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**Moratz**

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(54) **PHENOLIC BEARING CAGE WITH SELF-LUBRICATING COATING AND METHOD OF MANUFACTURING PHENOLIC BEARING CAGE WITH SELF-LUBRICATING COATING**

USPC ..... 384/463, 470, 527, 573  
See application file for complete search history.

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(57) **ABSTRACT**

A bearing cage, including: a body fabricated of phenolic material and having an outer circumferential surface and an inner circumferential surface; and a coating of molybdenum disulfide or polytetrafluoroethylene adhered to the outer circumferential surface or the inner circumferential surface. A method of manufacturing a bearing cage, including: fabricating a body from phenolic material, the body including an outer circumferential surface and an inner circumferential surface connecting first and second sides; and adhering a coating of molybdenum disulfide or polytetrafluoroethylene to the inner or outer circumferential surface.

**11 Claims, 5 Drawing Sheets**

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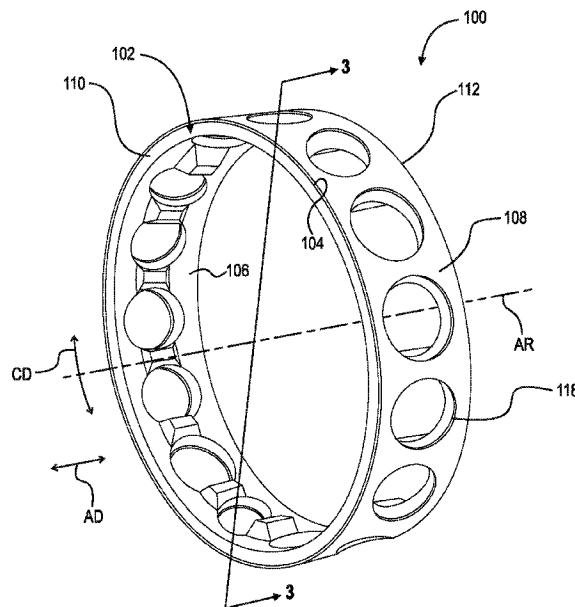
**Related U.S. Application Data**

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**F16C 33/44** (2006.01)  
**F16C 33/56** (2006.01)  
**F16C 33/66** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **F16C 33/565** (2013.01); **F16C 33/6696** (2013.01)

(58) **Field of Classification Search**  
CPC ..... F16C 33/445; F16C 33/565



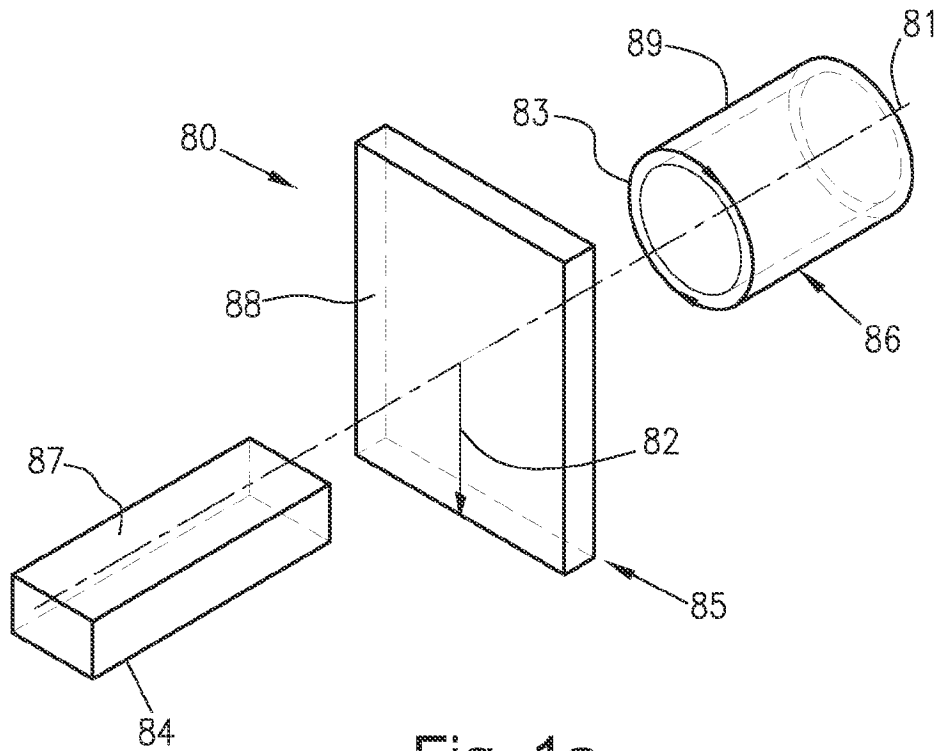


Fig. 1a

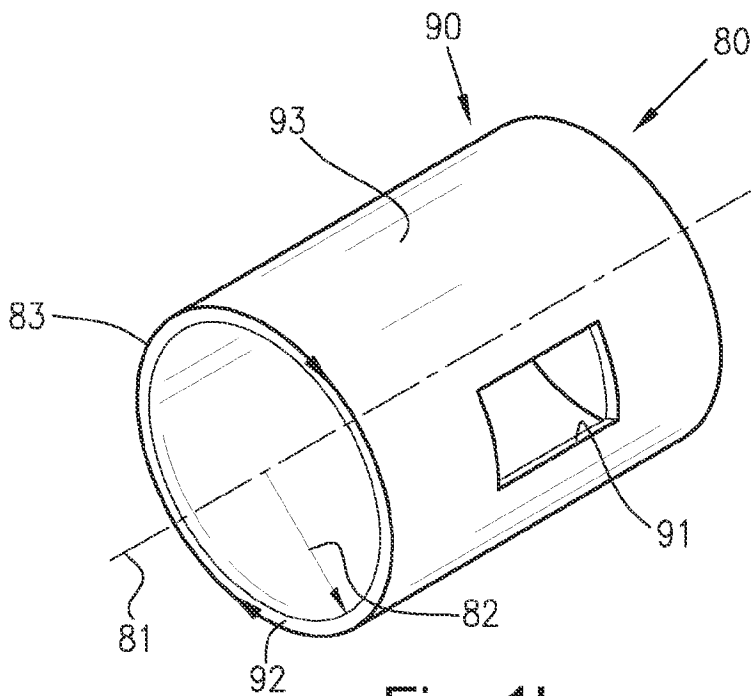


Fig. 1b

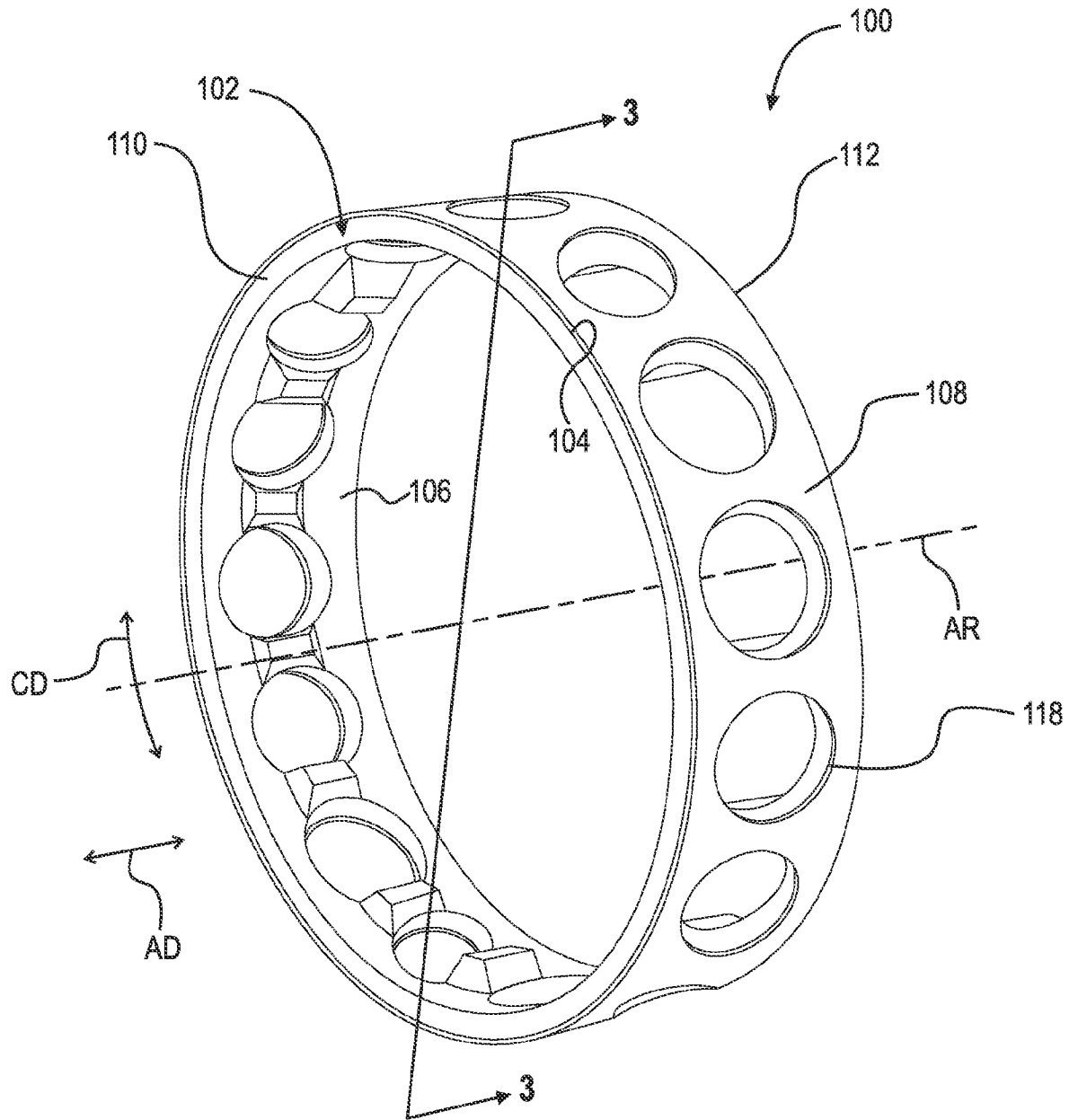


Fig. 2

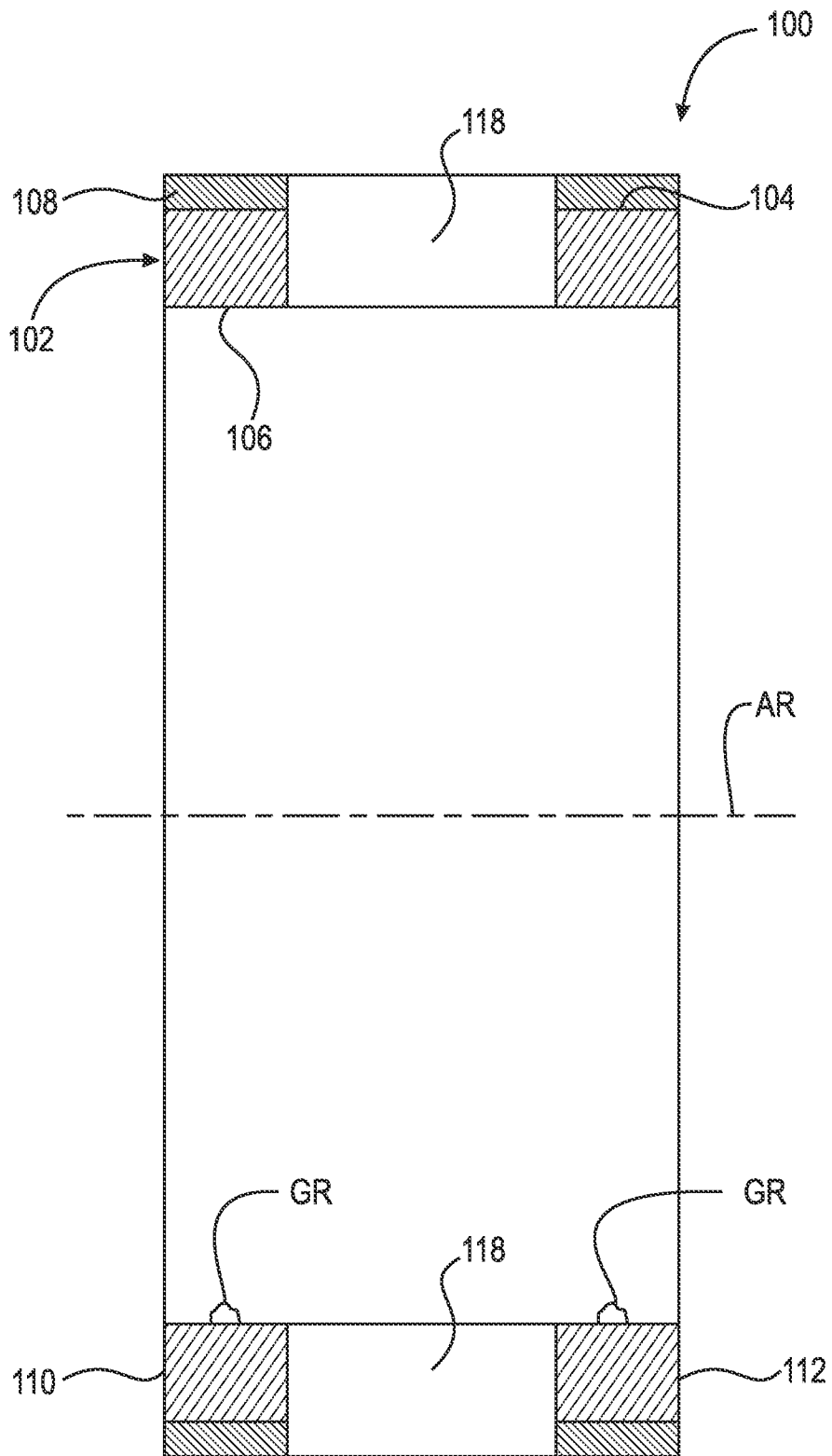


Fig. 3

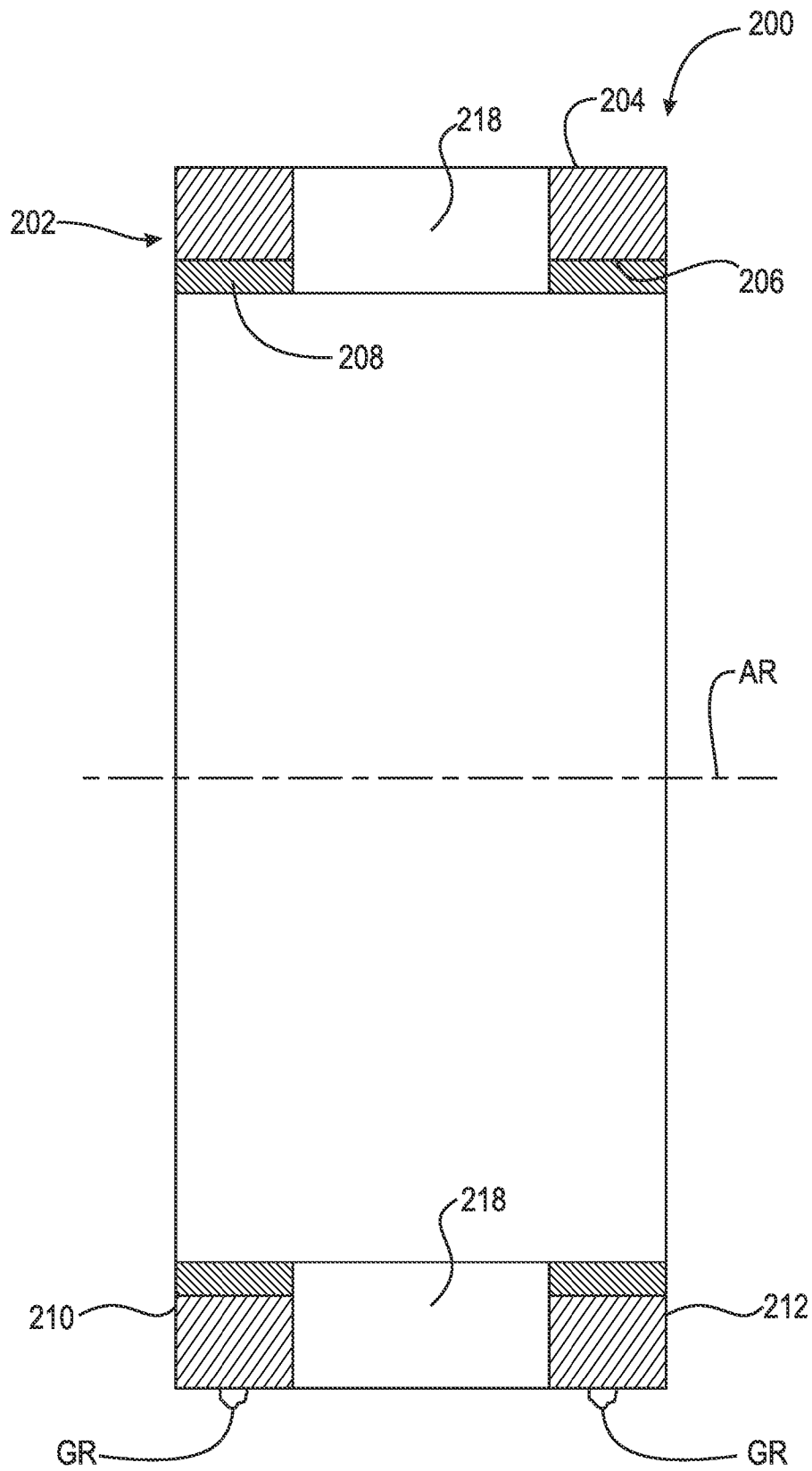


Fig. 4

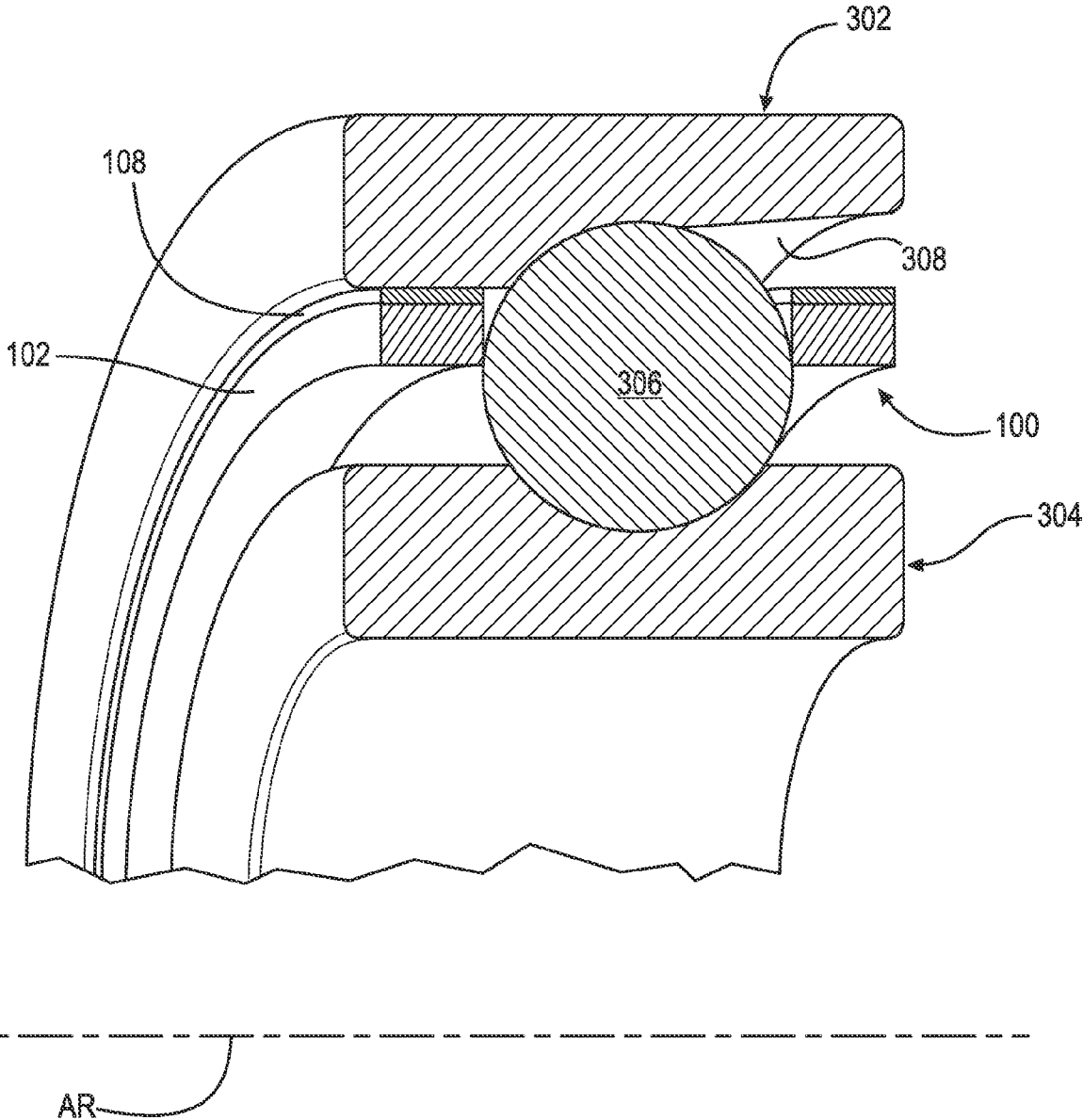


Fig. 5

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**PHENOLIC BEARING CAGE WITH  
SELF-LUBRICATING COATING AND  
METHOD OF MANUFACTURING PHENOLIC  
BEARING CAGE WITH SELF-LUBRICATING  
COATING**

CROSS-REFERENCE TO RELATED  
APPLICATIONS

This application claims the benefit under 35 U.S.C. §119 (e) of U.S. Provisional Patent Application No. 61/904,808, filed Nov. 15, 2013, which application is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present disclosure relates to a bearing cage with an inner or outer circumferential surface with a self-lubricating coating of molybdenum disulfide or polytetrafluoroethylene. The present disclosure relates to a method of manufacturing a bearing cage with an inner or outer circumferential surface with a self-lubricating coating of molybdenum disulfide or polytetrafluoroethylene. The present disclosure relates to a bearing assembly including a bearing cage with a self-lubricating coating of molybdenum disulfide or polytetrafluoroethylene.

BACKGROUND

It is known to use spindle bearings with phenolic cages for high-speed applications such as machine tools. Such spindle bearings typically have inner and outer rings, the phenolic bearing cage radially located between the inner and outer rings, and a plurality of roller elements retained by the bearing ring. In a radially outwardly guided configuration, an outer circumferential surface of the bearing cage (the land guiding surface) is engaged with and guided by an inner circumferential surface of the outer ring (land surface). Oil from bearing grease or similar lubricant forms a lubricant film between the land guiding surface and the land surface. In a radially inwardly guided configuration, an inner circumferential surface of the bearing cage (the land guiding surface) is engaged with and guided by an outer circumferential surface of the inner ring (land surface).

Oil from the bearing grease or similar lubricant forms a lubricant film between the land guiding surface and the land surface. Lubrication of the land guiding surface is critical for operation of the bearing. However, at start up, the lubricant film is not yet fully formed between the land surface and the land guiding surface and base oil has only starting to migrate to the land guiding surface. Known spindle bearings do not provide a desired level of lubrication of the land guiding surface at start up.

EP 0 695 884 B1 discloses a greased rolling bearing element with a solid lubricating coating. The description of EP 0 695 884 B1 mentions GB 826 091 A, which described cages with metallic bodies and a plastic coating of polyamide or poly tetrafluoroethylene containing about 3% of MoS<sub>2</sub> or graphite.

The description of EP 0 695 884 B1 mentions U.S. Pat. No. 3,500,525, JP-A-62 141 314 and JP-A-3 255 223, all of which disclose a coating of MoS<sub>2</sub> for a bearing cage. However, all these references relate to bearings for use in (high) vacuum and/or at elevated temperatures (250° C. or more). Grease lubrication cannot be used in (high) vacuum and/or at elevated temperatures.

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EP 0 695 884 B1 discloses use of a coating of MoS<sub>2</sub> and poly tetrafluoroethylene over a steel bearing cage.

SUMMARY

According to aspects illustrated herein, there is provided a bearing cage, including: a body fabricated of phenolic material and having an outer circumferential surface and an inner circumferential surface; and a coating of molybdenum disulfide or polytetrafluoroethylene adhered to the outer circumferential surface or the inner circumferential surface.

According to aspects illustrated herein, there is provided a bearing assembly including: an inner ring including a first outer circumferential surface; an outer ring including a first inner circumferential surface; a bearing cage fabricated of phenolic material and including first and second sides, a second outer circumferential surface connecting the first and second sides, a second inner circumferential surface connecting the first and second sides, and a coating of molybdenum disulfide or polytetrafluoroethylene adhered to the second outer circumferential surface or to the second inner circumferential surface; and a plurality of rolling elements retained by the bearing cage. The second outer circumferential surface is engaged with the first inner circumferential surface to guide the bearing cage. The second inner circumferential surface is engaged with the first outer circumferential surface to guide the bearing cage.

According to aspects illustrated herein, there is provided a method of manufacturing a bearing cage, including: fabricating a body from phenolic material, the body including an outer circumferential surface and an inner circumferential surface connecting first and second sides; and adhering a coating of molybdenum disulfide or polytetrafluoroethylene to the inner or outer circumferential surface.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments are disclosed, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, in which:

FIG. 1A is a perspective view of a cylindrical coordinate system demonstrating spatial terminology used in the present application;

FIG. 1B is a perspective view of an object in the cylindrical coordinate system of FIG. 1A demonstrating spatial terminology used in the present application;

FIG. 2 is a perspective view of a bearing cage with a self-lubricating coating on an outer circumference;

FIG. 3 is a schematic cross-sectional view generally along line 3-3 in FIG. 2;

FIG. 4 is a schematic cross-sectional view of a bearing cage with a coating on an inner circumferential surface; and,

FIG. 5 is a partial cut-away view of a bearing assembly including a bearing cage with a self-lubricating coating on an outer circumference.

DETAILED DESCRIPTION

At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements of the disclosure. It is to be understood that the disclosure as claimed is not limited to the disclosed aspects.

Furthermore, it is understood that this disclosure is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is also

understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the present disclosure.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure belongs. It should be understood that any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the disclosure.

FIG. 1A is a perspective view of cylindrical coordinate system **80** demonstrating spatial terminology used in the present application. The present disclosure is at least partially described within the context of a cylindrical coordinate system. System **80** has a longitudinal axis **81**, used as the reference for the directional and spatial terms that follow. The adjectives “axial,” “radial,” and “circumferential” are with respect to an orientation parallel to axis **81**, radius **82** (which is orthogonal to axis **81**), and circumference **83**, respectively. The adjectives “axial,” “radial” and “circumferential” also are regarding orientation parallel to respective planes. To clarify the disposition of the various planes, objects **84**, **85**, and **86** are used. Surface **87** of object **84** forms an axial plane. That is, axis **81** forms a line along the surface. Surface **88** of object **85** forms a radial plane. That is, radius **82** forms a line along the surface. Surface **89** of object **86** forms a circumferential plane. That is, circumference **83** forms a line along the surface. As a further example, axial movement or disposition is parallel to axis **81**, radial movement or disposition is parallel to radius **82**, and circumferential movement or disposition is parallel to circumference **83**. Rotation is with respect to axis **81**.

The adverbs “axially,” “radially,” and “circumferentially” are with respect to an orientation parallel to axis **81**, radius **82**, or circumference **83**, respectively. The adverbs “axially,” “radially,” and “circumferentially” also are regarding orientation parallel to respective planes.

FIG. 1B is a perspective view of object **90** in cylindrical coordinate system **80** of FIG. 1A demonstrating spatial terminology used in the present application. Cylindrical object **90** is representative of a cylindrical object in a cylindrical coordinate system and is not intended to limit the present invention in any manner. Object **90** includes axial surface **91**, radial surface **92**, and circumferential surface **93**. Surface **91** is part of an axial plane, surface **92** is part of a radial plane, and surface **93** is a circumferential surface.

FIG. 2 is a perspective view of bearing cage **100** with a self-lubricating coating on an outer circumference.

FIG. 3 is a cross-sectional view generally along line 3-3 in FIG. 2. The following should be viewed in light of FIGS. 2 and 3. Cage **100** includes axis of rotation **AR** and body **102** fabricated of phenolic material and having outer circumferential surface **104** and inner circumferential surface **106**. Body **102** can be fabricated of any phenolic material known in the art. Cage **100** includes coating **108** of molybdenum disulfide or polytetrafluoroethylene adhered to outer circumferential surface **104**. That is, surface **104** is at least partially covered with coating **108**. In an example embodiment, the coating is molybdenum disulfide. In an example embodiment, the coating is polytetrafluoroethylene. In an example embodiment, cage **100** includes grease **GR**. Grease **GR** is generally located proximate surface **106**. The thickness of coating **108** in FIGS. 2 and 3 has been exaggerated for purposes of illustration.

In an example embodiment, at least a portion of the coating forms a continuous ring, in circumferential direction **CD**, encircling surface **104**. In an example embodiment, an entirety, that is, all of the coating is continuous in circumfer-

ential direction **CD** on surface **104**. Body **102** includes sides **110** and **112**. Outer circumferential surface **104** and inner circumferential surfaces **106** connect sides **110** and **112**. That is, sides **110** and **112** bound the outer circumferential surface and the inner circumferential surface in axial direction **AD**. In an example embodiment, at least a portion of coating **108** is continuous from side **110** to side **112**, that is, between side **110** and **112**. In an example embodiment, an entirety, that is, all, of coating **108** is continuous from side **110** to side **112**, that is, between side **110** and **112**. Stated otherwise, surface **104** is completely covered with coating **108**.

FIG. 4 is a schematic cross-sectional view of bearing cage **200** with a coating on an inner circumferential surface. Cage **200** includes axis of rotation **AR** and body **202** fabricated of phenolic material and with outer circumferential surface **204** and inner circumferential surface **206**. Body **202** can be fabricated of any phenolic material known in the art. Cage **200** includes coating **208** of molybdenum disulfide or polytetrafluoroethylene adhered to inner circumferential surface **206**. That is, surface **206** is at least partially covered with coating **208**. In an example embodiment, the coating is molybdenum disulfide. In an example embodiment, the coating is polytetrafluoroethylene. In an example embodiment, cage **200** includes grease **GR**. Grease **GR** is generally located proximate surface **204**. The thickness of coating **208** has been exaggerated for purposes of illustration.

In an example embodiment, at least a portion of the coating forms a continuous ring in circumferential direction **CD** encircling surface **206**. In an example embodiment, an entirety, that is, all of the coating is continuous in circumferential direction **CD** on surface **206**. Body **202** includes sides **210** and **212**. Outer circumferential surface **204** and inner circumferential surfaces **206** connect sides **210** and **212**. That is, sides **210** and **212** bound the outer circumferential surface and the inner circumferential surface in axial direction **AD**. In an example embodiment, at least a portion of coating **208** is continuous from side **210** to side **212**, that is, between side **210** and **212**. In an example embodiment, an entirety, that is, all, of coating **208** is continuous from side **210** to side **212**, that is, between side **210** and **212**. Stated otherwise, surface **206** is completely covered with coating **208**.

FIG. 5 is a partial cut-away view of bearing assembly **300** including bearing cage **100** with a self-lubricating coating on an outer circumference. The following should be viewed in light of FIGS. 2, 3 and 5. Assembly **300** includes axis of rotation **AR**, bearing cage **100**, outer ring **302**, inner ring **304**, and at least one rolling element **306**. Ring **302** includes inner circumferential surface **308**, also referred to as land surface **308**. Outer circumferential surface **104** engages surface **308**.

Advantageously, bearings **100** and **200** addresses the problems noted above regarding the lack of lubrication on the surface of a bearing cage during start-up. Specifically, coatings **108** and **208** provide effective friction reduction prior to the build up of oil on surfaces **104** and **206**, respectively. There are no teachings, suggestions, or motivations in the prior art to use coating **108** on a phenolic bearing cage or that the use of coating **108** on a phenolic bearing cage would be successful.

It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.



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The invention claimed is:

**1.** A bearing cage, comprising:

a body:

fabricated of phenolic material; and,  
including an outer circumferential surface and an inner  
circumferential surface; and,

a coating of molybdenum disulfide or polytetrafluoroeth-  
ylene adhered to the outer circumferential surface or the  
inner circumferential surface, wherein:

for the coating of molybdenum disulfide or polytet-  
rafluoroethylene adhered to the outer circumferential  
surface, the bearing cage includes an oil-based lubri-  
ciant on the inner circumferential surface; and,

for the coating of molybdenum disulfide or polytet-  
rafluoroethylene adhered to the inner circumferential  
surface, the bearing cage includes an oil-based lubri-  
ciant on the outer circumferential surface.

**2.** The bearing cage of claim **1**, wherein:

the outer circumferential surface is arranged to engage an  
outer ring for a bearing assembly; or,

the inner circumferential surface is arranged to engage an  
inner ring for a bearing assembly.

**3.** The bearing cage of claim **1**, wherein:

at least a portion of the coating forms a continuous ring  
completely encircling the inner circumferential surface  
in a circumferential direction; or,

at least a portion of the coating forms a continuous ring  
completely encircling the outer circumferential surface  
in a circumferential direction.

**4.** The bearing cage of claim **1**, wherein:

the body includes first and second sides bounding the inner  
and outer circumferential surfaces in an axial direction;  
and,

at least a portion of the coating is continuous between the  
first and second sides.

**5.** The bearing cage of claim **1**, wherein:

the body includes first and second sides bounding the inner  
and outer circumferential surfaces in an axial direction;  
and,

an entirety of the coating is continuous between the first  
and second sides.

**6.** A bearing assembly comprising:

an inner ring including a first outer circumferential surface;  
an outer ring including a first inner circumferential surface;  
a bearing cage fabricated of phenolic material and includ-  
ing:

first second, third and fourth sides;

a second outer circumferential surface connecting the  
first and second sides;

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a second inner circumferential surface connecting the  
first and second sides; and

a third outer circumferential surface connecting the third  
and fourth sides; and,

a coating of only molybdenum disulfide or polytet-  
rafluoroethylene adhered to the second outer circum-  
ferential surface; and,

a plurality of rolling elements:

axially located between the second and third outer cir-  
cumferential surfaces; and,

retained by the bearing cage, wherein:

the coating is in contact with the first inner circumferential  
surface to guide the bearing cage; and

the coating is free of contact with the first inner circumfer-  
ential surface.

**7.** The bearing assembly of claim **6**, further comprising  
grease applied to the bearing cage.

**8.** The bearing assembly of claim **6**, further comprising an  
oil-based lubricant applied to the bearing cage.

**9.** A method of manufacturing a bearing cage, comprising:  
fabricating a body from phenolic material, the body includ-  
ing an outer circumferential surface and an inner cir-  
cumferential surface connecting first and second sides;  
and,

adhering a coating of molybdenum disulfide or polytet-  
rafluoroethylene to the inner circumferential surface and  
an oil-based lubricant to the outer circumferential sur-  
face; or,

adhering a coating of molybdenum disulfide or polytet-  
rafluoroethylene to the outer circumferential surface and  
an oil-based lubricant to the inner circumferential sur-  
face.

**10.** The method of claim **9**, wherein:

adhering the coating of molybdenum disulfide or polytet-  
rafluoroethylene to the inner circumferential surface  
includes adhering only molybdenum disulfide; or,  
adhering the coating of molybdenum disulfide or polytet-  
rafluoroethylene to the outer circumferential surface  
includes adhering only molybdenum disulfide.

**11.** The method of claim **9**, wherein:

adhering the coating of molybdenum disulfide or polytet-  
rafluoroethylene to the inner circumferential surface  
includes adhering only polytetrafluoroethylene; and,  
adhering the coating of molybdenum disulfide or polytet-  
rafluoroethylene to the outer —circumferential surface  
includes adhering only polytetrafluoroethylene.

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