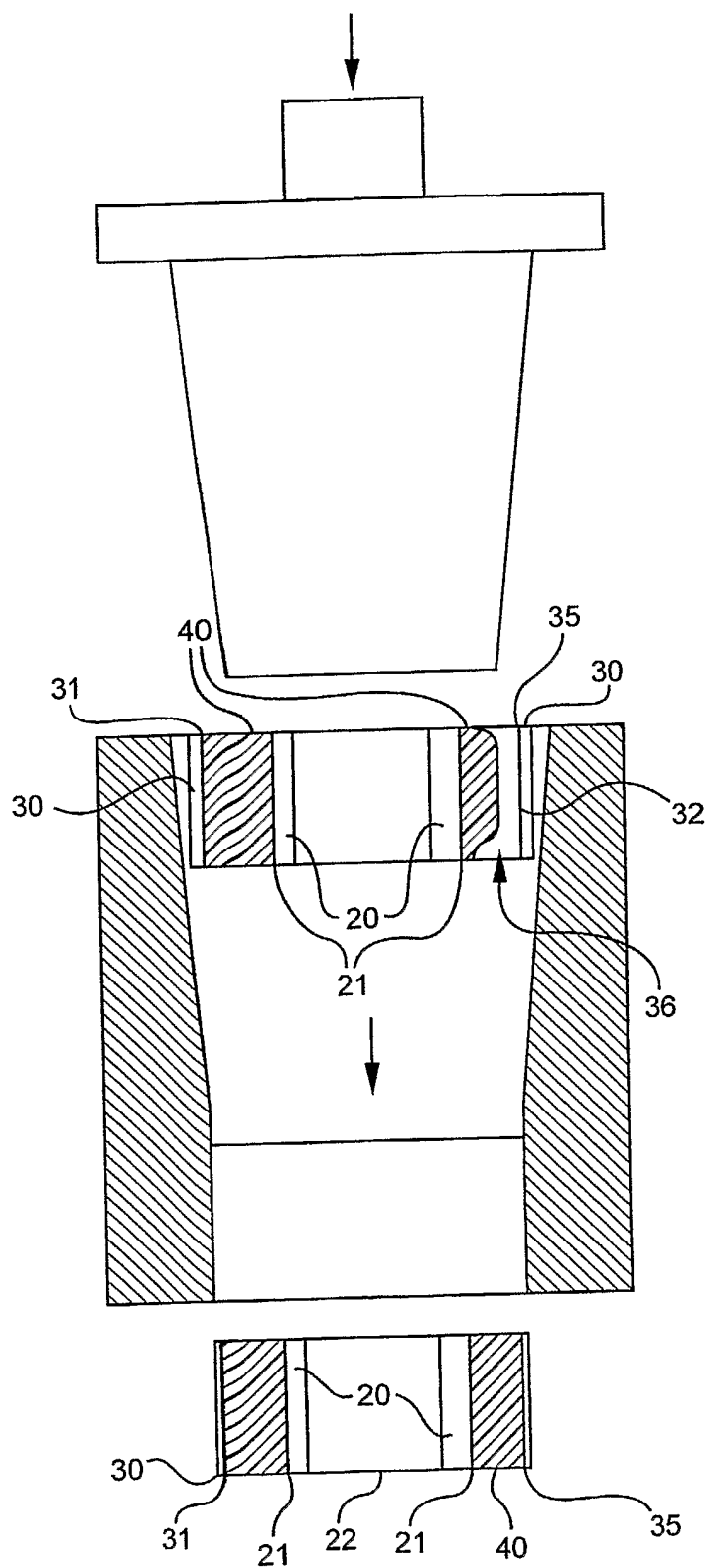


FIG. 5A

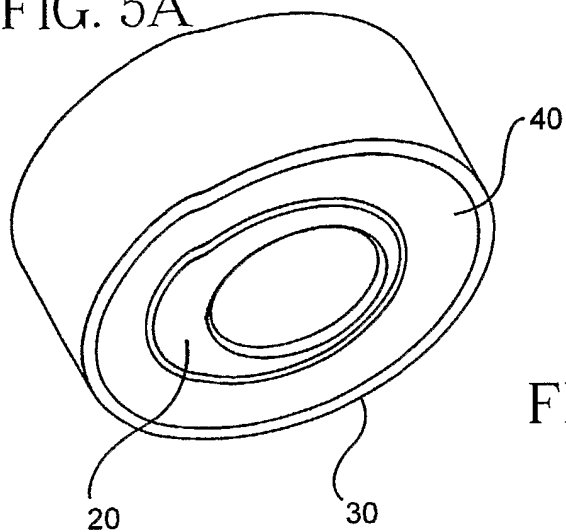


FIG. 5B

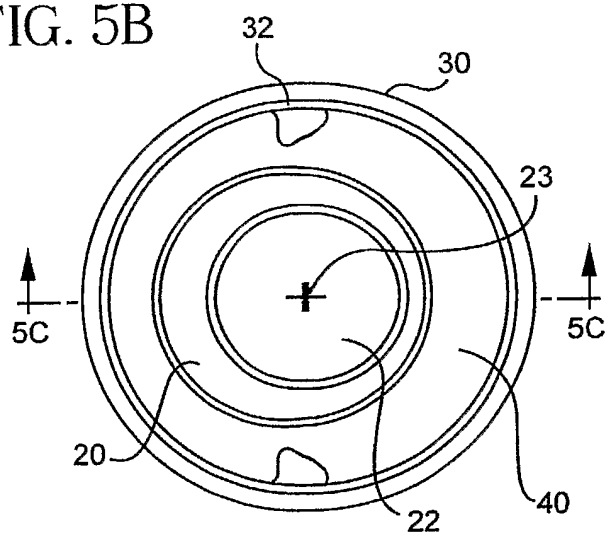


FIG. 5C

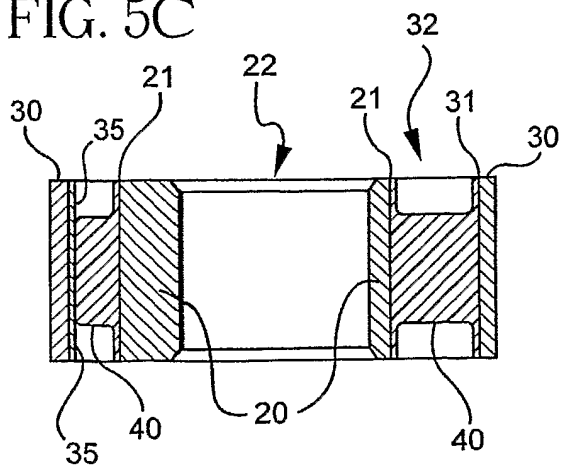


FIG. 5D

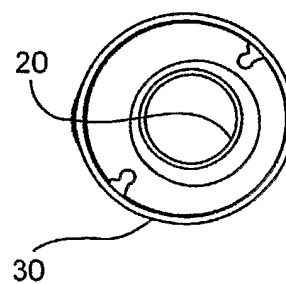


FIG. 6A

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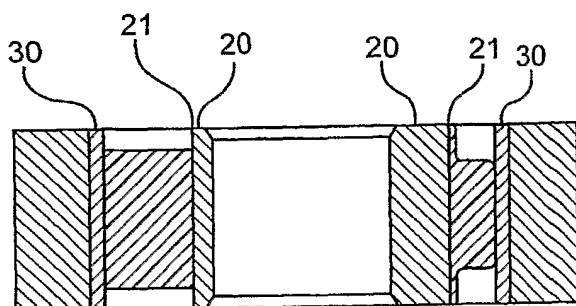


FIG. 6A

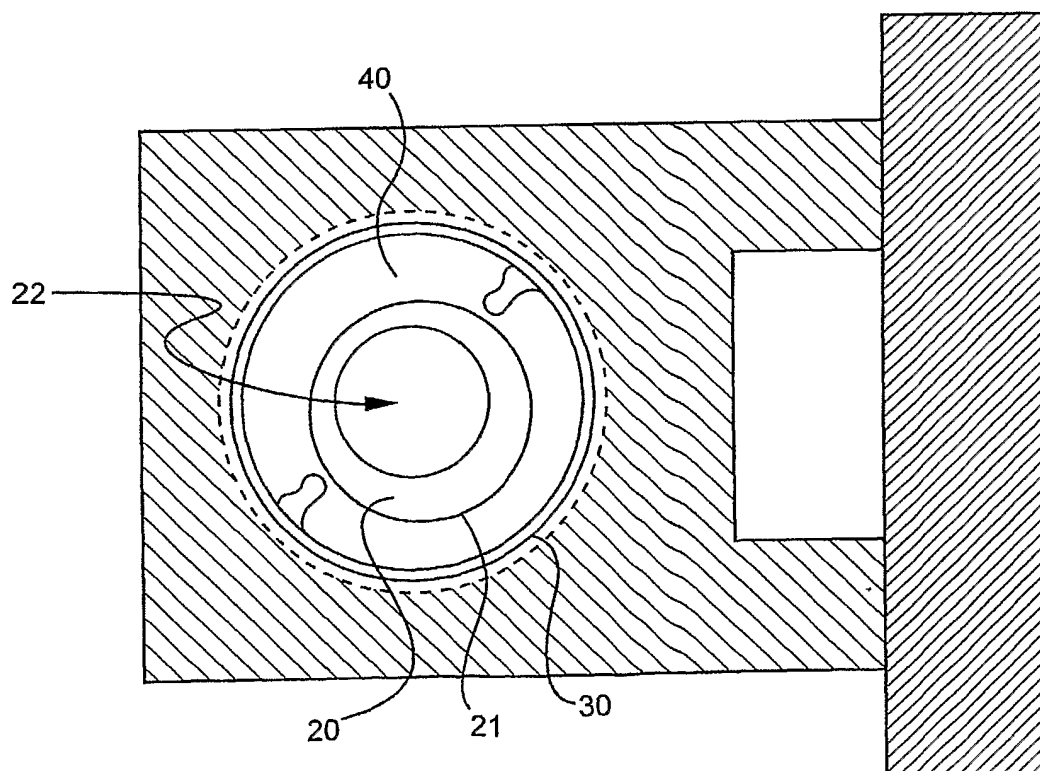


FIG. 7A

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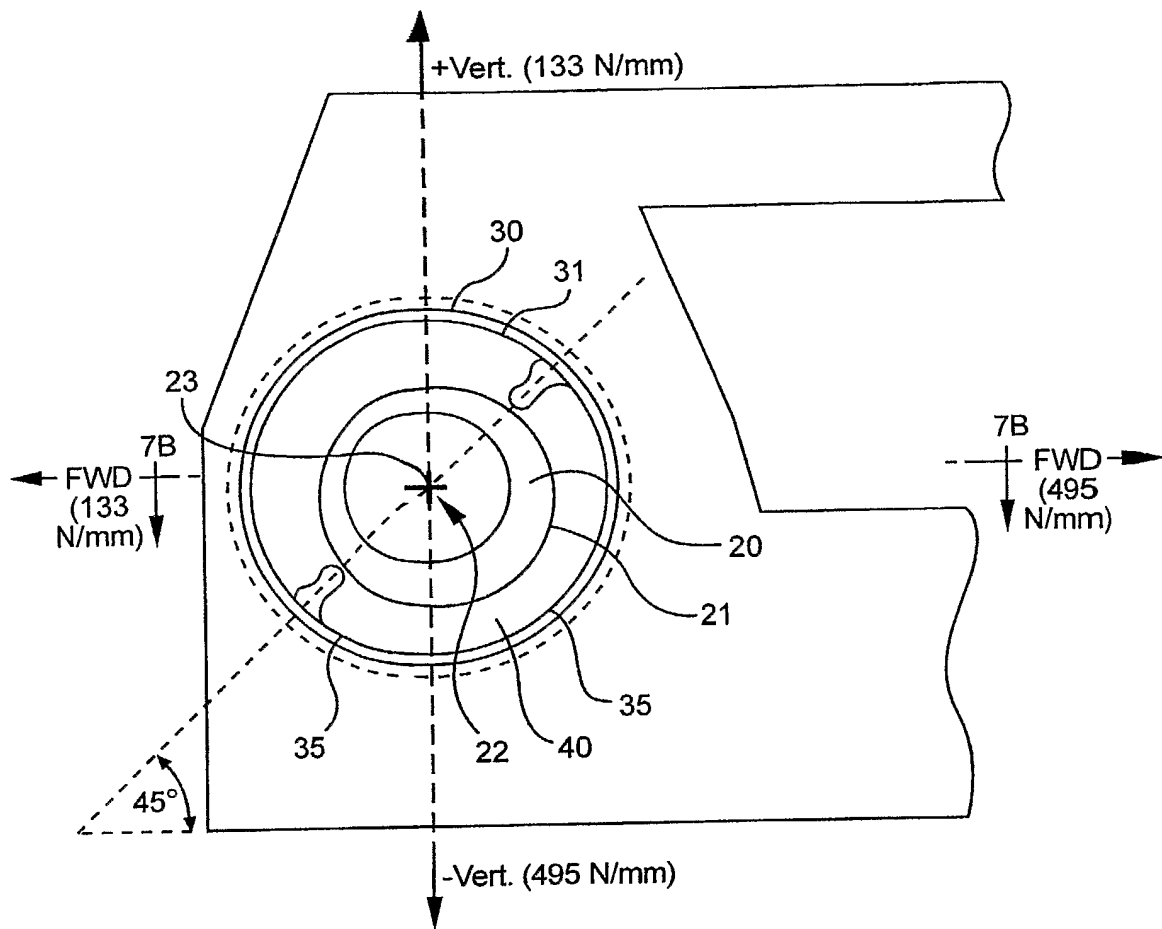
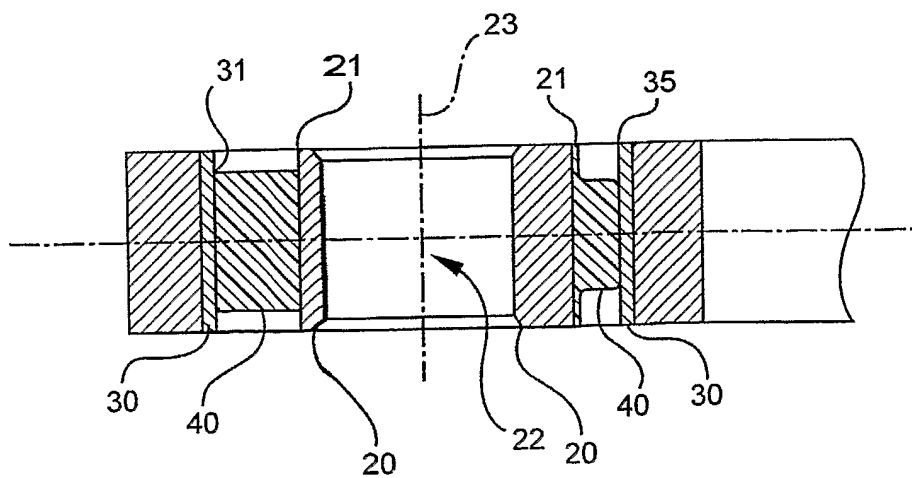


FIG. 7B



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INTERNATIONAL SEARCH REPORT

International application No

 /US2005/038219

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