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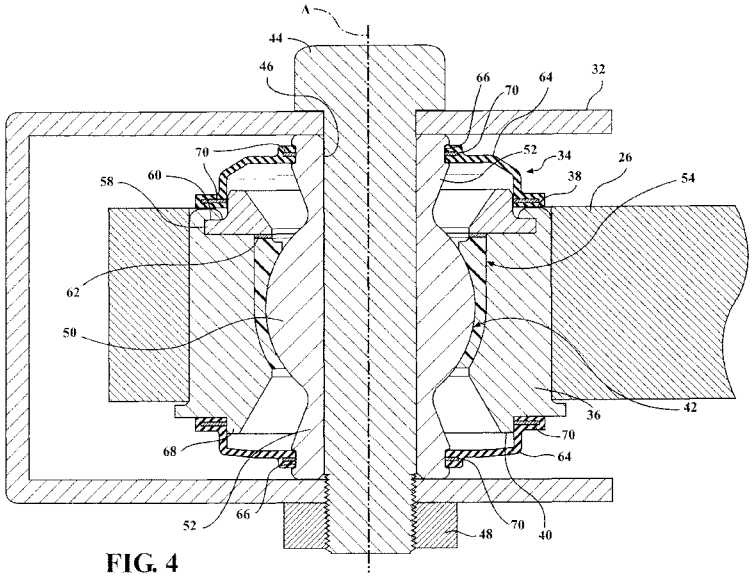

FIG. 4

(57) Abstract: A control arm for a vehicle suspension is provided. The control arm includes a control arm body having a connector for attachment to a wheel assembly, a horizontal bushing for coupling the control arm with a vehicle frame and a vertical socket for also coupling the control arm with a vehicle frame. The vertical socket has a housing which is press fit into an opening of the control arm body and a stud which extends through the housing for engagement with the vehicle frame. A bearing is positioned within the housing between the housing and the stud. The stud has a rounded outer surface, and the bearing has a rounded inner surface for allowing rotational movement of the bearing and housing relative to the stud. A retainer member is in engagement with the housing and the bearing for retaining the bearing in the inner bore of the housing.

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ASSEMBLY OF A BALL JOINT AND A TRIANGULAR SUSPENSION ARM

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of application serial number 61/656,094 filed on June 4, 2012.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] This invention relates generally to control arms and to methods of making the same.

2. Related Art

[0003] Many automotive vehicles today employ suspension systems commonly known as MacPherson strut systems or double-wishbone systems. Such systems typically include a lower control arm (also referred to as an A-arm) which pivots relative to the vehicle's frame to allow a wheel and tire to move upwardly and downwardly relative to the frame during cornering or in response to encountering an object, such as a pot hole in the road.

[0004] A lower control arm **10** for a Macpherson strut type of suspension system is generally shown in Figure 1. The lower control arm **10** includes a ball joint **12** for connection with a steering knuckle (not shown) of a hub assembly and a pair of bushings **14, 16** for guiding the pivoting movement of the lower control arm **10** relative to the vehicle's frame (not shown). One of the bushings is a horizontal bushing **14** which is configured to pivot relative to the vehicle frame about longitudinally extending bolt (not shown). The other bushing **16** is a vertical bushing which is configured to pivot relative to the vehicle frame about a vertically extending bolt (not shown).

[0005] Referring now to Figures 2A-C, an conventional vertical bushing **16** is generally shown. As best shown in Figure 2C, the conventional vertical bushing **16** has an outer metallic sleeve **18**, which is press fit into an opening in the lower control arm **10**, a rubber cushion **20** and an inner metallic sleeve **22**. The rubber cushion **20** extends radially between and interconnects the outer and inner metallic sleeves **18, 22**. In operation, the inner metallic sleeve **22** pivots or twists relative to the outer metallic sleeve **18** during movement of the vehicle suspension, such as when the vehicle encounters a pot hole in the road. The rubber cushion **20** deforms elastically to allow the pivoting movement between these sleeves **18, 22** and absorbs/deforms due to a radial load. As such, during operation of the vehicle, the rubber cushion **20** is exposed to both a radial load and a twisting load motion. Exposure to the radial load and twisting motion leads to deterioration in the rubber cushion **20**, thereby reducing the life of the vertical bushing **16**.

SUMMARY OF THE INVENTION

[0006] An aspect of the present invention provides for an improved control arm for a vehicle suspension which will have improved durability and provides a longer life than other known control arms. The control arm includes a control arm body with a connector for attachment to a wheel assembly a horizontal bushing that extends in a longitudinal direction for coupling the control arm body with a vehicle frame and a vertical socket that extends in a vertical direction for also coupling the control arm body with a vehicle frame. A housing is press fit into an opening in the control arm body. The housing extends along a vertical axis between first and second open ends and has an inner bore which extends between the open ends. A bearing is disposed within the inner bore of the housing, and the bearing has a curved inner surface. A retainer member is in engagement with the housing and the bearing and retains the bearing within the inner bore of the housing. A stud extends through the inner bore of the housing and past the open first and second ends for

engaging the vehicle frame on opposite sides of the housing. The stud has a curved outer surface which is in sliding engagement with the curved inner surface of the bearing for allowing rotational movement of the housing and the control arm body relative to the stud and the vehicle frame. In operation, rotational movement of the housing and control arm body relative to the stud does little to no damage to the vertical socket, thus providing the control arm with improved durability and operating life.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other features and advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0008] Figure 1 is a perspective elevation view of an conventional control arm with a conventional vertical bushing;

[0009] Figure 2A is a perspective view of the conventional vertical bushing of Figure 1;

[0010] Figure 2B is a top view of the conventional vertical bushing of Figure 1;

[0011] Figure 2C is a cross-sectional side view of the conventional vertical bushing of Figure 1;

[0012] Figure 3 is a perspective elevation view of a control arm including a first exemplary embodiment of a vertical socket;

[0013] Figure 4 is a cross-sectional view of the first exemplary embodiment of the vertical socket coupled to a vehicle frame and a control arm body;

[0014] Figure 5 is another cross-sectional view of the first exemplary embodiment of the vertical socket and illustrating the control arm body being pivoted or twisted in one direction;

[0015] Figure 6 is yet another cross-sectional view of the first exemplary embodiment of the vertical socket and illustrating the control arm body being pivoted or twisted in an opposite direction;

[0016] Figure 7 is an exploded view of the first exemplary embodiment of the vertical socket

[0017] Figure 8 is a chart illustrating the performance of the first exemplary embodiment in comparison to a conventional vertical bushing;

[0018] Figure 9 is a cross-sectional view of a second exemplary embodiment of the vertical socket;

[0019] Figure 10 is a cross-sectional view of a second exemplary embodiment of the vertical socket; and

[0020] Figure 11 is a cross-sectional view of a third exemplary embodiment of the vertical socket.

DESCRIPTION OF THE ENABLING EMBODIMENT

[0021] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, an exemplary control arm **24** for use in a vehicle suspension is generally shown in Figure 3. The control arm **24** is configured for use in a range of different types of vehicle suspensions including, for example, MacPherson strut suspensions or double wishbone suspensions. The exemplary control arm **24** includes a control arm body **26**, a connector **28** (such as a ball joint) for attachment to a wheel assembly (not shown); a horizontal bushing **30** which extends in a longitudinal direction for joining the control arm body **26** with a vehicle frame **32** (shown in Figure 4); and a vertical socket **34**

which extends in a vertical direction for also joining the control arm body **26** with the vehicle frame **32**. Referring to Figures 4-6, during operation of the vehicle suspension, the vertical socket **34** and the horizontal bushing **30** (shown in Figure 3) allow the control arm body **26** to rotate relative to the vehicle frame **32** when, for example, the wheel assembly encounters a pot hole or an obstacle in the road to maintain a tire on the wheel assembly in engagement with the road and also to provide a more comfortable ride for any passengers within the vehicle.

[0022] Referring still to Figures 4-6, a first exemplary embodiment of the vertical socket **34** is shown in engagement with a control arm body **26** and a vehicle frame **32**. The exemplary vertical socket **34** includes a housing **36** which is press fit into an opening in the control arm body **26**. The housing **36** could be of any desirable metal including, for example, steel or an aluminum alloy. The housing **36** has an inner bore that extends along a vertical axis **A** between an open upper end **38** and an open lower end **40**. The vertical socket **34** also includes a stud **42** which extends axially through the inner bore of the housing **36** and past the housing's **36** upper and lower ends **40**. As shown, the stud **42** is in engagement with the vehicle frame **32** both above and below the housing **36**. More precisely, in the first exemplary embodiment, the stud **42** is joined with the vehicle frame **32** through a bolt **44** which extends through an axially extending passage **46** in the stud **42** and a nut **48**, which is joined to the bolt **44**. However, it should be appreciated that the stud **42** could alternately be attached with the frame **32** through any suitable fastening means. During normal operation of the suspension system, the bolt **44** fixes the stud **42** relative to the vehicle frame **32** while the control arm body **26** and the metal housing **36** pivot upwardly and downwardly relative to the frame **32** and the stud **42**. This movement of the control arm body **26** and the metal housing **36** is depicted in Figures 5 and 6. The stud **42** may be formed of any suitable metal, such as heat treated (for improved wear resistance) SAE alloy steel.

[0023] The exemplary stud **42** includes a rounded central portion **50** and a pair of generally frustoconical end portions **52** disposed on either axial side of the rounded central portion **50**. The outer surface of the rounded central portion **50** is generally semi-spherically shaped. A bearing **54** is disposed within the inner bore of the housing **36** and slidably engages rounded central portion **50** of the stud **42** to permit the rotational movement of the housing **36** and the control arm body **26** relative to the stud **42**. Specifically, the bearing **54** has a curved inner surface with a curvature that generally matches the curvature on the central portion **50** of the stud **42** to provide a slidable interface between these components. The bearing **54** may be formed of a metal, a carbon fiber polymer, an engineering polymer or any suitable material that provides a low friction interface between the stud **42** and the bearing **54**. Grease, or any other lubricant, may also be included in the inner bore of the housing **36** to further reduce friction between the stud **42** and bearing **54**.

[0024] In the first exemplary embodiment of the vertical socket **34**, the bearing **54** is a one piece snap over bearing **54** and engages the curved middle portion of the stud **42** both vertically above and below its equator. As best shown in Figure 7, the bearing **54** of the first exemplary embodiment includes a plurality of slots **56** which allow the bearing **54** to be snapped onto the rounded central portion **50** of the stud **42**. The slots **56** also function as channels for carrying grease to lubricate the contact surface between the stud **42** and the bearing **54**.

[0025] Referring back to Figures 4-6, the vertical socket **34** of the first exemplary embodiment additionally includes a retainer member **58**, or a cover plate, which is disposed adjacent the upper open end **38** of the housing **36** and retains the bearing **54** within the inner bore of the housing **36**. Specifically, in the first exemplary embodiment of the vertical socket **34**, the bearing **54** is trapped on one axial side by a curved feature in the housing **36** itself and on the other axial side by the retainer member **58**. A projection **60** on

the housing **36** is bent inwardly to engage a flange on the retainer member **58**, thereby holding the retainer member **58** and the bearing **54** within the inner bore of the housing **36**. It should be appreciated that the retainer member **58** could be engaged with the housing **36** through any suitable connection including, for example, spinning, crimping or a threaded connection.

[0026] In the first exemplary embodiment, a spring **62** is disposed axially between the retainer member **58** and the bearing **54** to bias the bearing **54** towards the lower end **40** of the housing **36**. The spring **62** is preferably a Belleville washer **62** (also known as a washer spring **62**) but any suitable type of spring **62** may alternately be employed including, for example, an O-ring or a rubber cushion. The spring **62** allows for improved tolerances during the manufacture and assembly of the vertical socket **34**.

[0027] The retainer member **58** and the open lower end **40** of the housing **36**, which is the end that is opposite of the retainer member **58**, are both chamfered so that the openings on each end of the inner bore are generally frustoconically shaped. The frustoconical end portions **52** of the stud **42** and the chamfered surfaces on the housing **36** and retainer member **58** allows for the pivotal movement of the housing **36** and the control arm body **26** relative to the stud **42** and the vehicle frame **32**.

[0028] The first exemplary embodiment of the vertical socket **34** further includes a pair of boots **64** of an elastomeric material. One of the boots **64** is sealed against a groove **66** located adjacent one end of the stud **42** and an axially extending flange **68** at the lower end **40** of the housing **36**. The other boot **64** is sealed against a groove **66** on the opposite end of the stud **42** and an outer surface of the retainer member **58**. Each boot **64** has a pair of metal inserts **70** overmolded at least partially within it for establishing press-fit engagements against the respective components to which it is sealed. The boots **64** maintain the grease or lubricant in contact with the rounded central portion **50** of the stud **42** and the

bearing **54** and also keep debris and other contaminants away from the internal components of the vertical socket **34**.

[0029] In operation, rotational movement and radial loading of the housing **36** relative to the stud **42** does little or no damage to the vertical socket **34**, thus providing the vertical socket **34** with improved durability and operating life as compared to other known vertical bushings. The first exemplary embodiment of the vertical socket **34** has been found to last approximately 10 times longer than conventional vertical socket with little to no loss in performance. For example, the test results shown in Figure 8 illustrate that the vertical socket **34** of the first exemplary embodiment may provide exceptional operational performance for one million cycles or more without failure, whereas the conventional vertical bushing of Figures 1 and 2A-C typically fails at around 100,000 cycles. The vertical socket **34** also allows for the transfer of radial forces from the control arm body **26** to the vehicle frame **32**.

[0030] To assemble the first exemplary embodiment of the vertical socket **34**, the bearing **54** is preferably engaged with the rounded central portion **50** of the stud **42** first, and then these components are inserted into the inner bore of the housing **36**. Then, with the bearing **54** in place, then a Belleville washer **62** positioned on an upper surface of the bearing **54**. Next, the retainer member **58** is positioned on top of the Belleville washer **62** such that the Belleville washer **62** is sandwiched axially between the retainer member **58** and the bearing **54**. The retainer member **58** could alternately be placed directly on the upper surface of the bearing **54** if no Belleville washer **62** is included. A projection **60** on the housing **36** is then bent, or mechanically deformed, radially inwardly to secure the retainer member **58**, Belleville washer **62** (if included) and bearing **54** all within the inner bore of the housing **36**. The boots **64** are then sealed against their respective components. The vertical socket **34** may

then be press fit into an opening of a control arm body **26** and attached to a vehicle frame **32** and a wheel assembly.

[0031] A second exemplary embodiment of the vertical socket **134** is generally shown in Figure 9 with like numerals, separated by a factor of **100**, being used to show features corresponding to the first exemplary embodiment discussed above. The second exemplary embodiment is similar to the first exemplary embodiment of the vertical socket **34** discussed above but lacks the Belleville washer **62**. Rather, in the second exemplary embodiment, the retainer member **158** is engaged directly with the upper surface of the bearing **142**.

[0032] A third exemplary embodiment of the vertical socket **234** is generally shown in Figure 10 with like numerals, separated by a factor of **200**, being used to show features corresponding to the first exemplary embodiment discussed above. In this exemplary embodiment, a rubber cushion **272** which has a generally cylindrical shape is disposed about and substantially encircles the metal housing **236**, and an outer shell **274** substantially encircles the rubber cushion **272**. As such, in the third exemplary embodiment, the outer shell **274** is the radially outer-most component of the vertical socket **234**. The outer shell **274** is sized to be press fit into an opening in a control arm body (such as the control arm body **26** of Figure 3). In operation, the rubber cushion **272** absorbs radial forces between the control arm body and the vehicle frame. One end of each of the boots **264** is engagement with a groove **266** in the stud **242** and the other end of each boot **264** is sandwiched between a lip on the outer shell **274** and the rubber cushion **272**. Additionally, the outer shell **274** includes a bead **276** formed therein which functions as a stopping point when inserting the vertical socket **234** into an opening in a control arm body. The rubber cushion **272** may be formed of any suitable elastomeric material, such as urethane rubber, and the outer shell **274** may be formed of any suitable metal, such as low carbon 1010 steel.

[0033] A fourth exemplary embodiment of the vertical socket **334** is generally shown in Figure 11 with like numerals, separated by a factor of **300**, being used to show features corresponding to the first exemplary embodiment discussed above. Like the third exemplary embodiment discussed above, the fourth exemplary embodiment includes a rubber cushion **372** and an outer shell **374**. However, in this exemplary embodiment, the bearing **354** only engages an upper area of the curved middle portion **350** on the stud **342**, and the housing **336** has a curved surface which slidably engages a lower area of the curved middle portion **350**. As such, both the bearing **354** and the housing **336** are in sliding contact with the stud **342**. The spring **362** thus applies a pre-load on the bearing **354** which translates that preload to the stud **354**. In this exemplary embodiment, a washer **378** is disposed adjacent one end of the outer shell **374**. Additionally, in this exemplary embodiment, the end portions **352** of the stud **342** are generally cylindrically, non frusto-conically, shaped.

[0034] Obviously, many modifications and variations of the present invention are possible in light of the above teachings and may be practiced otherwise than as specifically described while within the scope of the invention.

CLAIMS

What is claimed is:

1. A control arm for a vehicle suspension, comprising:

a control arm body having a connector for attachment to a wheel assembly and a horizontal bushing that extends in a longitudinal direction for coupling said control arm body with a vehicle frame;

a housing press-fit into an opening in said control arm body, said housing extending along a vertical axis between open first and second ends, and said housing having an inner bore which extends between said open first and second ends;

a bearing disposed within said inner bore of said housing, said bearing having a curved inner surface;

a retainer member in engagement with said bearing and said housing and retaining said bearing within said inner bore of said housing; and

a stud extending through said inner bore of said housing past said open first and second ends for engaging the vehicle frame on opposite sides of said housing, and said stud having a curved outer surface in sliding engagement with said curved inner surface of said bearing for allowing rotational movement of said housing and said control arm body relative to said stud and the vehicle frame.

2. The control arm as set forth in claim 1 further including a spring disposed axially between said bearing and said retainer member.

3. The control arm as set forth in claim 1 wherein one end of said housing is bent radially inwardly to engage said retainer member.

4. The control arm as set forth in claim 1 wherein said curved outer surface on said stud is semi-spherically shaped.

5. The control arm as set forth in claim 1 wherein said stud has a passage extending axially therethrough to receive a fastener for coupling said stud with the vehicle frame.

6. The control arm as set forth in claim 5 wherein said fastener is a bolt.

7. The control arm as set forth in claim 1 wherein said housing is of metal.

8. The control arm as set forth in claim 1 further including a cushion of an elastomeric material substantially circumferentially surrounding said metal housing and a metal shell substantially circumferentially surrounding said rubber cushion.

9. The control arm as set forth in claim 1 wherein said retainer member is chamfered on a side opposite of said bearing for promoting said rotational movement of said housing relative to said stud and wherein the one of said open ends of said housing opposite of said retainer member is chamfered for further promoting said rotational movement of said housing relative to said stud.

10. The control arm as set forth in claim 1 wherein said housing has an inner surface that is at least partially curved and in sliding contact with said curved outer surface of said stud.

11. A method of making a control arm for a vehicle suspension, comprising:

slidably coupling a curved inner surface of a bearing with a curved outer surface of an axially extending stud to allow rotational movement of the bearing relative to the stud;

positioning the bearing in an inner bore of a housing having axially spaced open ends such that the stud extends past the housing through the opposite open ends to allow rotational movement of the housing relative to the stud;

engaging a retainer member with the housing and the bearing to retain the bearing within the inner bore of the housing; and

press fitting the housing into an opening in a control arm body to allow rotational movement of the control arm body relative to the stud.

12. The method as set forth in claim 11 further including the step of positioning a spring in the inner bore of the housing between the bearing and the retainer member.

13. The method as set forth in claim 11 further including the step of deforming a portion of the housing to engage the retainer member.

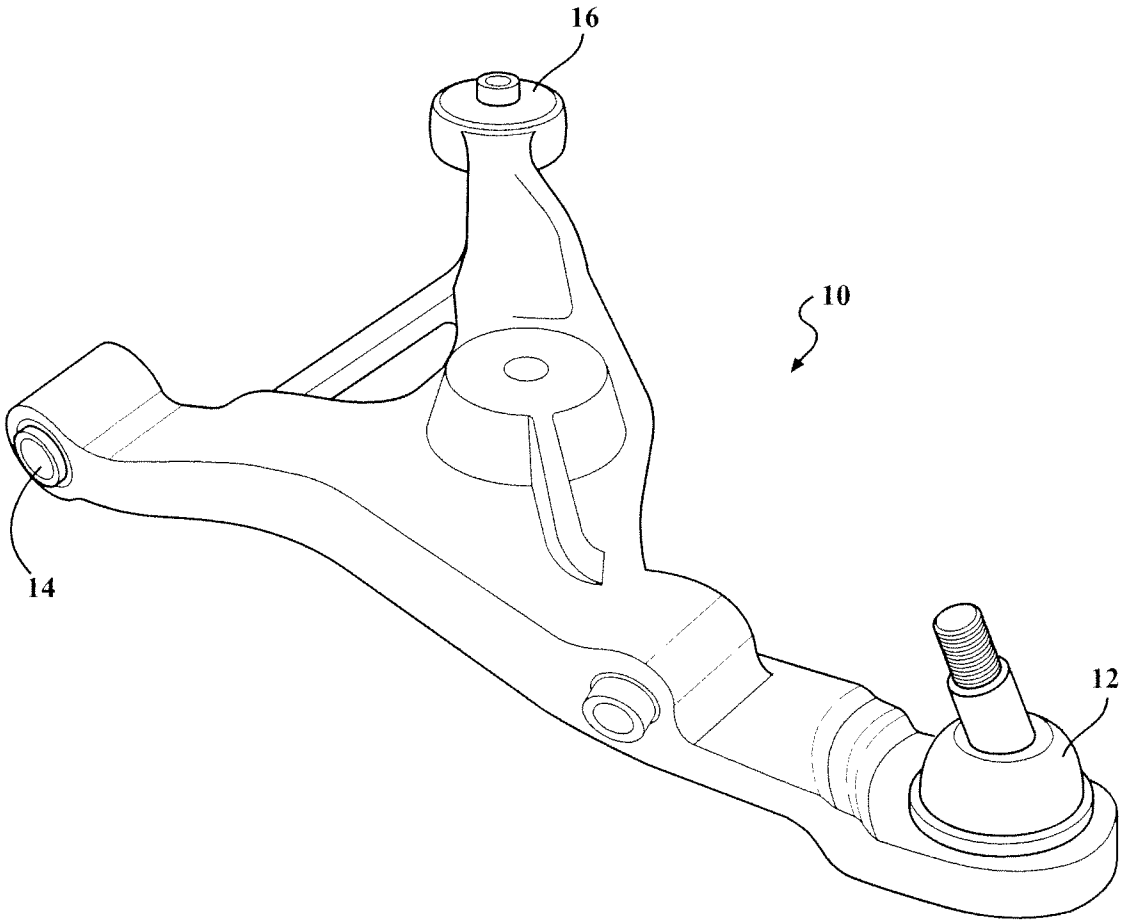

FIG. 1
PRIOR ART

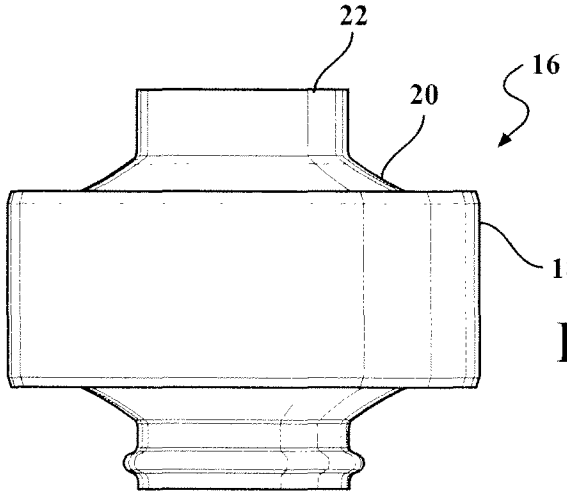

FIG. 2A
PRIOR ART

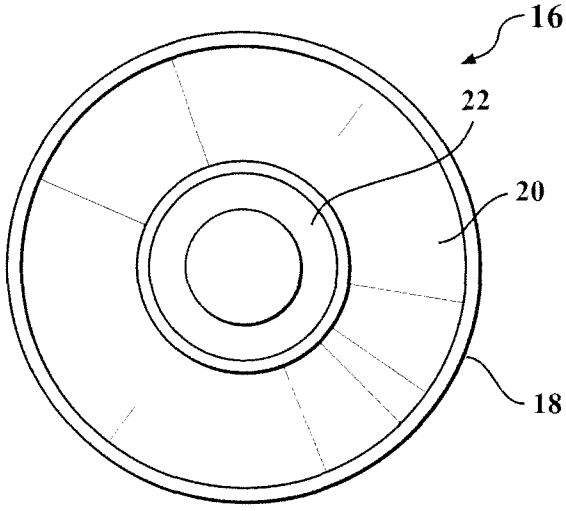

FIG. 2B
PRIOR ART

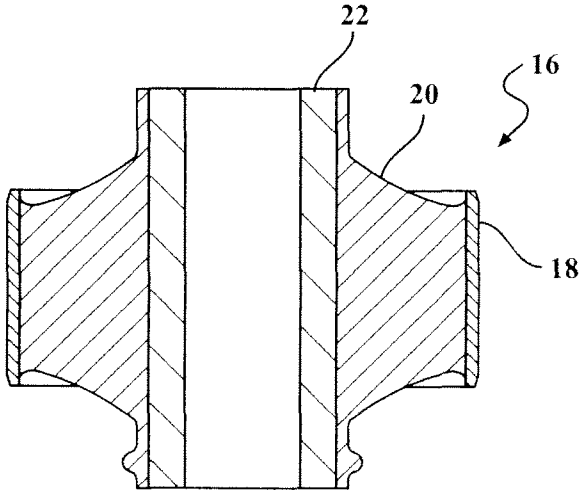

FIG. 2C
PRIOR ART

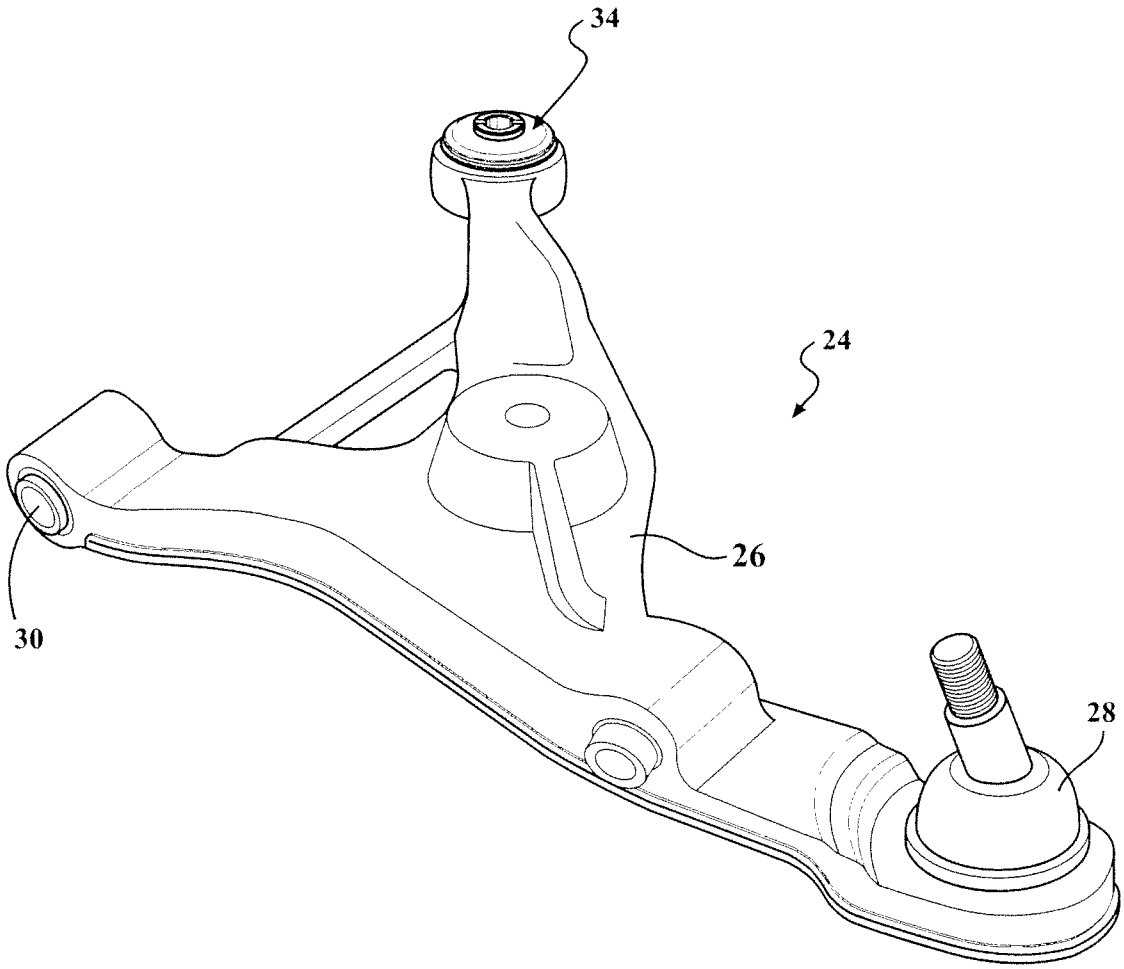

FIG. 3

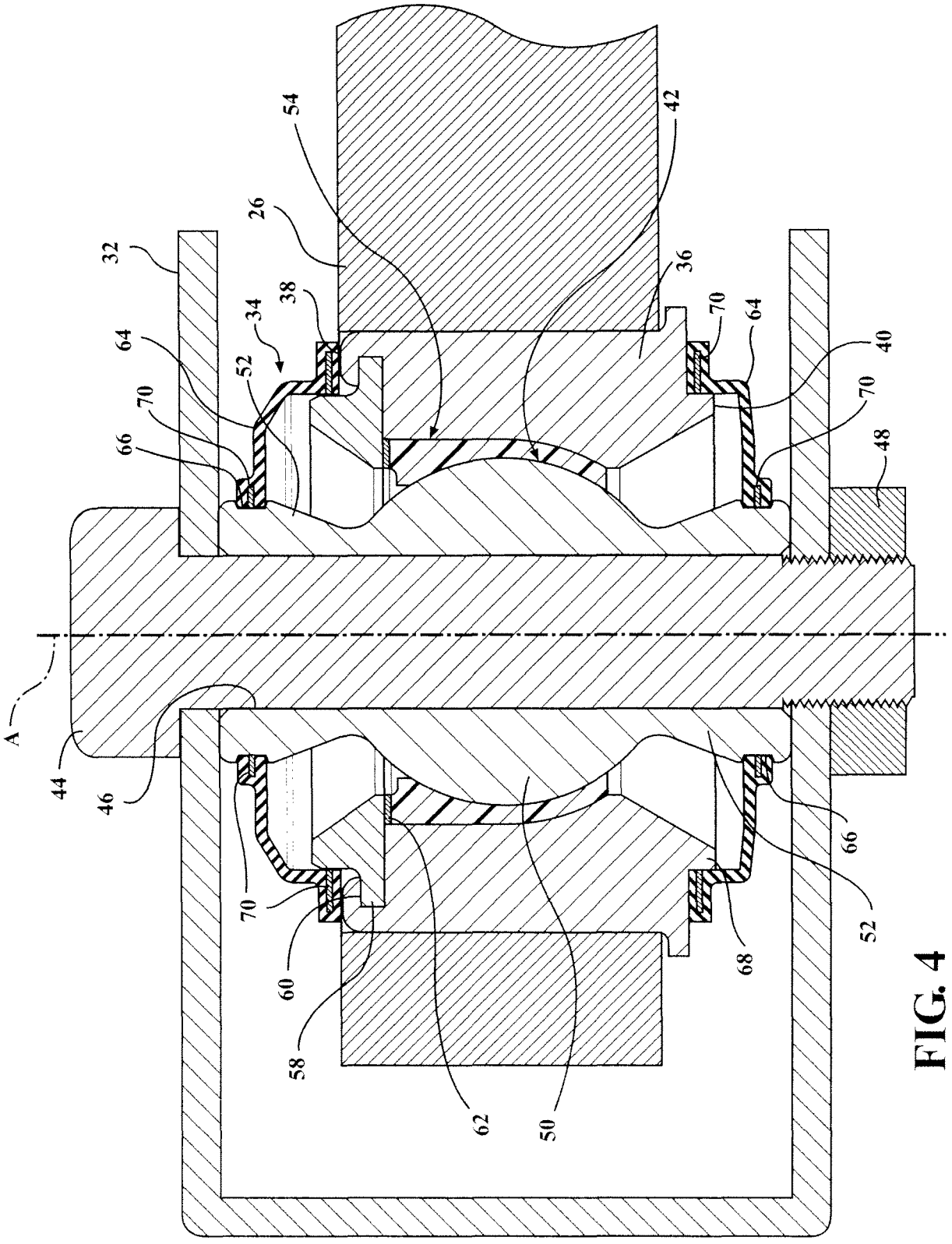
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FIG. 4

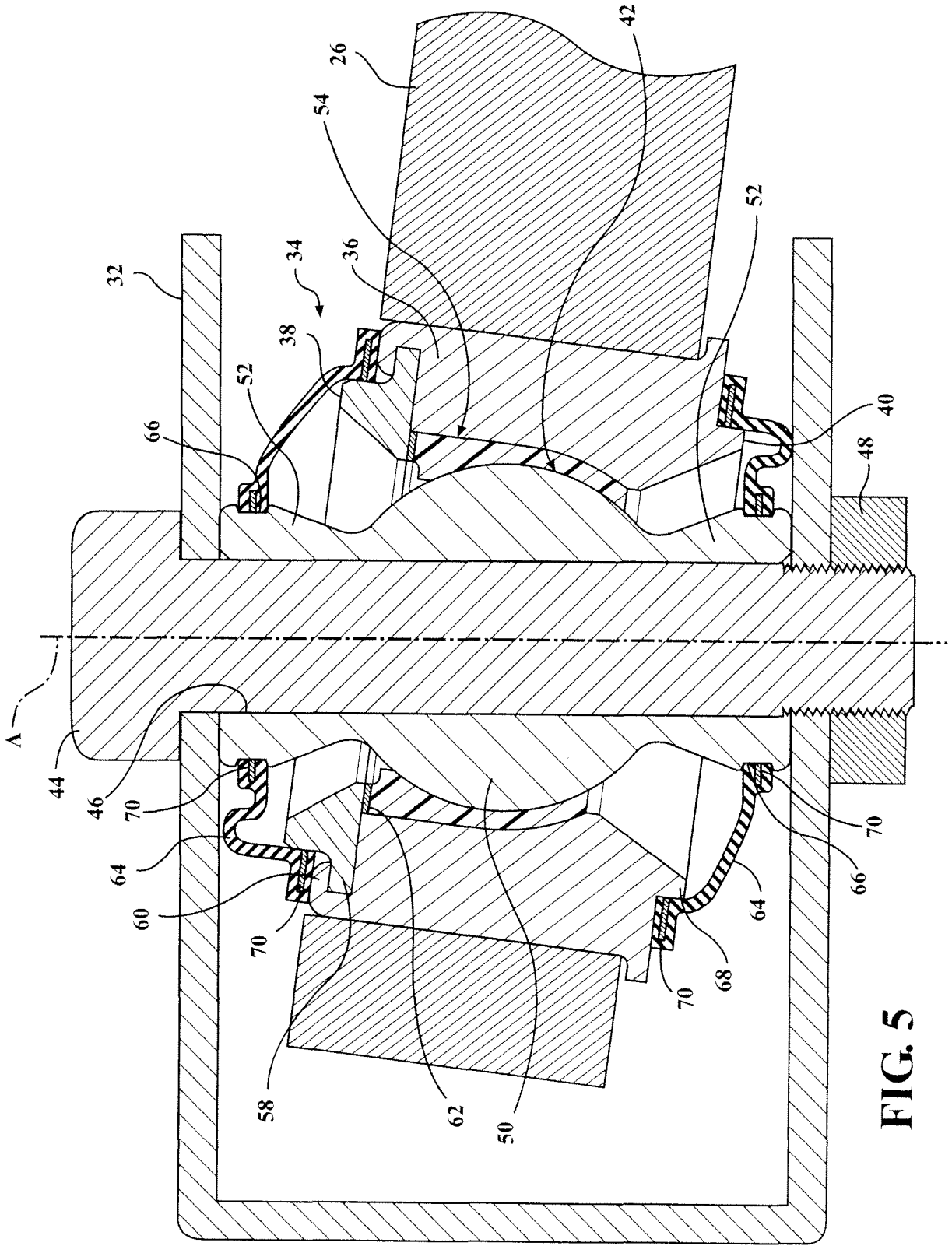
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FIG. 5

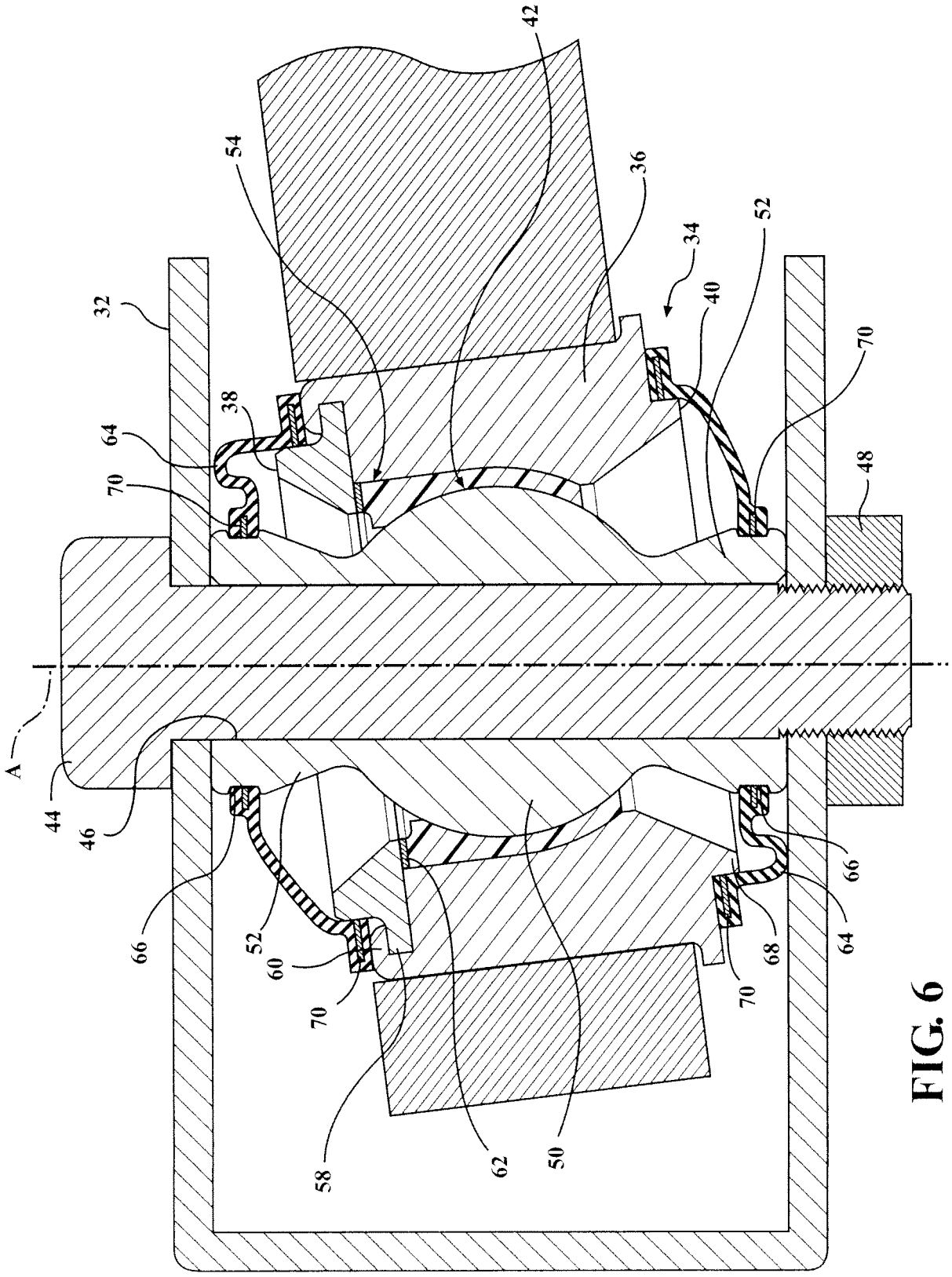
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FIG. 6

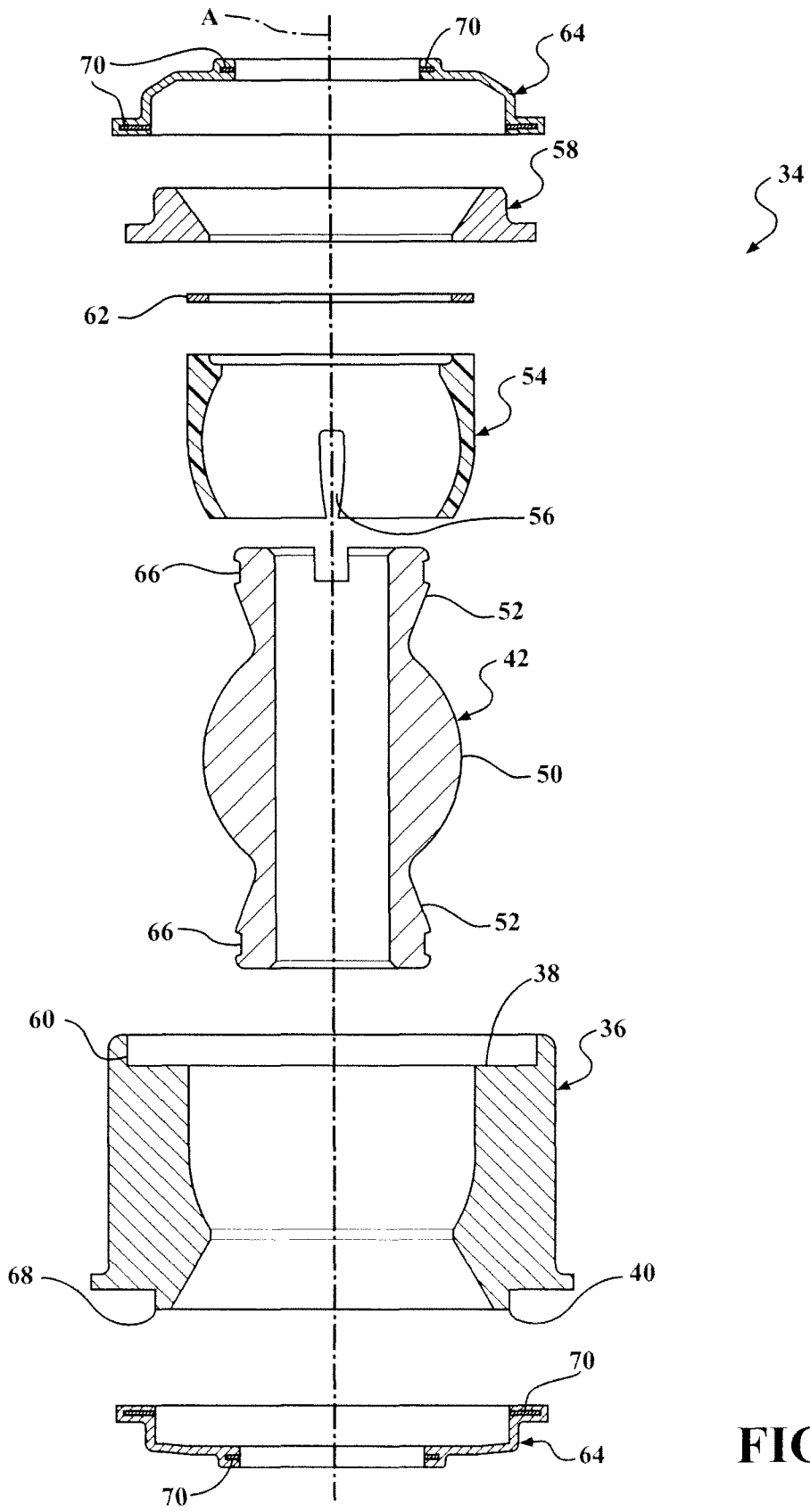
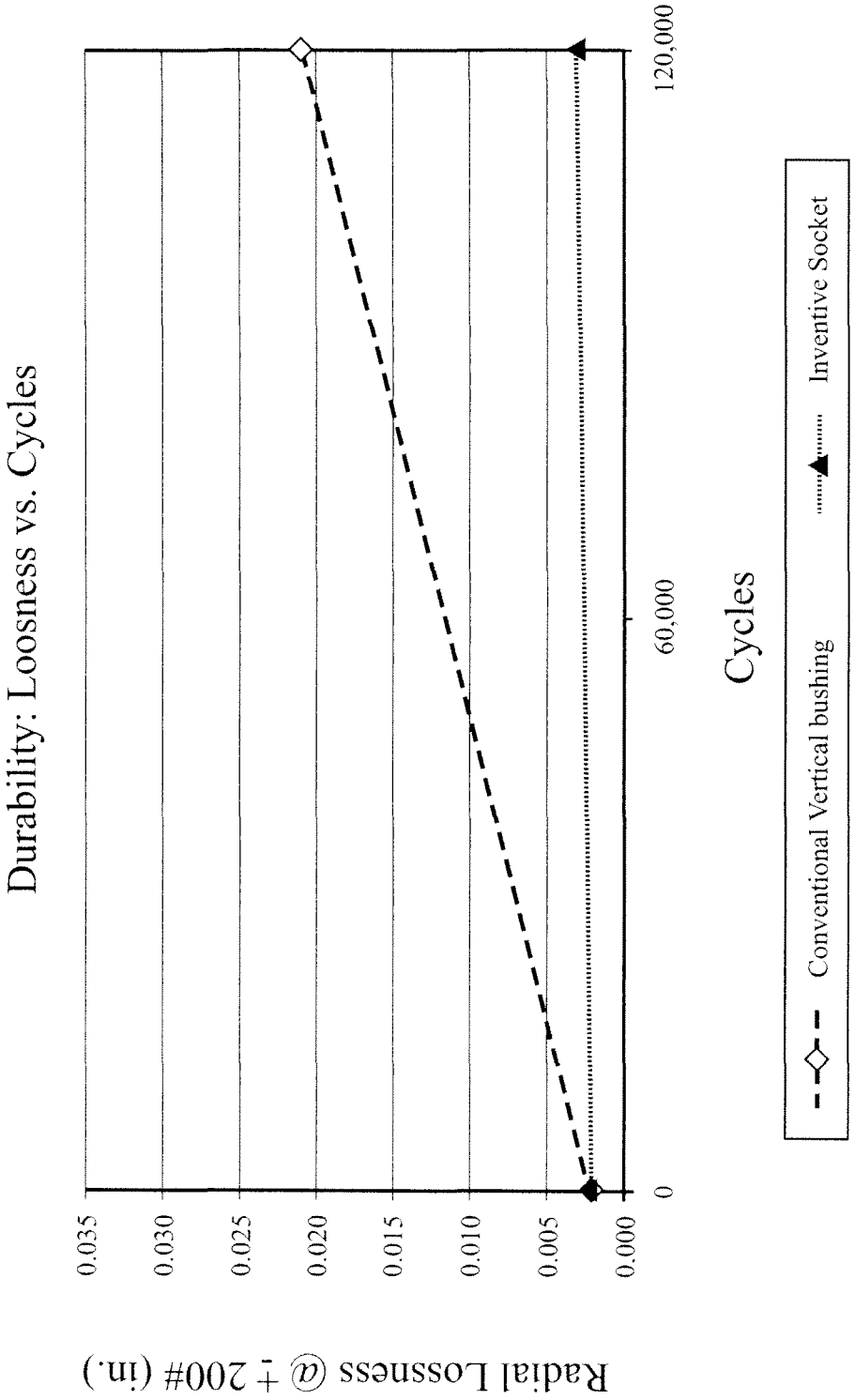


FIG. 7


Durability: Loosness vs. Cycles
Radial Lossness @ ± 200# (in.)
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0.000
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120,000
Cycles
Conventional Vertical bushing
Inventive Socket

FIG. 8

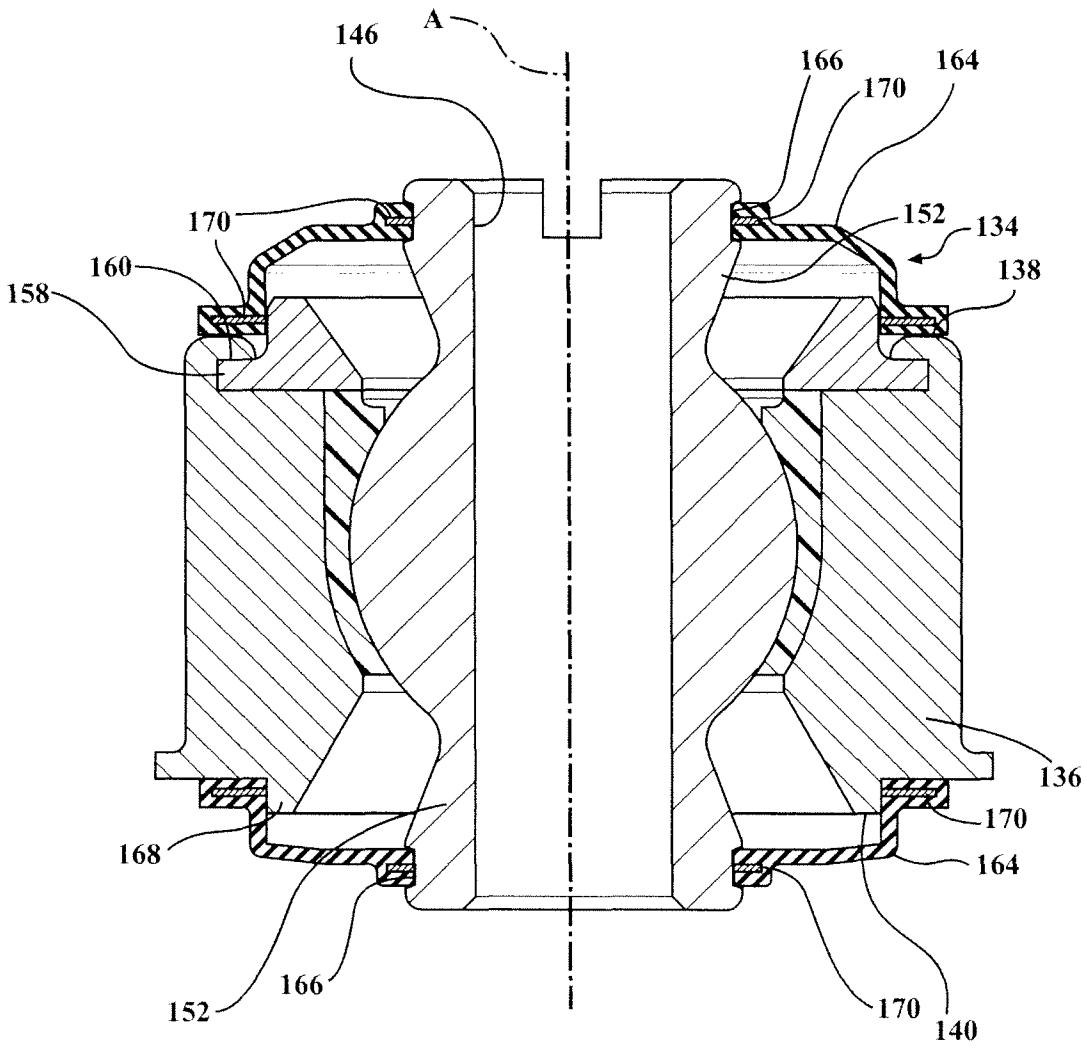
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FIG. 9

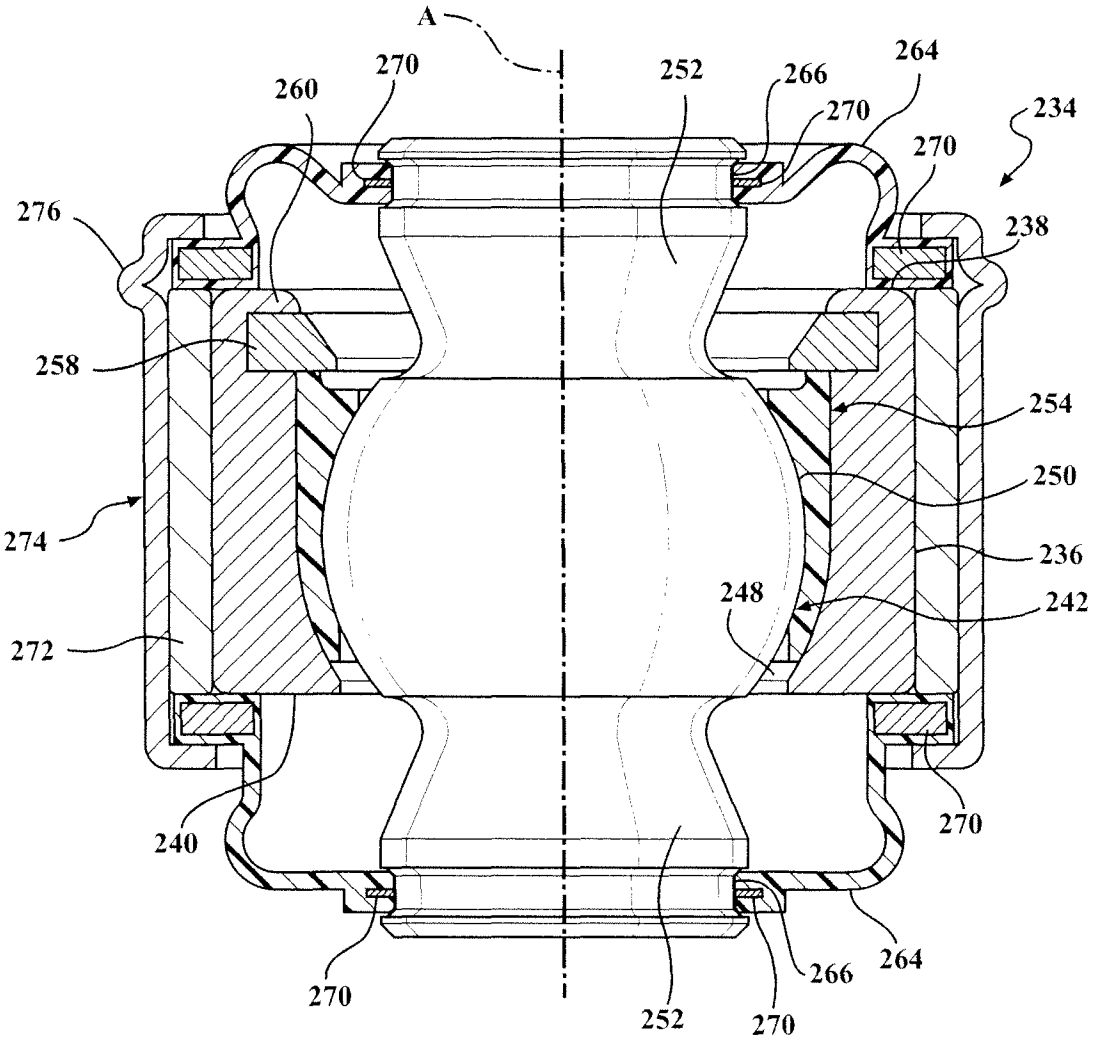
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FIG. 10

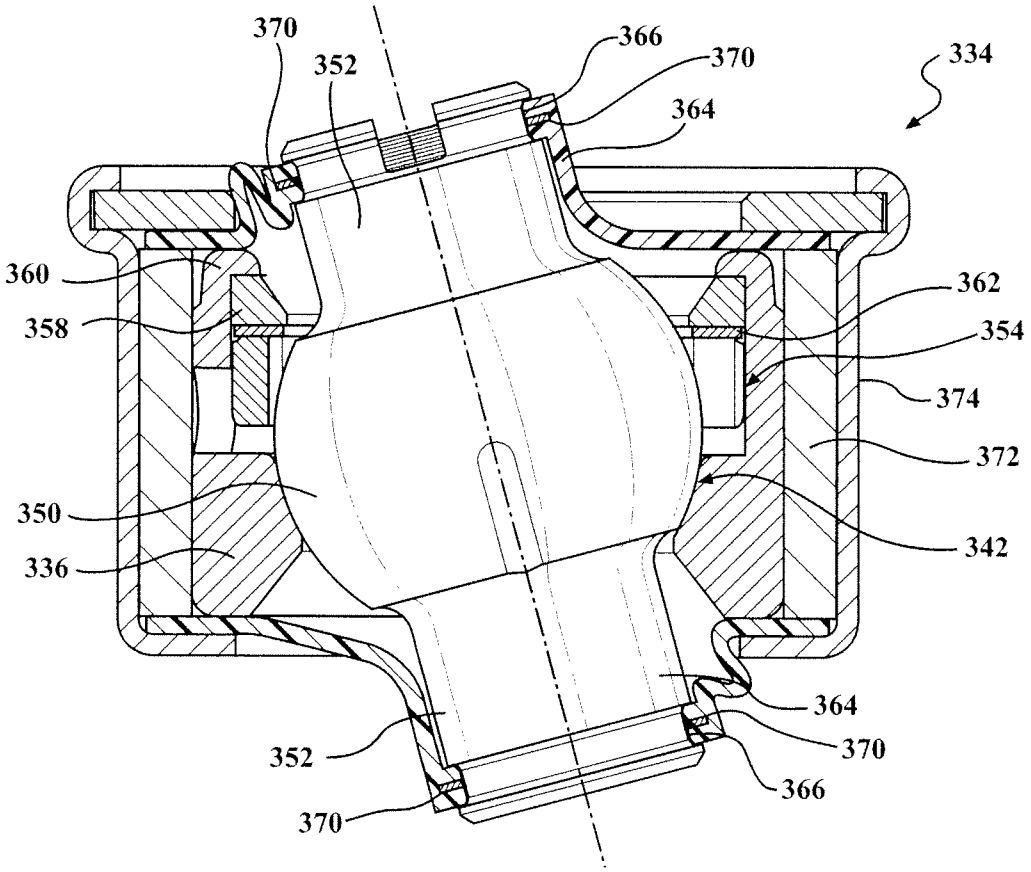
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FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/031827

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60G7/00 B60G7/02 F16C11/06
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)
B60G F16C

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	US 5 230 580 A (HENKEL GUENTHER [DE]) 27 July 1993 (1993-07-27) the whole document	1-13
X	US 3 317 256 A (ERNEST RICHARD B) 2 May 1967 (1967-05-02) the whole document	1-13
X A	US 4 718 780 A (TRUDEAU WILLIAM H [US]) 12 January 1988 (1988-01-12) the whole document	1,2,4-10 3

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 June 2013	20/06/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Savelon, Olivier

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/031827

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5230580 A	27-07-1993	BR 9200994 A	24-11-1992
		DE 4109697 C1	25-06-1992
		EP 0505719 A1	30-09-1992
		JP 3145768 B2	12-03-2001
		JP H0587120 A	06-04-1993
		US 5230580 A	27-07-1993
US 3317256 A	02-05-1967	BE 655470 A	01-03-1965
		GB 1090119 A	08-11-1967
		IL 22546 A	27-11-1968
		US 3317256 A	02-05-1967
US 4718780 A	12-01-1988	NONE	