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(71) Applicant: **THE TIMKEN COMPANY** [US/US]; 4500 Mount Pleasant NW, North Canton, OH 44720 (US).

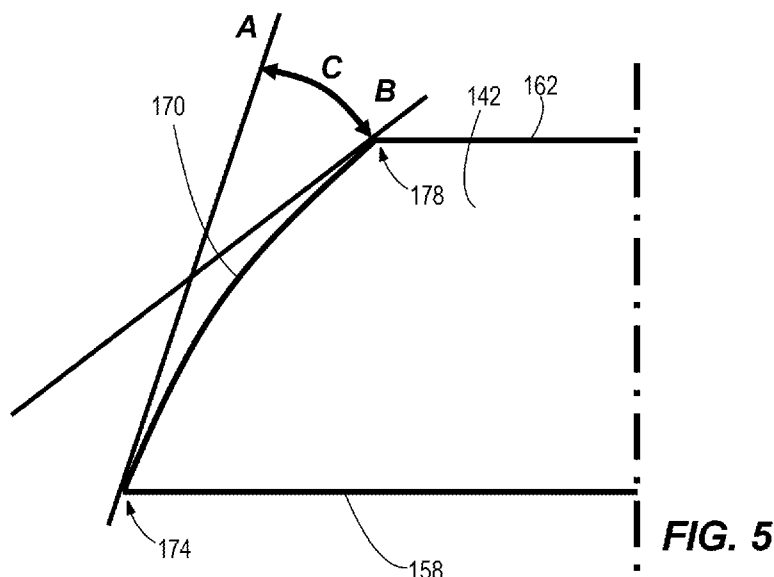
(72) Inventor: **JOKI, Mark, A.**; 5930 North American Rd NW, Dover, OH 44622 (US).

(74) Agent: **NITZ, Caleb M.**; Michael Best & Friedrich LLP, 790 N. Water Street, Suite 2500, Milwaukee, WI 53202 (US).

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(54) Title: HIGH-CAPACITY CYLINDRICAL ROLLER BEARING AND CAGE



(57) Abstract: A roller bearing includes an outer ring defining an outer raceway, an inner ring defining an inner raceway, a plurality of rolling elements positioned between the inner raceway and the outer raceway such that the outer ring is rotatable relative to the inner ring about a rotational axis, and a cage extending around the inner ring at a location between the inner ring and the outer ring, the cage having a plurality of bridges that at least partially define a plurality of openings, each opening configured to receive a corresponding one of the plurality of rolling elements therein to separate the plurality of rolling elements from one another. Each bridge includes a contact surface configured to contact an outer periphery of a corresponding one of the rolling elements. The contact surfaces have a convex curvilinear form as viewed in a section taken through a plane normal to the rotational axis.

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HIGH-CAPACITY CYLINDRICAL ROLLER BEARING AND CAGE

HIGH-CAPACITY CYLINDRICAL ROLLER BEARING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of and priority to U.S. Provisional Patent Application No. 63/219,431, filed July 8, 2021, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] U.S. Patent No. 10,753,402 describes a bearing cage for a cylindrical roller bearing that enables a high load capacity due to a large quantity of rolling elements made possible by small cage bridges. The cage surface contacting the rolling element is a planar face placed at an angle to control the location of contact with the rolling element.

SUMMARY

[0003] The present disclosure relates to a roller bearing. The roller bearing includes an outer ring defining an outer raceway, an inner ring defining an inner raceway, a plurality of rolling elements positioned between the inner raceway and the outer raceway such that the outer ring is rotatable relative to the inner ring about a rotational axis, and a cage extending around the inner ring at a location between the inner ring and the outer ring, the cage having a plurality of bridges that at least partially define a plurality of openings, each opening configured to receive a corresponding one of the plurality of rolling elements therein to separate the plurality of rolling elements from one another. Each bridge of the plurality of bridges includes a contact surface configured to contact an outer periphery of a corresponding one of the rolling elements. The contact surfaces have a convex curvilinear form as viewed in a section taken through a plane normal to the rotational axis.

[0004] The present disclosure relates further to a cage for a roller bearing. The cage includes a first cage flange ring, a second cage flange ring, and a plurality of bridges that extend between the first cage flange ring and the second cage flange ring to connect the first cage flange ring to the second cage flange ring. The first cage flange ring, the second cage flange ring, and the bridges collectively define a plurality of pocket openings, each pocket opening configured to retain a corresponding one of a plurality of rolling elements. A contact surface of each of the plurality of bridges has a convex curvilinear form as viewed in a plane that is perpendicular to a rotational axis of the cage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Fig. 1 is an isometric view of a high capacity bearing cage of the prior art.

[0006] Fig. 2 is an axial-cut cross-sectional view of a high-capacity bearing guided by inner ring flanges of the prior art.

[0007] Fig. 3 is a radial-cut cross section diagram of the prior art roller body to cage contact illustrating the condition when the cage is eccentric, and its position is being limited by the rolling elements seated in the pockets.

[0008] Fig. 4 is a radial-cut cross section diagram of the prior art roller body to cage contact illustrating the condition when cage is eccentric, and its position is being limited by the ring flange.

[0009] Fig. 5 is a radial-cut cross section diagram of a roller body contacting surface of a cage bridge, according to a first embodiment.

[0010] Fig. 6 is a radial-cut cross section diagram of roller bodies positioned relative to the cage bridge of Fig. 5.

[0011] Fig. 7 is an axial-cut cross-sectional view of a high-capacity bearing having a cage that incorporates the cage bridge of Fig. 5.

[0012] Fig. 8 is a radial-cut cross section diagram of a roller body contacting surface of a cage bridge, according to a second embodiment.

DETAILED DESCRIPTION

[0013] Before any embodiments are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The disclosure is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising” or “having” and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. The terms “mounted,” “connected” and “coupled” are used broadly and encompass both direct and

indirect mounting, connecting, and coupling. Further, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings, and can include hydraulic or electrical connections or couplings, whether direct or indirect.

[0014] With reference to Fig. 1, a cage 34 of the prior art for a roller bearing 10 (Fig. 2), as shown a cylindrical roller bearing, has multiple pocket openings 46, each pocket opening 46 sized to hold a roller or rolling element 30 (Figs. 2-4). The cage 34 includes two cage flange rings 38 spaced apart and axially aligned with one another. The cage 34 also includes bridges 42 that connect the cage flange rings 38 together. The cage flange rings 38 and bridges 42 define the pocket openings 46. As shown in Fig. 1, in some embodiments, the bridges 42 include a projection 50 situated approximately at a desired location along the axial length and on the radial inner side of the bridge 42.

[0015] With reference to Fig. 2, the cage 34 is placed around the inner ring 22 of the cylindrical roller bearing 10 so as to prevent roller-to-roller contact between adjacent rolling elements 30 (i.e., cylindrical rollers). The illustrated configuration is a two-row bearing. The cage 34 functions in combination with the inner and outer rings 22, 14 to maintain the relative positions of each rolling element 30, with the rolling elements 30 being removable from the cage 34 when the outer ring 14 is not present. The inner ring 22 defines an inner raceway 26 thereon and the outer ring 14 defines an outer raceway 18 such that the rolling elements 30 are positioned on the raceways 18, 26. The bridges 42 are located between adjacent rolling elements 30 and are therefore not visible in Fig. 2.

[0016] As shown in Figs. 3-4, the bridges 42 have angled contact surfaces 70 that interact with adjacent roller bodies 30. There is substantial clearance (e.g., 0.3-0.6% of the diameter of the inner ring flange 54) between a radially inner surface 58 of the cage 34 and the outer surface of the inner ring flange 54 (i.e., at the outer diameter of the inner ring flange 54), resulting in potential eccentricity of the cage 34 relative to the circular profile of the inner ring flange 54. In the illustrated embodiment, the eccentricity of the cage 34 is limited at one extreme by cage contact with the outer periphery of the inner ring flange 54 (see Fig. 4). In other embodiments, the eccentricity of the cage 34 can be limited at one extreme by cage contact with the inner raceway 26. The eccentricity of the cage 34 is at another extreme (i.e., diametrically opposed from the extreme shown in Fig. 4) limited by either adjacent rolling elements 30 that are fully seated in adjacent cage pockets 46 (see Fig. 3) or otherwise by contact between the rolling element 30 and two opposing bridges 42 that form the cage

pocket 46 surrounding the rolling element 30. Written another way, one bridge 42 contacts two adjacent rolling elements 30 simultaneously and/or one rolling element 30 contacts two opposing bridges 42 simultaneously.

[0017] In some embodiments, as shown in Fig. 3, the radially inner surface 58 of the cage 34 corresponds to an inner diameter of the cage 34, with the bridges 42 and the cage flange rings 38 sharing an inner diameter. Similarly, a radially outer surface 62 (located radially outward from the radially inner surface 58) of the cage 34 corresponds to an outer diameter of the cage 34, with the bridges 42 and the cage flange rings 38 sharing a common outer diameter. In other embodiments, the bridges 42 may have an inner and/or outer diameter that differs from the inner diameter of the cage flange rings 38.

[0018] With reference to Fig. 3, at a location where the radially inner surface 58 of the cage 34 is spaced apart from the outer surface of the inner ring flange 54 (due to the eccentricity of the cage 34), a rolling element 30 is seated in a pocket 46. A contact surface 70 of a bridge 42 of the prior art extends between the radially inner and outer surfaces 58, 62 of the cage 34 for contacting the rolling element 30. As shown, each bridge 42 includes two contact surfaces 70, each configured to engage an adjacent rolling element 30. In the prior art embodiment shown in Fig. 3, the radially outer surface 62 of the bridge 42 is smaller in width than the radially inner surface 58 such that the contact surface is a planar surface angled relative to a radial direction of the cage 34. The eccentricity illustrated in Fig. 3 results in contact that is low on the bridge 42. In other words, the contact between the bridge 42 and the rolling element 30 is at or adjacent to the radially inner surface 58 of the cage 34 (i.e., nearer to the radially inner surface 58 of the bridge 42 than the outer radial surface 62 of the bridge 42). Contact at the inner edge 74 of the bridge surface (the edge defined by the intersection between the contact surface 70 and the radially inner surface 58 of the bridge 42) can cause scraping of oil film, resulting in accelerated wear. The inner edge 74 is illustrated in Fig. 1 and further in Fig. 3, the edge 74 extending parallel to the rotational axes of the rolling elements 30 (i.e., into the page) in Fig. 3. The inclination angle of the contact surface 70 can assist in keeping the roller contact away from the inner edge 74. The included angle between the two opposing planar contact surfaces 70 on one bridge 42 is typically 40-55 degrees in the prior art.

[0019] With reference to Fig. 4, at a location where the radially inner surface 58 of the cage 34 is in contact with the outer surface of the inner ring flange 52 (i.e., diametrically

opposed to the location shown in Fig. 3), the contact between the rolling element 30 and the prior art bridge 42 of the cage 34 is at the highest point (i.e., furthest away from the radially inner surface 58 of the cage 34). At the inclination of the planar contact surface 70 in the prior art shown in Fig. 4, a high bridge thickness prevents contact with the rolling element 30 at the outer edge 78 (the edge defined by the intersection between the contact surface 70 and the radially outer surface 62 of the bridge 42) of the cage 34. The outer edge 78 is illustrated in Fig. 1 and further in Fig. 4, the edge 78 extending parallel to the rotational axes of the rolling elements 30 (i.e., into the page) in Fig. 4.

[0020] The preferred embodiment illustrated in Figs. 5-7 includes a bridge 142 for a cage 134. The cage 134 is similar to the cage 34 except as otherwise described. As shown in Fig. 7, the cage 134 is positioned about the inner ring 22 of a cylindrical roller bearing 10 in a similar manner as the cage 34 shown in Fig. 4.

[0021] With reference to Figs. 5-6, the bridge 142 has oppositely-facing contact surfaces 170, each having a shape that is modified relative to the contact surface 70 illustrated in Figs. 1, 3, and 4. The shape of the contact surfaces 170 shown in Figs. 5-6 minimizes the variation in contact location allowing for a smaller bridge thickness relative to the prior art bridge 42, thereby reducing manufacturing difficulty. Fig. 5 illustrates a cross-section of half of a bridge 142, while Fig. 6 illustrates the entire bridge 142 in cross section, in which the contact surfaces 170 are mirror images of one another.

[0022] In the preferred embodiment, the roller body contact surface 170 of the bridge 142 is a convex curved (curvilinear) surface in cross section (the cross-sectional plane being perpendicular to the axis of the cage 134 and the axes of the rolling elements 30 positioned within the cage 134). The contact surface 170 extends radially outward from the radially inner surface 158 of the bridge 142 towards the radially outer surface 162 of the bridge 142, with the width of the bridge 142 monotonically decreasing (the width being perpendicular to the radial direction) from the radially inner surface 158 towards the radially outer surface 162. As shown in Fig. 5, the minimum width of the bridge 142 is located at or adjacent to the radially outer surface 162 of the cage 134 and the maximum width is located towards the radially inner surface 158. In some embodiments, the contact surface 170 extends to the radially inner surface 158 of the bridge 142, though in other embodiments, (for example, as shown in Fig. 8), a separate surface 182 (e.g., a surface generated from the process of

perforating the pockets) may extend between the contact surface 170 and the radially inner surface 158 of the bridge 142.

[0023] The inclination of a first portion of the contact surface 170 that is closer to the radially inner surface 158 of the bridge 142 (i.e., a first radial extreme, at the inner edge 174), as illustrated by tangent line A, is smaller than the inclination of a second portion of the contact surface 170 that is radially outward of the radially inner surface 158 of the cage 134 at the maximum distance away from the radially inner surface 158 of the cage 134 (i.e., a second radial extreme, at the outer edge 178), as illustrated by tangent line B. The first radial extreme may correspond to the radially inner surface 158 of the cage 134 and the second radial extreme may correspond to a radially outer surface 162 of the cage 134. The reference axis from which the inclination is measured is radial, such that a rectangular bridge section would have zero inclination angle of the contact face. The maximum in-tolerance inclination of the first portion of the contact surface (i.e., line A; nearest the radially inner surface 158 of the cage 134) provides a contact point 186 (Fig. 6) for engaging the rolling element 30 that is spaced apart from the first and second edges 174, 178 (Fig. 5) when a rolling element 30 is seated in the pocket 46, as shown in Fig. 6. The convex, curved contact surface 170 ensures that the roller contact will not reach the edges 174, 178, regardless of a radial spacing between a radially inner surface 158 of the cage 134 and a radially outer surface of the inner ring 22. The angle C between the inclinations at the two extreme locations (line B to line A) is two to ten degrees and is preferably four degrees. This angle C is exaggerated in Figs. 5, 6, and in the second embodiment shown in Fig. 8, to better illustrate the differences in line A and line B. In the scenario where the rolling element 30 contacts the bridge 142 at the highest possible location (as in Fig. 6), the height of that contact 186 with the rolling element 30 is substantially lower on the bridge 142 than in the corresponding position of the prior art bridge 42 shown in Fig. 4, permitting manufacture and use of a thinner bridge 142 (in the radial direction). A small difference between the inclination angles of the tangent lines A and B (e.g., less than two degrees) does not result in a substantial bridge thickness reduction benefit. Additionally, a large difference between the inclination angles of the tangent line A and B (e.g., greater than ten degrees) results in higher pressure at the contact surface 170 and an increased tendency to wear.

[0024] The shape of the curved surface 170 is preferably cylindrical for simplicity, however more complex shapes (e.g., non-cylindrical curvilinear) may also be employed.

[0025] The preferred method of manufacture of the cage 134 is by press-working sheet metal: drawing, perforating, and shaping of the contact surfaces. These processes have increased difficulty with increased thickness especially as the cage diameter is increased. The manufacturing is facilitated by this preferred embodiment. Alternatively, the cage 134 may be produced by forging, turning, and milling. Various combinations of processes can alternatively be applied.

[0026] The invention can be applied to the described configuration where the cage 134 is smaller than the pitch circle of the bearing 10 or it can be applied to a cage 134 larger than the pitch circle that is centered by contact with the flange of the outer ring 14.

[0027] Although some aspects have been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of one or more independent aspects as described. Various features and advantages of the invention are set forth in the following claims.

CLAIMS

What is claimed is:

1. A roller bearing comprising:
 - an outer ring defining an outer raceway;
 - an inner ring defining an inner raceway;
 - a plurality of rolling elements positioned between the inner raceway and the outer raceway such that the outer ring is rotatable relative to the inner ring about a rotational axis;
 - and
 - a cage extending around the inner ring at a location between the inner ring and the outer ring, the cage having a plurality of bridges that at least partially define a plurality of openings, each opening configured to receive a corresponding one of the plurality of rolling elements therein to separate the plurality of rolling elements from one another,
 - wherein each bridge of the plurality of bridges includes a contact surface configured to contact an outer periphery of a corresponding one of the rolling elements, and
 - wherein the contact surfaces have a convex curvilinear form as viewed in a section taken through a plane normal to the rotational axis.
2. The roller bearing of claim 1, wherein the cage is limited in radial position at one extreme by contact with one of the outer ring or the inner ring.
3. The roller bearing of claim 1, wherein the contact surface extends between an inner edge at or adjacent to a radially inner surface of the bridge and an outer edge at or adjacent to a radially outer surface of the bridge.
4. The roller bearing of claim 3, wherein an angle formed between a first line tangent to the inner edge and a second line tangent to the outer edge is no greater than ten degrees.
5. The roller bearing of claim 3, wherein the contact surface extends from the radially inner surface of the bridge to the radially outer surface of the bridge.
6. The roller bearing of claim 3, further comprising a surface separate from the contact surface extending between the inner edge of the contact surface and the radially inner surface of the bridge.

7. The roller bearing of claim 3, wherein an angle formed between a first line tangent to the inner edge and a second line tangent to the outer edge is between two and ten degrees.
8. The roller bearing of claim 3, wherein the contact surface is configured to contact the corresponding one of the rolling elements at a location between the inner edge and the outer edge regardless of a radial spacing between a radially inner surface of the cage and a radially outer surface of the inner ring.
9. The roller bearing of claim 1, wherein the cage further comprises a first cage flange ring coupled to a second cage flange ring via the plurality of bridges, wherein the first and second cage flange rings at least partially define the plurality of openings configured to receive the plurality of rolling elements therein.
10. The roller bearing of claim 1, wherein an inner diameter of the cage is greater than an outer diameter of the inner ring by at least 0.3-0.6% of the outer diameter of the inner ring resulting in eccentricity of the cage relative to the inner ring.
11. The roller bearing of claim 1, wherein the contact surface is a first contact surface, and wherein each bridge of the plurality of bridges includes a second contact surface configured to contact an outer periphery of a different one of the rolling elements.
12. The roller bearing of claim 11, wherein a width of the bridge between the first and second contact surfaces monotonically decreases from the radially inner surface of the bridge to the radially outer surface of the bridge.
13. The roller bearing of claim 11, wherein the first contact surface is a mirror image of the second contact surface.
14. The roller bearing of claim 1, wherein the cage is configured to selectively contact the inner ring.
15. The roller bearing of claim 1, wherein the convex curvilinear form of the contact surface is cylindrical.
16. A cage for a roller bearing, the cage comprising:

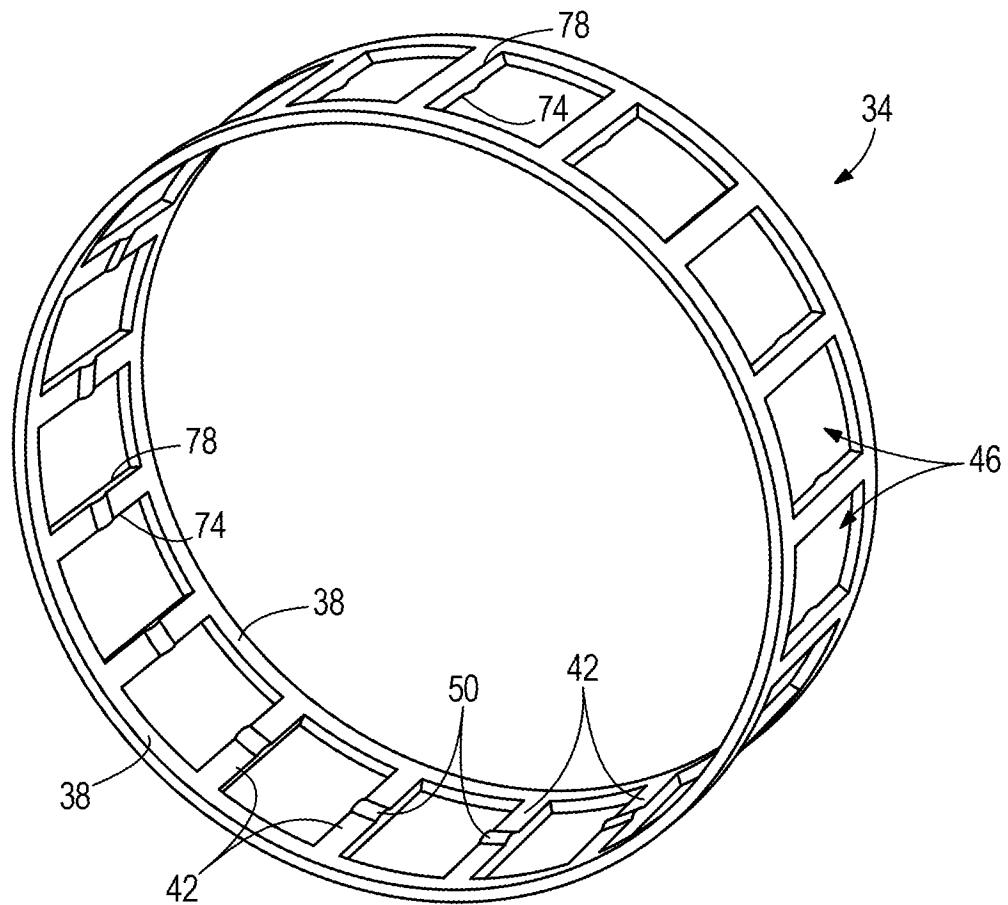
a first cage flange ring;
a second cage flange ring; and
a plurality of bridges that extend between the first cage flange ring and the second cage flange ring to connect the first cage flange ring to the second cage flange ring,
wherein the first cage flange ring, the second cage flange ring, and the bridges collectively define a plurality of pocket openings, each pocket opening configured to retain a corresponding one of a plurality of rolling elements, and
wherein a contact surface of each of the plurality of bridges has a convex curvilinear form as viewed in a plane that is perpendicular to a rotational axis of the cage.

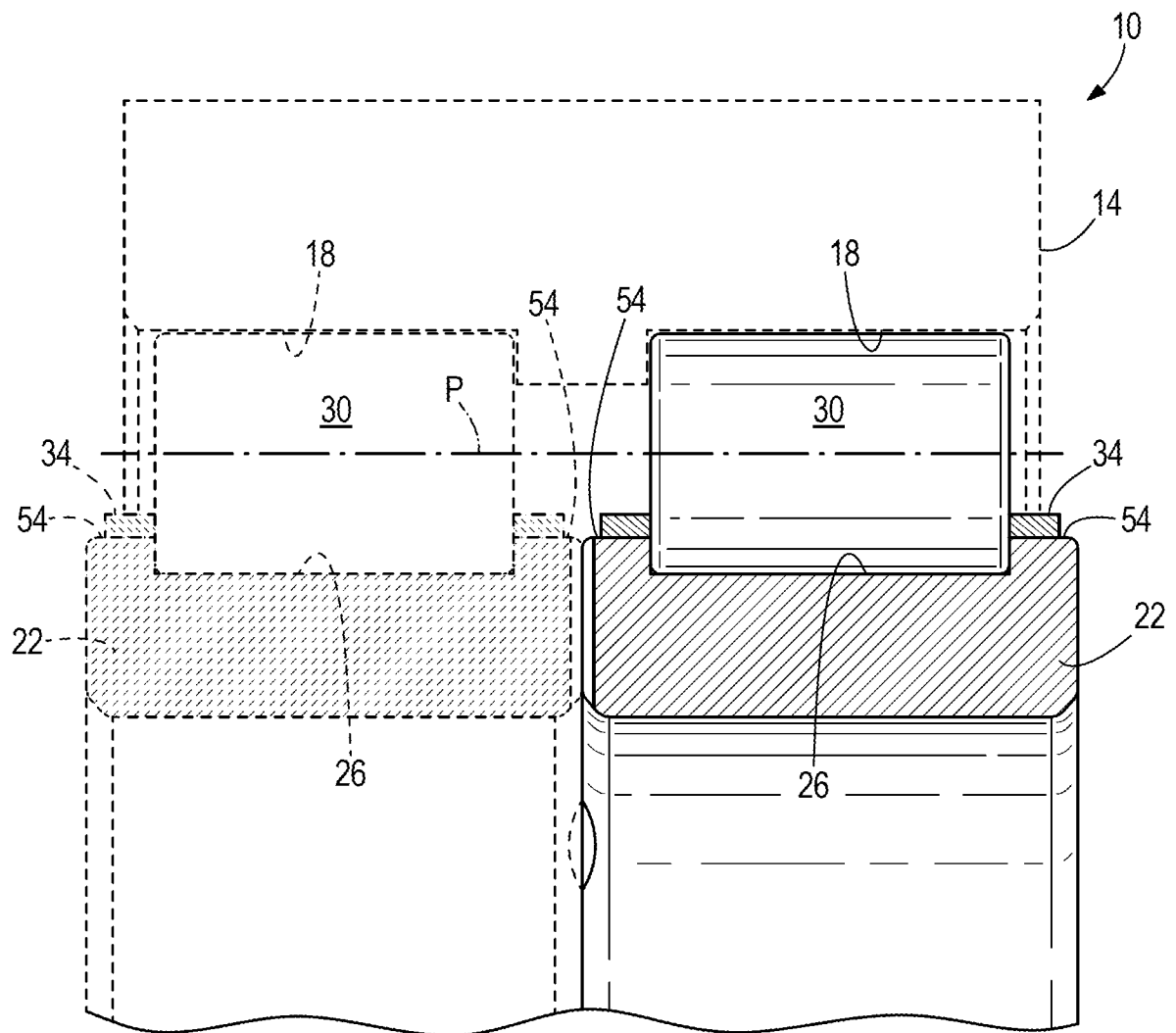
17. The cage of claim 16, wherein the contact surface extends between a first radial extreme and a second radial extreme, wherein a first line tangent to the convex curvilinear form at the first radial extreme and a second line tangent to the convex curvilinear form at the second radial extreme form an angle therebetween no greater than ten degrees.

18. The cage of claim 17, wherein the contact surface is configured to contact a corresponding one of the rolling elements at a location between the first and second radial extremes of the contact surface.

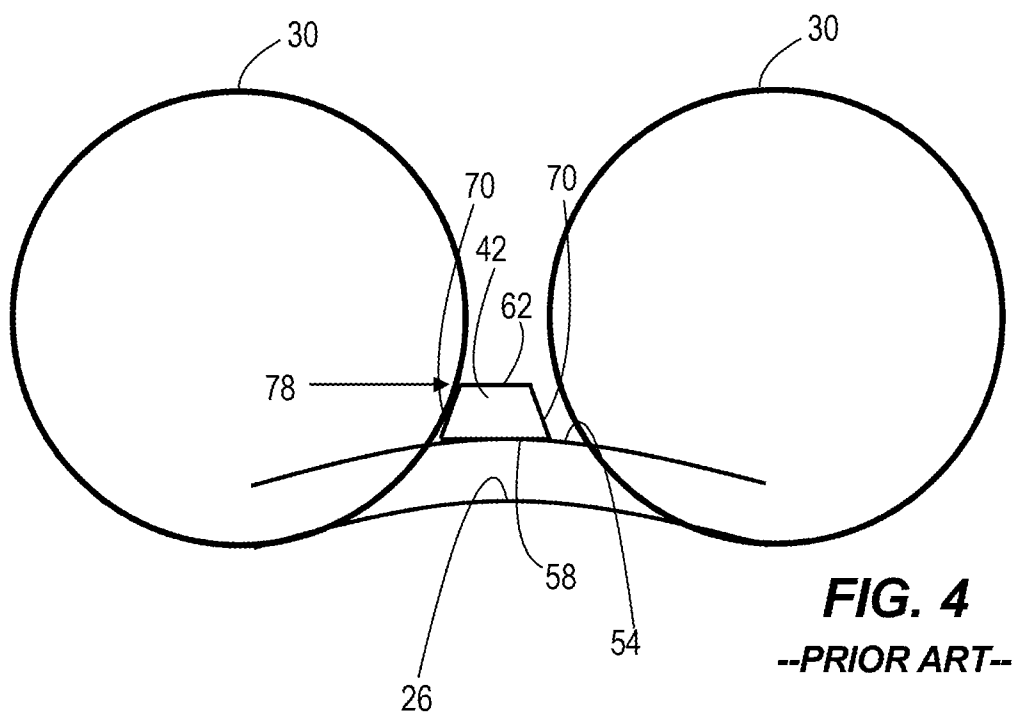
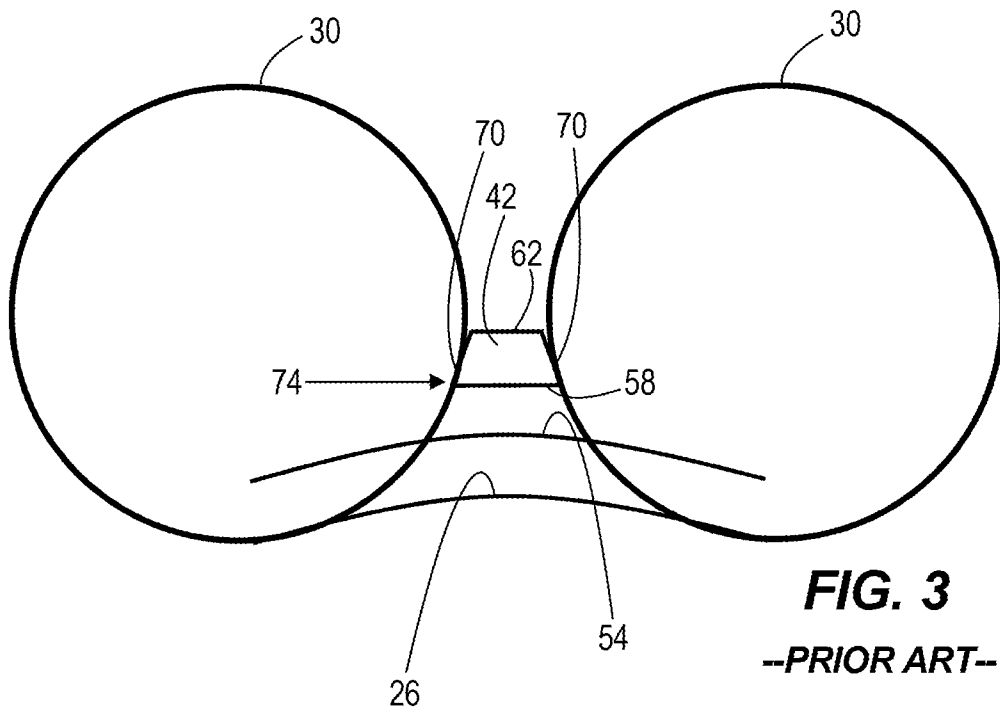
19. The cage of claim 16, wherein the contact surface extends from a radially inner surface of the bridge to a radially outer surface of the bridge.

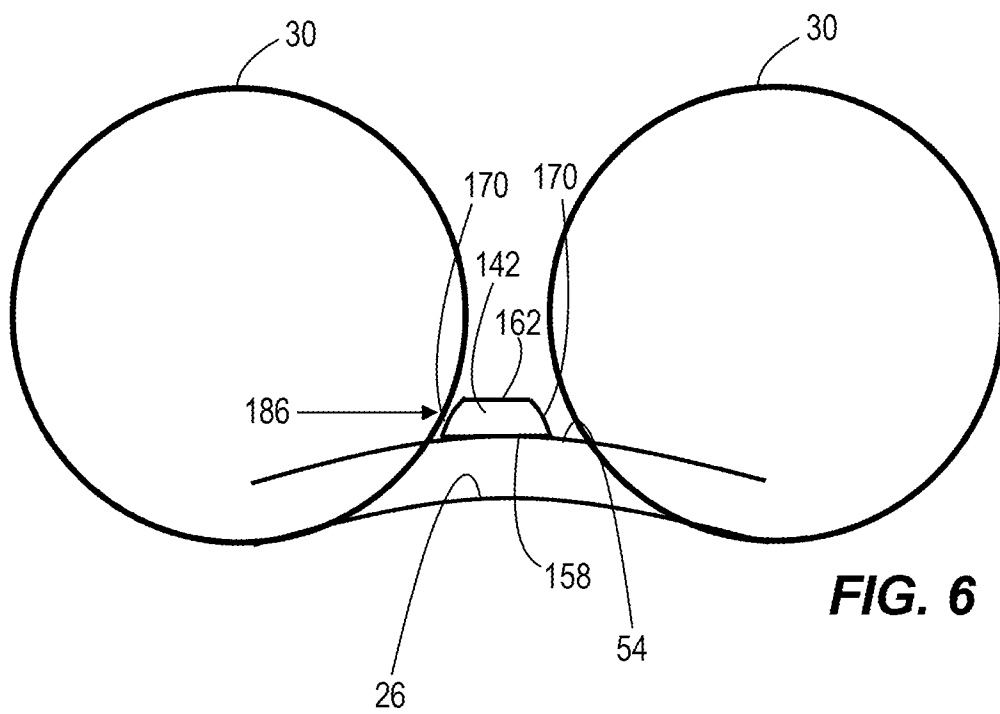
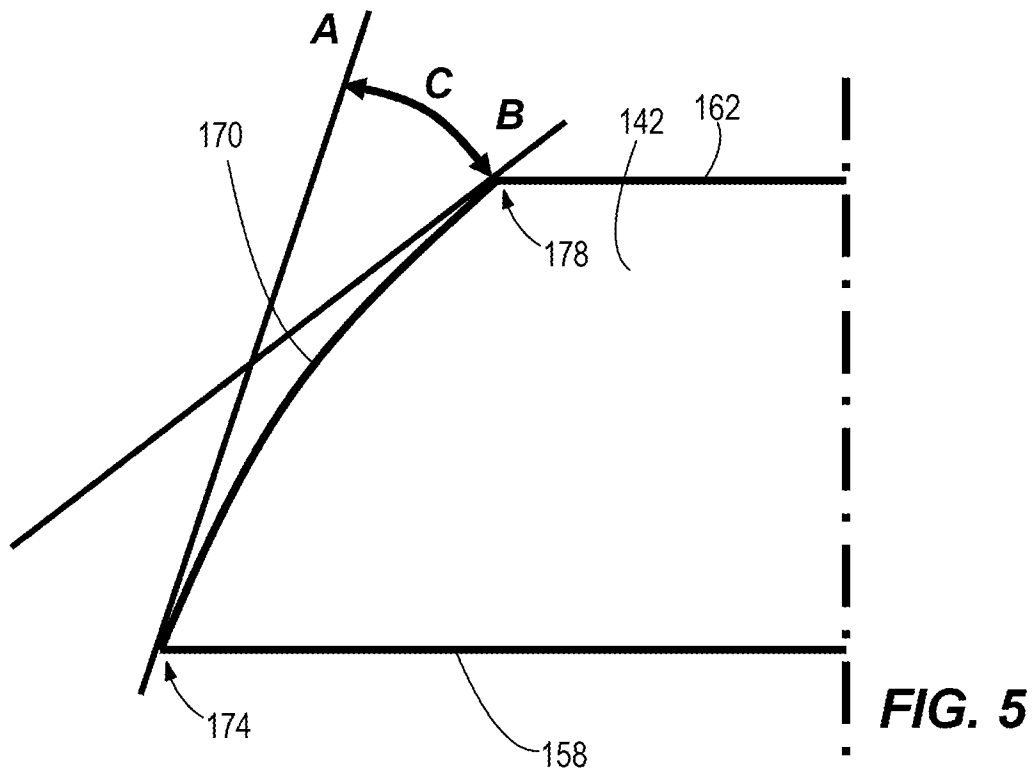
20. The cage of claim 16, wherein a separate surface extends at least partially in a radial direction between the contact surface and a radially inner surface of the cage.

**FIG. 1****--PRIOR ART--**

**FIG. 2**

--PRIOR ART--





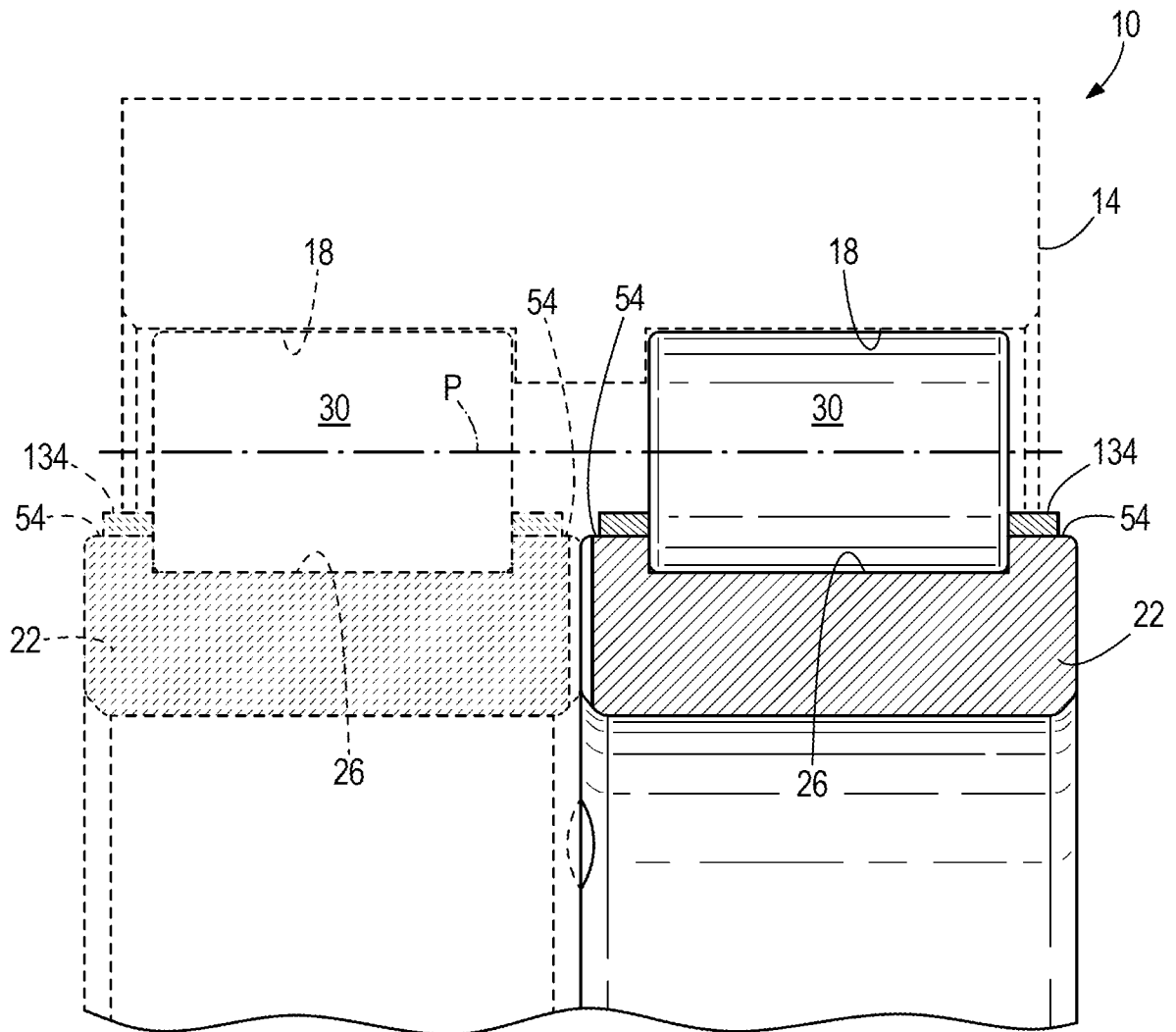
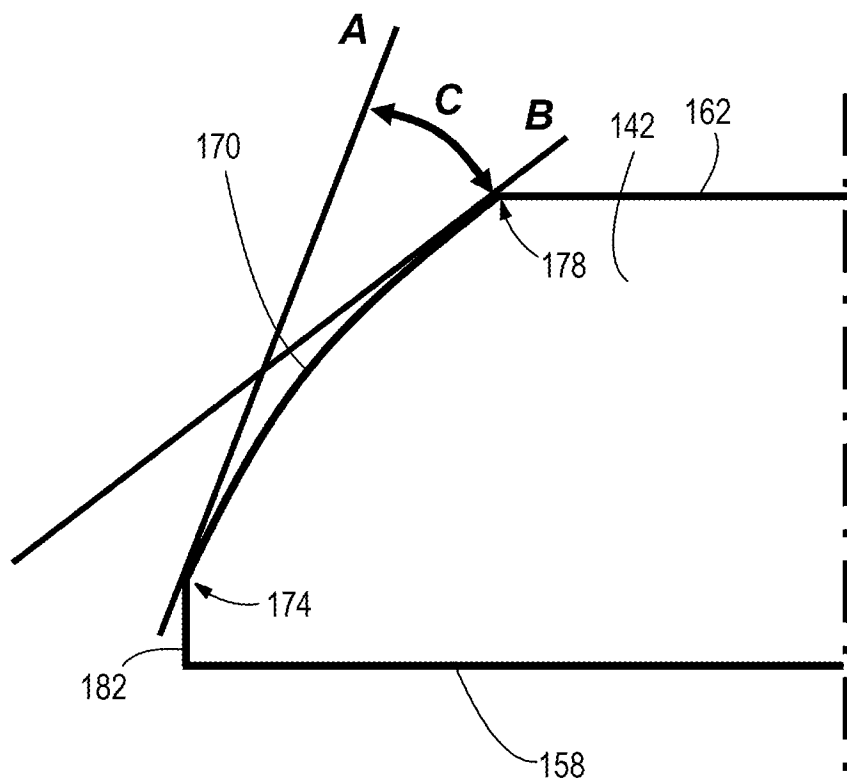


FIG. 7

**FIG. 8**

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2022/035445

A. CLASSIFICATION OF SUBJECT MATTER**INV. F16C33/46 F16C19/24****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)

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2008 069904 A (NSK LTD) 27 March 2008 (2008-03-27) figures 1, 4, 7 paragraph [0025] The references cited refer to the annexed automated translation of this document. -----	1-20
X	JP 2016 142278 A (NTN TOYO BEARING CO LTD) 8 August 2016 (2016-08-08) figures 1, 2, 3 paragraph [0024] The references cited refer to the annexed automated translation of this document. ----- -/--	1-5, 7-19



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

5 October 2022

Date of mailing of the international search report

11/10/2022

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European Patent Office, P.B. 5818 Patentlaan 2

NL - 2280 HV Rijswijk

Tel. (+31-70) 340-2040,

Fax: (+31-70) 340-3016

Authorized officer

Frechard, Fabrice

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2022/035445

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	figures 1, 2, 4 paragraphs [0001], [0026] -----	2
A	JP 2006 022935 A (NTN TOYO BEARING CO LTD) 26 January 2006 (2006-01-26) figure 5 -----	2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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