(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 412 924 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.12.2018 Bulletin 2018/50

(21) Application number: **18176503.3**

(22) Date of filing: **07.06.2018**

(51) Int Cl.:
F16C 13/00 *(2006.01)* ***F16H 53/06*** *(2006.01)*
F16C 33/60 *(2006.01)* ***F16C 33/78*** *(2006.01)*
F16C 19/06 *(2006.01)* ***F16C 33/58*** *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **07.06.2017 US 201762516244 P**

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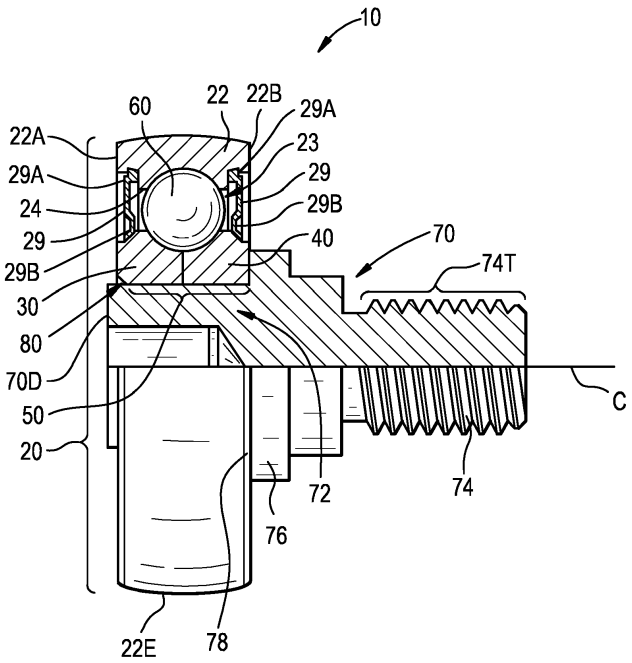
(54) BALL BEARING CAM FOLLOWER FOR AN ADJUSTABLE AIRCRAFT SEAT

(57) A cam follower assembly includes a ball bearing having an outer ring and an inner assembly which includes two or more segments. The inner assembly is disposed in the outer ring with a full complement of balls disposed therebetween. The outer ring and inner assembly each include a race having a gothic arch cross sectional configuration that causes the balls to roll on two portions of each race.

FIG. 1



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Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a non-provisional application of, and claims priority to, U.S. Provisional Application No. 62/516244, entitled "Ball Bearing Cam Follower For An Adjustable Aircraft Seat", filed on June 7, 2017, the entirety of which is incorporated by reference herein.

FIELD OF THE INVENTION

[0002] This invention relates to a cam follower for an adjustable aircraft seat and more particularly to a cam follower having a ball bearing that has a full complement of balls and an outer ring and inner assembly that each have a gothic arch bearing surface thereon, that is configured to accommodate misalignment of a track that the ball bearing travels in. The present invention also includes a method for assembling a cam follower.

BACKGROUND

[0003] Cam follower assemblies are used in many industrial manufacturing and conveying applications. The cam follower assemblies include a rolling bearing having an outer ring disposed around an inner ring with a plurality of rolling elements, typically needle rollers or balls, disposed in a cavity therebetween. In the case of ball bearing cam followers, it can be difficult to assemble cam follower because of limited space between the outer ring and inner ring for receiving the rolling elements. Typically, less than a full complement of balls is employed to provide space between the outer ring and inner ring for inserting the balls therebetween. When less than a full complement of balls is employed, the balls do not engage each other and there can be uneven spaces between the rolling elements. Typically, spacer rings are employed to evenly space the balls apart from one another. In addition, when less than a full complement of balls is employed the load capacity of the ball bearing is less than a comparable bearing using a full complement of balls. An annular seal is positioned on each axial end thereof, between the inner ring and the outer ring to keep debris from entering the cavity. The seals occupy an axial length of the cam follower assemblies and the yoke roller assemblies

[0004] Cam follower assemblies are subject to asymmetric loads when used in various applications causing misalignment between the cam follower and the surface it rolls on. The life and performance of the cam follower assemblies can be reduced as a result of the asymmetric loads and resulting misalignment. Cam followers are sometimes used in adjustable seats for aircraft. Use of the seats by people can impart the asymmetric loads on the cam follower due to misalignment of the seat structure relative to the cam follower.

[0005] Typically, standard needle roller cam followers are limited in handling side loads.

[0006] Thus, there is a need for an improved ball bearing cam follower that can overcome the foregoing problems associated with asymmetric loads, misalignment and assembly.

SUMMARY

[0007] There is disclosed herein a cam follower assembly that has a ball bearing disposed thereon. The ball bearing includes an outer ring that has an interior area which is defined by an inner surface extending between a first axial end and a second axial end of the outer ring. The inner surface has a first radially inward facing bearing surface and a second radially inward facing bearing surface. The inner surface also has a radially outward extending and inwardly facing first recessed surface located between the first radially inward facing bearing surface and a second radially inward facing bearing surface. The ball bearing includes an inner assembly that extends into the interior area of the outer ring. The inner assembly includes a first inner segment extending from a third axial end to a fourth axial end thereof; and a second inner segment extending from a fifth axial end to a sixth axial end thereof. The first inner segment has a first radially outward facing bearing surface and the second inner segment has a second radially outward facing bearing surface. The fourth axial end and the fifth axial end are abutted against each other. The inner assembly has a radially inward extending and radially outward facing second recessed surface located between the first radially outward facing bearing surface and the second radially outward facing bearing surface. A plurality balls is positioned in the interior area between the outer ring and the inner assembly. The balls are in rolling engagement with the first radially inward facing bearing surface and the second radially inward facing bearing surface of the outer ring. The balls are also in rolling engagement with the first radially outward facing bearing surface and the second radially outward facing bearing surface of the inner assembly. The plurality of balls rollingly engaging each other and are spaced apart from the first recessed surface and the second recessed surface. The cam follower assembly includes a shaft that has a bearing receiving portion and a mounting portion extending from the bearing receiving portion. The ball bearing is disposed on the bearing receiving portion such that the inner assembly is secured to the shaft.

[0008] In one embodiment, the cam follower has a shoulder positioned between the bearing receiving portion and the mounting portion. The shoulder extends radially outward from and circumferentially around the shaft. The second inner segment of the inner assembly abuts an axial face of the shoulder. The first inner segment is secured to the shaft, for example, by swaging, staking, pinning, a thermal fit and/or an interference press fit. In one embodiment, when the first inner segment is secured to the shaft by staking, an axial looseness of the first inner segment relative to the outer ring is between

about 0.0002 inches and about 0.0020 inches.

[0009] In one embodiment, the outer ring has a crowned exterior surface, for example, an arcuate shape having a radius of curvature.

[0010] In one embodiment, the ball bearing has one or more seals extending between the outer ring and the inner assembly.

[0011] In one embodiment, the mounting portion has a male threaded area thereon or a female threaded area therein.

[0012] In one embodiment, each of the plurality of balls has a radius that extends from a center of the ball. The centers of the balls trace a reference circle around the inner assembly. The centers of the balls are aligned along a common radially extending reference plane. The first radially inward facing bearing surface has a first radius of curvature that extend from a first origin located radially inward from the reference circle and axially offset from the reference plane towards the second inner segment. The second radially inward facing bearing surface having a second radius of curvature that extends from a second origin located radially inward from the reference circle and axially offset from the reference plane towards the first inner segment, such that the first recessed surface, the first radially inward facing bearing surface and the second radially inward facing bearing surface form a first gothic arch cross sectional configuration. The first radially outward facing bearing surface has a third radius of curvature extending from a third origin located radially outward from the reference circle and axially offset from the reference plane towards the second inner segment. The second radially outward facing bearing surface has a fourth radius of curvature that extends from a fourth origin located radially outward from the reference circle and axially offset from the reference plane towards the first inner segment, such that the second recessed surface, the first radially outward facing bearing surface and the second radially outward facing bearing surface form a second gothic arch cross section configuration. The first gothic arch and the second gothic arch are configured to accommodate external loads applied to the ball bearing due to misalignment.

[0013] There is further disclosed herein a track roller bearing assembly that includes a frame and a cam follower assembly. The frame includes a base section that has a first side and a second side opposite the first side. The frame includes a connection section that extends outwardly from the first side. The connection section has one or more legs that can form a channel for receiving a rail of an adjustable aircraft seat. The frame includes a track that extends from the second side. The track has a first bearing containment member and a second bearing containment member that extends outwardly from the second side. The first bearing containment member and the second bearing containment member are spaced apart from one another creating a cavity for receiving a ball bearing therein. The first bearing containment member has a leg that has a extending therefrom which has a rolling engagement surface thereon. The rolling engagement surface is substantially parallel to and faces the second side. The second bearing containment member has an opening extending therethrough. The track roller bearing assembly includes a cam follower assembly. The cam follower assembly has a ball bearing disposed thereon. The ball bearing includes an outer ring that has an interior area which is defined by an inner surface extending between a first axial end and a second axial end of the outer ring. The inner surface has a first radially inward facing bearing surface and a second radially inward facing bearing surface. The inner surface also has a radially outward extending and inwardly facing first recessed surface located between the first radially inward facing bearing surface and a second radially inward facing bearing surface. The ball bearing includes an inner assembly that extends into the interior area of the outer ring. The inner assembly includes a first inner segment extending from a third axial end to a fourth axial end thereof; and a second inner segment extending from a fifth axial end to a sixth axial end thereof. The first inner segment has a first radially outward facing bearing surface and the second inner segment has a second radially outward facing bearing surface. The fourth axial end and the fifth axial end are abutted against each other. The inner assembly has a radially inward extending and radially outward facing second recessed surface located between the first radially outward facing bearing surface and the second radially outward facing bearing surface. A plurality balls is positioned in the interior area between the outer ring and the inner assembly. The balls are in rolling engagement with the first radially inward facing bearing surface and the second radially inward facing bearing surface of the outer ring. The balls are also in rolling engagement with the first radially outward facing bearing surface and the second radially outward facing bearing surface of the inner assembly. The plurality of balls rollingly engaging each other and are spaced apart from the first recessed surface and the second recessed surface. The cam follower assembly includes a shaft that has a bearing receiving portion and a mounting portion extending from the bearing receiving portion. The ball bearing is disposed on the bearing receiving portion such that the inner assembly is secured to the shaft.

[0014] In one embodiment, the cam follower has a shoulder positioned between the bearing receiving portion and the mounting portion. The shoulder extends radially outward from and circumferentially around the shaft. The second inner segment of the inner assembly abuts an axial face of the shoulder. The first inner segment is secured to the shaft, for example, by swaging, staking, pinning, a thermal fit and/or an interference press fit. In one embodiment, when the first inner segment is secured to the shaft by staking, an axial looseness of the first inner segment relative to the outer ring is between about 0.0002 inches and about 0.0020 inches.

[0015] In one embodiment, the outer ring has a crowned exterior surface, for example, an arcuate shape

having a radius of curvature.

[0016] In one embodiment, the ball bearing has one or more seals extending between the outer ring and the inner assembly.

[0017] In one embodiment, the mounting portion has a male threaded area thereon or a female threaded area therein.

[0018] In one embodiment, each of the plurality of balls has a radius that extends from a center of the ball. The centers of the balls trace a reference circle around the inner assembly. The centers of the balls are aligned along a common radially extending reference plane. The first radially inward facing bearing surface has a first radius of curvature that extend from a first origin located radially inward from the reference circle and axially offset from the reference plane towards the second inner segment. The second radially inward facing bearing surface having a second radius of curvature that extends from a second origin located radially inward from the reference circle and axially offset from the reference plane towards the first inner segment, such that the first recessed surface, the first radially inward facing bearing surface and the second radially inward facing bearing surface form a first gothic arch cross sectional configuration. The first radially outward facing bearing surface has a third radius of curvature extending from a third origin located radially outward from the reference circle and axially offset from the reference plane towards the second inner segment. The second radially outward facing bearing surface has a fourth radius of curvature that extends from a fourth origin located radially outward from the reference circle and axially offset from the reference plane towards the first inner segment, such that the second recessed surface, the first radially outward facing bearing surface and the second radially outward facing bearing surface form a second gothic arch cross section configuration. The first gothic arch and the second gothic arch are configured to accommodate external loads applied to the ball bearing due to misalignment.

[0019] There is further disclosed herein a method for assembling a cam follower. The method includes providing an outer ring, an inner assembly having at least two inner segments, a plurality of balls and a shaft having a shoulder formed thereon. Each of the outer ring and the two inner segments has a gothic arch shaped bearing surface therein. The method includes disposing the second inner segment in the outer ring. The method includes installing a full complement of balls between the outer ring and the second inner segment so that the balls engage a portion of the bearing surface. The method includes disposing the first inner segment in the outer ring so that the balls are retained between the outer ring and the inner assembly and so that the balls engage the first radially outward facing bearing surface. The method includes disposing the outer ring and inner assembly with the full complement of balls therein on the shaft such that the second inner segment engages the shoulder and the first inner segment and the second inner segment abut against each other. The method includes securing first inner segment to the shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is a split cross sectional and front view of the cam follower assembly of the present invention;

FIG. 2 is a perspective view of the cam follower assembly of FIG. 1 with a portion cut away to show a plurality of balls therein;

FIG. 3 is an enlarged view of an outer ring and a portion of a ball of a ball bearing employed in the cam follower assembly of the present invention;

FIG. 4 is an enlarged view of an inner assembly and a portion of a ball of a ball bearing employed in the cam follower assembly of the present invention;

FIG. 5 is a cross sectional view of the cam follower assembly of the present invention shown installed in an aircraft seat structure and track for a seat of an aircraft, shown in an unloaded state;

FIG. 6 is a cross sectional view of the cam follower assembly of the present invention shown installed in an aircraft structure and track for a seat of an aircraft, shown in an asymmetrically loaded state with the track misaligned relative to the ball bearing;

FIG. 7 is a perspective view of the cam follower assembly of FIG. 2 rollingly engaged with a surface of a track for a seat of an aircraft; and

FIG. 8 is partial split cross sectional and front view of the cam follower assembly of FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

[0021] Referring to FIGS. 1 and 2, a cam follower assembly is generally designated by the numeral 10. The cam follower assembly 10 includes a ball bearing 20. The ball bearing 20 includes an outer ring 22 having an interior area 23. The interior area 23 is defined by an inner surface 24 extending between a first axial end 22A and a second axial end 22B of the outer ring 22. As best shown in FIG. 3, the inner surface 24 has a first radially inward facing bearing surface 26A and a second radially inward facing bearing surface 26B and a radially outward extending and inwardly facing first recessed surface 26C therebetween.

[0022] As shown in FIG. 1 the ball bearing 20 includes an inner assembly 50 that extends into (e.g., is disposed in) the interior area 23 of the outer ring 22. As best shown in FIG. 4, the inner assembly 50 includes a first inner segment 30 that extends from a third axial end 30A to a fourth axial end 30B thereof. The inner assembly 50 also includes a second inner segment 40 that extends from a fifth axial end 40A to a sixth axial end 40B thereof. The first inner segment 30 has a first radially outward facing bearing surface 32 and the second inner segment 40 has a second radially outward facing bearing surface 42. The

fourth axial end 30B and the fifth axial end 40A are abutted against each other and form a juncture 34. A radially inward extending and radially outward facing second recessed surface 50C, 50C' are formed between the first radially outward facing bearing surface 32 and the second radially outward facing bearing surface 42.

[0023] As shown in FIGS. 1, 3 and 4, in one embodiment, the ball bearing 20 includes a seal 29 that extends between the outer ring 22 and the inner assembly 50. As best seen in FIG. 1, the seal 29 includes an anchor portion 29A that is secured to the outer ring 22 and a sealing portion 29B that slidingly engages the inner assembly 50.

[0024] As shown in FIGS. 1 and 2, a plurality of balls 60 (i.e., a full complement of spherical balls) is positioned in the interior area 23 in rolling engagement with the first radially inward facing bearing surface 26A and the second radially inward facing bearing surface 26B and the first radially outward facing bearing surface 32 and the second radially outward facing bearing surface 42. The plurality of balls 60 are positioned between the outer ring 22 and the inner assembly 50. The plurality of balls 60 rollingly engage each other to form the full complement of balls with no spacers or gaps between the balls 60 to increase load capacity of the ball bearing 20 compared to other ball bearings having less than a full complement of balls. The balls 60 are spaced apart from the first recessed surface 26C and the second recessed surface 50C, 50C' such that rolling of the balls 60 is not interrupted or otherwise disturbed by the juncture 34.

[0025] As shown in FIGS. 1 and 2, the cam follower assembly 10 includes a shaft 70 having a bearing receiving portion 72 and a mounting portion 74 extending from the bearing receiving portion 72. In one embodiment the mounting portion 74 includes a threaded area 74T (e.g., male thread as shown or a female thread, not shown, inside the mounting portion 74). The ball bearing 20 is disposed on the bearing receiving portion 72 such that the inner assembly 50 is secured to the shaft 70. The shaft 70 includes a shoulder 76 positioned between the bearing receiving portion 72 and the mounting portion 74. The shoulder 76 extends radially outward from and circumferentially around the shaft 70. The sixth axial end 40B of the second inner segment 40 abuts an axial face 78 of the shoulder 76.

[0026] As shown in FIG. 1, the first inner segment 30 is secured to the shaft 70 proximate a distal end 70D thereof, by staking. The second inner segment 40 is secured against the axial face 78 of the shoulder 76 by the first inner segment 30 being abutted against the second inner segment 40. While the first inner segment 30 is shown and described as being secured to the shaft 70 by staking, the present invention is not limited in this regard as the first inner segment 30 may be secured to the shaft 70 by swaging, staking, pinning, a thermal fit and/or an interference press fit.

[0027] As shown in FIG. 8 the first inner segment 30 is secured to the shaft 70 by staking at a staking area 80. If the first inner segment 30 is under staked (i.e., staked too loosely), it will result in separation of the first inner segment 30 and the second inner segment 40. In particular, if under staked, separation of the first inner segment 30 and the second inner segment 40 from one another occurs in directions D_3 and D_4, respectively. Directions D_3 and D_4 are parallel relative to the centerline C of the bearing 10. If the first inner segment 30 is over staked (i.e., staked too tightly), it will result in the first inner segment 30 and the second inner segment 40 moving towards each other in directions opposite of directions D_3 and D_4. It is preferred that the first inner segment 30 is secured to the shaft 70 by staking to create an axial looseness between the inner segments 30, 40 and the outer ring 22, as shown by distances D_4 and D_5. In one embodiment, the sum of distance D_4 and distance D_5 is between about 0.0002 inches to about 0.0020 inches. In one embodiment, a staking groove 20G is provided in the distal end 70D so that a portion 20Q of the distal end 70D is plastically deformed into the staking area 80 as indicated by the arrow Q10 in FIG. 8.

[0028] As best shown in FIG. 3, the outer ring 22 has a crowned exterior surface 22E, for example, an arcuate surface having a radius of curvature.

[0029] As best shown in FIG. 3, each of the plurality of balls 60 has a radius R1 extending from a center 60C of the ball 60. The centers 60C of the plurality of balls 60 trace a reference circle around the inner assembly 50. The centers 60C of the balls 60 are aligned along a common radially extending reference plane P1. The first radially inward facing bearing surface 26A has a first radius of curvature R2 that extends from a first origin C2 located radially inward from the reference circle and axially offset (i.e., in the direction of the arrow K1) from the reference plane P1 towards the second inner segment 40. The second radially inward facing bearing surface 26B has a second radius of curvature R3 that extends from a second origin C3 located radially inward from the reference circle and axially offset (i.e., in the direction of the arrow K2) from the reference plane P1 towards the first inner segment 30, such that the first recessed surface 26C, the first radially inward facing bearing surface 26A and the second radially inward facing bearing surface 26B form a first gothic arch cross sectional configuration.

[0030] As shown in FIG. 4, the first radially outward facing bearing surface 32 has a third radius of curvature R4 that extends from a third origin C4 located radially outward from the reference circle and axially offset (i.e., in the direction of the arrow K1) from the reference plane P1 towards the second inner segment 40. The second radially outward facing bearing surface 42 has a fourth radius of curvature R5 that extends from a fourth origin C5 located radially outward from the reference circle and axially offset (i.e., in the direction of the arrow K2) from the reference plane P1 towards the first inner segment 30, such that the second recessed surface 50C, 50C', the first radially outward facing bearing surface 32 and the second radially outward facing bearing surface 42 form a second gothic arch cross section configuration.

The first gothic arch and the second gothic arch are configured to accommodate external loads applied to the ball bearing 20 due to misalignment as described herein.

[0031] As shown in FIG. 5, a track roller bearing assembly 100 includes a frame 90. The frame 90 has a base section 91 having a first side 91A and a second side 91B opposite the first side 91A. A connection section 92 extends outwardly from the first side 91A and has two legs 92A and 92B that form a channel 92C therebetween. The connection section 92 is secured to a seat rail 99 (e.g., a seat rail of a slidable aircraft seat) with fasteners 93. A track 94 extends from the second side 91B. The second side 91B is spaced apart from the exterior surface 22E of the outer ring 22 by a gap G5. The track 94 has a first bearing containment member 95A and a second bearing containment member 95B that extends outwardly from the second side 91B. The first bearing containment member 95A and the second bearing containment member 95B are spaced apart from one another. The first bearing containment member 95A has a leg 96 extending therefrom. The leg 96 has a rolling engagement surface 96E thereon. The rolling engagement surface 96E is substantially parallel to and faces the second side 91B. A portion of the second containment member 95B includes a lip 95B' that extends away from the leg 96, towards the second side 91B. The second bearing containment member 95B has an opening 95C between the second bearing containment member 95B and the lip 95B'.

[0032] As shown in FIGS. 5 and 6, the mounting portion 74 of the cam follower assembly 10 is secured to a structural seat member 98 of the aircraft. The track 94 guides the outer ring 22 of the cam follower assembly 10 as the ball bearing 20 rolls in the track 94 (i.e., the exterior surface 22E of the outer ring 22 in rolling contact with the rolling engagement surface 96E) when the structural seat member 98 moves during adjustment of the position of the aircraft seat. If loads on the seat are below a predetermined threshold, the rolling contact between the exterior surface 22E of the outer ring 22 and the rolling engagement surface 96E are aligned along the reference plane P1. The mounting portion 72 of the shaft 70 extends through the opening 95C between the second containment member 95B and the lip 95B', such that the exterior surface 22E of the outer ring 22 rollingly engages the rolling engagement surface 96E.

[0033] As shown in FIG. 6, the exterior surface 22E is configured to accommodate misalignment of the frame 90 relative to the ball bearing 20 by maintaining rolling engagement of the exterior surface 22E with the rolling engagement surface 96E during such misalignment. For example, as shown in FIG. 6, when a load is applied to the seat, a torque T1 is applied to the structural seat member 98 so that the frame 90 is misaligned relative to the ball bearing 20 such that a central plane P2 of the frame 90 is angularly displaced by an angle θ relative to the reference plane P1. With a load applied to the seat, rolling contact between the exterior surface 22E of the outer ring 22 and rolling engagement surface 96E are aligned along the reference plane P2. In the misaligned configuration or upon application of axial loads to the structural seat member 98, the axial ends 22A and 22B of the outer ring 22 slidingly engage and are retained by inside surfaces of the first bearing containment member 95A, the first bearing containment member 95B and the lip 95B'. In one embodiment, one or more spacers (e.g., metal discs or rings or lubricious pads, rings or discs) are disposed between: 1) the axial end 22A and the inside surface of the first bearing containment member 95A; and/or 2) the axial end 22B and the inside surface of the second bearing containment member 95B and/or the lip 95B'.

[0034] The ball bearing 20 accommodates the misalignment of the frame 90 relative to the ball bearing 20by transferring load applied to the outer ring 22 by the seat rail 99 to a two point contact with the balls 60 and the outer ring 22 at circumferential lines of contact X1 and X2 and from the balls 60 and the inner assembly 50 at circumferential lines of contact Y1 and Y2 (shown in FIGS. 3 and 4).

[0035] The ball bearing 20 facilitates movement of the cam follower assembly 10 a distance along the rolling engagement surface 96E of the track 94. As shown in FIG. 7, the cam roller assembly 10 can move in a first direction D_1 and a second direction D_2 along the rolling engagement surface 96E. In one embodiment, the cam follower assembly 10 moves a distance between about 2.0 inches to about 3.0 inches in either first direction D_1 or second direction D_2. In another embodiment, the cam follower assembly 10 moves a distance between about 2.5 inches to about 3.0 inches in either first direction D_1 or second direction D_2. The ball bearing 20 is subject to multiple revolutions during use of the cam follower assembly 10. When the cam follower assembly 10 moves a distance between about 2.5 inches to about 3.0 inches, the outer ring 22 undergoes between about 1 to about 1.5 revolutions.

[0036] The present invention also includes a method for assembling a cam follower assembly 10. The method includes providing an outer ring 22, an inner assembly 50 having at least two inner segments 30, 40, a plurality of balls 60 and a shaft 70 having a shoulder 76 formed thereon. Each of the outer ring 22 and at least two inner segments 30, 40 has a gothic arch shaped bearing surface (i.e., the first gothic arch configuration including the first recessed surface 26C, the first radially inward facing bearing surface 26A and the second radially inward facing bearing surface 26B, as shown in FIG. 3; and the second gothic arch configuration including the second recessed surface 50C, 50C', the first radially outward facing bearing surface 32 and the second radially outward facing bearing surface 42, as shown in FIG. 4) therein. The method includes disposing the second inner segment 40 in the outer ring 22. The method includes installing a full complement of balls 60 between the outer ring 22 and the second inner segment 40 so that the balls 60

engage a portion of the bearing surface (e.g., the second radially outward facing bearing surface 42, the first radially inward facing bearing surface 26A and the second radially inward facing bearing surface 26B). The method includes disposing the first inner segment 30 in the outer ring 22 so that the balls 60 are retained between the outer ring 22 and the inner assembly 50 and so that the balls engage the first radially outward facing bearing surface 32. The method includes disposing the outer ring 22 and inner assembly 50 with the full complement of balls 60 therein on the shaft 70 such that the second inner segment 40 engages the shoulder 76 and the first inner segment and the second inner segment abut against each other. The method includes securing first inner segment 30 to the shaft 70.

[0037] Although the invention has been described with reference to particular embodiments thereof, it will be understood by one of ordinary skill in the art, upon a reading and understanding of the foregoing disclosure that numerous variations and alterations to the disclosed embodiments will fall within the scope of this invention and of the appended claims.

Claims

1. A cam follower assembly (10) comprising:

a ball bearing (20) comprising:

an outer ring (22) having an interior area (23), the interior area (23) being defined by an inner surface (24) extending between a first axial end (22A) and a second axial end (22B) of the outer ring (22), the inner surface (23) having a first radially inward facing bearing surface (26A) and a second radially inward facing bearing surface(26B) and a radially outward extending and inwardly facing first recessed surface (26C) therebetween;

an inner assembly (50) extending into the interior area (23), the inner assembly (50) comprising a first inner segment (30) extending from a third axial end (30A) to a fourth axial end (30B) thereof and a second inner segment (40) extending from a fifth axial end (40A) to a sixth axial end (40B) thereof, the first inner segment (30) having a first radially outward facing bearing surface (32) and the second inner segment (40) having a second radially outward facing bearing surface (42), the fourth axial end (30B) and the fifth axial end (40A) being abutted against each other and a radially inward extending and radially outward facing second recessed surface (50C, 50C') between the first radially outward facing bearing surface (32) and the second radially outward facing bearing surface (42); and

a plurality of balls (60) positioned in the interior area (23) between the outer ring (22) and the inner assembly (50) and in rolling engagement with the first radially inward facing bearing surface (26A) and the second radially inward facing bearing surface (26B) and the first radially outward facing bearing surface (32) and the second radially outward facing bearing surface (42), the plurality of balls (60) rollingly engaging each other and being spaced apart from the first recessed surface (26C) and the second recessed surface (50C, 50C');

a shaft (70) having a bearing receiving portion (72) and a mounting portion (74) extending from the bearing receiving portion (72); and

the ball bearing (20) being disposed on the bearing receiving portion (72) such that the inner assembly (50) is secured to the shaft (70).

2. The cam follower assembly (10) of claim 1, further comprising a shoulder (76) positioned between the bearing receiving portion (72) and the mounting portion (74), the shoulder (76) extending radially outward from and circumferentially around the shaft (70) and the second inner segment (40) abutting an axial face (78) of the shoulder (76).

3. The cam follower assembly (10) of any one of the preceding claims, wherein the first inner segment (30) is secured to the shaft (70) by at least one of swaging, staking, pinning, a thermal fit and an interference press fit, wherein when the first inner segment is secured to the shaft by staking, an axial looseness of the first inner segment (30) relative to the outer ring (22) is between about 0.0002 inches and about 0.0020 inches.

4. The cam follower assembly (10) of any one of the preceding claims, wherein the outer ring (22) comprises a crowned exterior surface (22E) comprising an arcuate shape having a radius of curvature.

5. The cam follower assembly (10) of any one of the preceding claims further comprising at least one seal (29) extending between the outer ring (22) and the inner assembly (50).

6. The cam follower assembly (10) of any one of the preceding claims, wherein the mounting portion (74) comprises a threaded area (74T).

7. The cam follower assembly (10) according to any one of the preceding claims, wherein each of the plurality of balls (60) has a radius (R1) extending

from a center (60C) of the ball (60), the centers (60C) of the plurality of balls (60) tracing a reference circle around the inner assembly (50), the centers (60C) of the balls (60) being aligned along a common radially extending reference plane (P1);

the first radially inward facing bearing surface (26A) having a first radius of curvature (R2) extending from a first origin (C2) located radially inward from the reference circle and axially offset from the reference plane (P1) towards the second inner segment (40), the second radially inward facing bearing surface (26B) having a second radius of curvature (R3) extending from a second origin (C3) located radially inward from the reference circle and axially offset from the reference plane (P1) towards the first inner segment (30), such that the first recessed surface (26C), the first radially inward facing bearing surface (26A) and the second radially inward facing bearing surface (26B) form a first gothic arch cross sectional configuration;
the first radially outward facing bearing surface (32) having a third radius of curvature (R4) extending from a third origin (C4) located radially outward from the reference circle and axially offset from the reference plane (P1) towards the second inner segment (40), the second radially outward facing bearing surface (42) having a fourth radius of curvature (R5) extending from a fourth origin (C5) located radially outward from the reference circle and axially offset from the reference plane (P1) towards the first inner segment (30), such that the second recessed surface (50C, 50C'), the first radially outward facing bearing surface (32) and the second radially outward facing bearing surface (42) form a second gothic arch cross section configuration; and
wherein the first gothic arch and the second gothic arch are configured to accommodate external loads applied to the ball bearing (20) due to misalignment.

8. The cam follower assembly (10) according to any one of claims 1-7 installed in a track roller bearing assembly (100), the track roller bearing assembly (100) comprising:

a frame (90) comprising:

a base section (91) having a first side (91A) and a second side (91B) opposite the first side (91A);
a connection section (92) extending outwardly from the first side (91A), the connection section (92) having at least one first leg (92A, 92B);
a track (94) extending from the second side (91B), the track (94) having a first bearing containment member (95A) and a second bearing containment member (95B) extending outwardly from the second side (91B), the first bearing containment member (95A) and the second bearing containment member (95B) being spaced apart from one another, the first bearing containment member (95A) has a second leg (96) extending therefrom, the second leg (96) having a rolling engagement surface (96E) extending therefrom, the rolling engagement surface (96E) being substantially parallel to and facing the second side (91B), the second bearing containment member (95B) having an opening (95C) extending therethrough;

the mounting portion (72) extending through the opening (95C) in the second containment member (95B) such that the exterior surface (22E) of the outer ring (22) rollingly engages the rolling engagement surface (96E), the exterior surface (22E) being configured to accommodate misalignment of the frame (90) relative to the ball bearing (20) by maintaining rolling engagement of the exterior surface (22E) with the rolling engagement surface (96E) during such misalignment.

9. The cam follower assembly (10) of claim 8, further comprising a shoulder (76) positioned between the bearing receiving portion (72) and the mounting portion (74), the shoulder (76) extending radially outward from and circumferentially around the shaft (70) and the second inner segment (40) abutting an axial face (78) of the shoulder (76).

10. The cam follower assembly (10) of claim 8 or claim 9, wherein the first inner segment (30) is secured to the shaft (70) by at least one of swaging, staking, pinning, a thermal fit and an interference press fit, wherein when the first inner segment is secured to the shaft by staking, an axial looseness of the first inner segment (30) relative to the outer ring (22) is between about 0.0002 inches and about 0.0020 inches.

11. The cam follower assembly (10) according to any one of claims 8-10, wherein the exterior surface (22E) of the outer ring (22) is crowned, wherein the crowned surface comprises an arcuate shape having a radius of curvature.

12. The cam follower assembly (10) according to any one of claims 8-11, further comprising at least one seal (29) extending between the outer ring (22) and the inner assembly (50).

13. The cam follower assembly (10) according to any one of claims 8-12, wherein the mounting portion (74) comprises a threaded area (74T).

14. The cam follower assembly (10) according to any one of claims 8-13, wherein each of the plurality of balls (60) has a radius (R1) extending from a center (60C) of the ball (60), the centers (60C) of the plurality of balls (60) tracing a reference circle around the inner assembly (50), the centers (60C) of the balls (60) being aligned along a common radially extending reference plane (P1);

the first radially inward facing bearing surface (26A) having a first radius of curvature (R2) extending from a first origin (C2) located radially inward from the reference circle and axially offset from the reference plane (P1) towards the second inner segment (40), the second radially inward facing bearing surface (26B) having a second radius of curvature (R3) extending from a second origin (C3) located radially inward from the reference circle and axially offset from the reference plane (P1) towards the first inner segment (30), such that the first recessed surface (26C), the first radially inward facing bearing surface (26A) and the second radially inward facing bearing surface (26B) form a first gothic arch cross sectional configuration;

the first radially outward facing bearing surface (32) having a third radius of curvature (R4) extending from a third origin (C4) located radially outward from the reference circle and axially offset from the reference plane (P1) towards the second inner segment (40), the second radially outward facing bearing surface (42) having a fourth radius of curvature (R5) extending from a fourth origin (C5) located radially outward from the reference circle and axially offset from the reference plane (P1) towards the first inner segment (30), such that the second recessed surface (50C, 50C'), the first radially outward facing bearing surface (32) and the second radially outward facing bearing surface (42) form a second gothic arch cross section configuration; and

wherein the first gothic arch and the second gothic arch are configured to accommodate external loads applied to the ball bearing (20) due to misalignment of the frame (90) relative to the ball bearing.

15. A method for assembling a cam follower assembly (10) according to any one of the preceding claims, the method comprising:

providing the outer ring (22), the inner assembly (50) having the at least two inner segments (30, 40), the plurality of balls (60) and the shaft (70) having a shoulder (76) formed thereon, each of the outer ring (22) and at least two inner segments (30, 40) having a gothic arch shaped bearing surface therein;

disposing a first of the at least two inner segments (30, 40) in the outer ring (22);

installing a full complement of balls (60) between the outer ring (22) and the first of the at least two inner segments (40) so that the balls (60) engage a portion of the bearing surface;

disposing a second of the at least two inner segments (30) in the outer ring (22) so that the balls(60) are retained between the outer ring (22) and the inner assembly (50);

disposing the outer ring (22) and inner assembly (50) with the full complement of balls (60) therein on the shaft (70) such that one of the at least two inner segments (30, 40) engages the shoulder (76); and

securing at least one of the at least two inner segments (30, 40) to the shaft (70).

FIG. 1

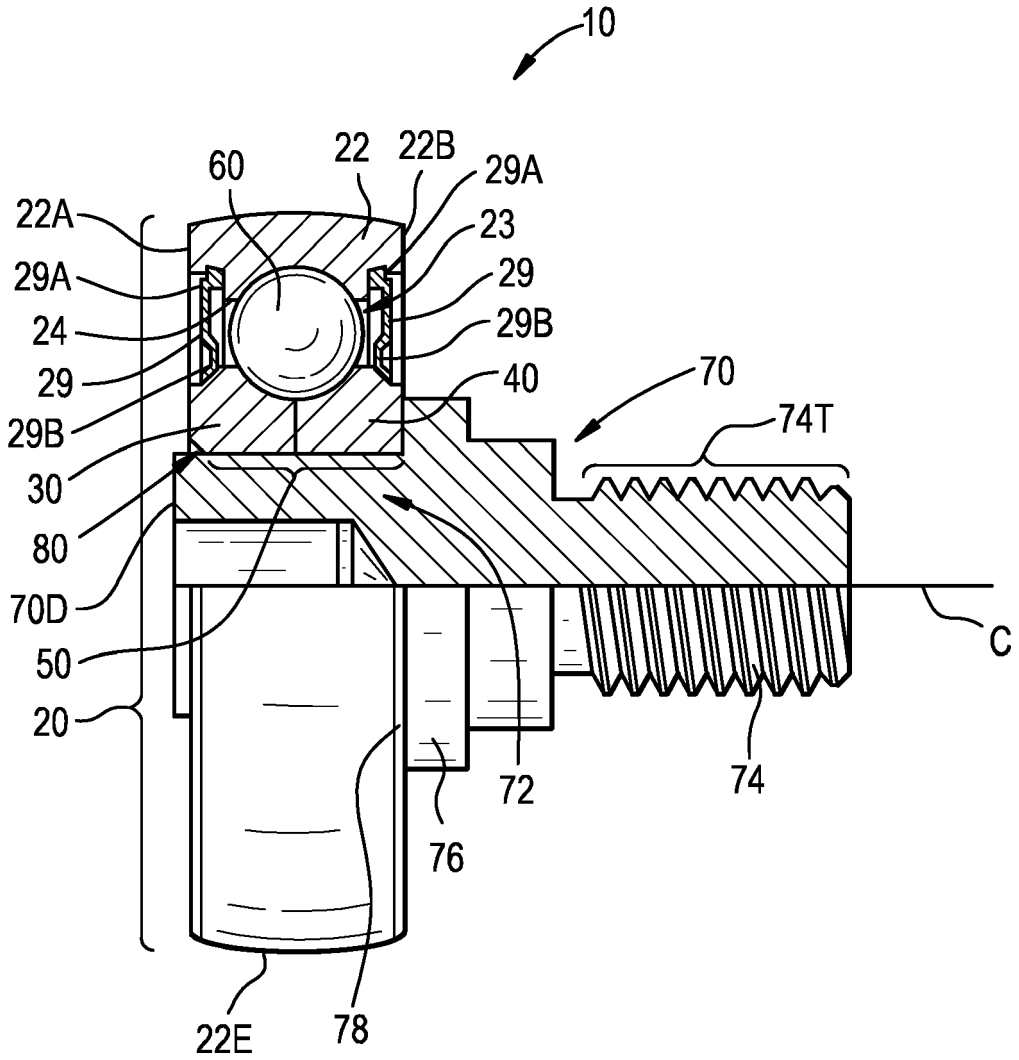

10
60
22
22B
29A
22A
23
29A
29
24
29B
29
40
70
29B
74T
30
80
70D
50
20
C
72
74
76
22E
78

FIG. 2

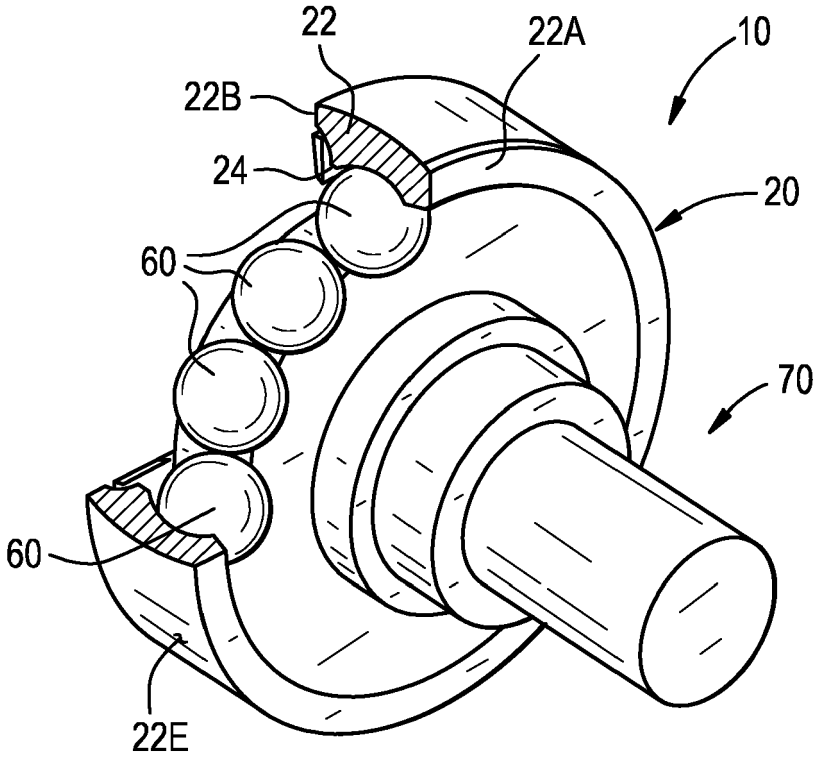


FIG. 3

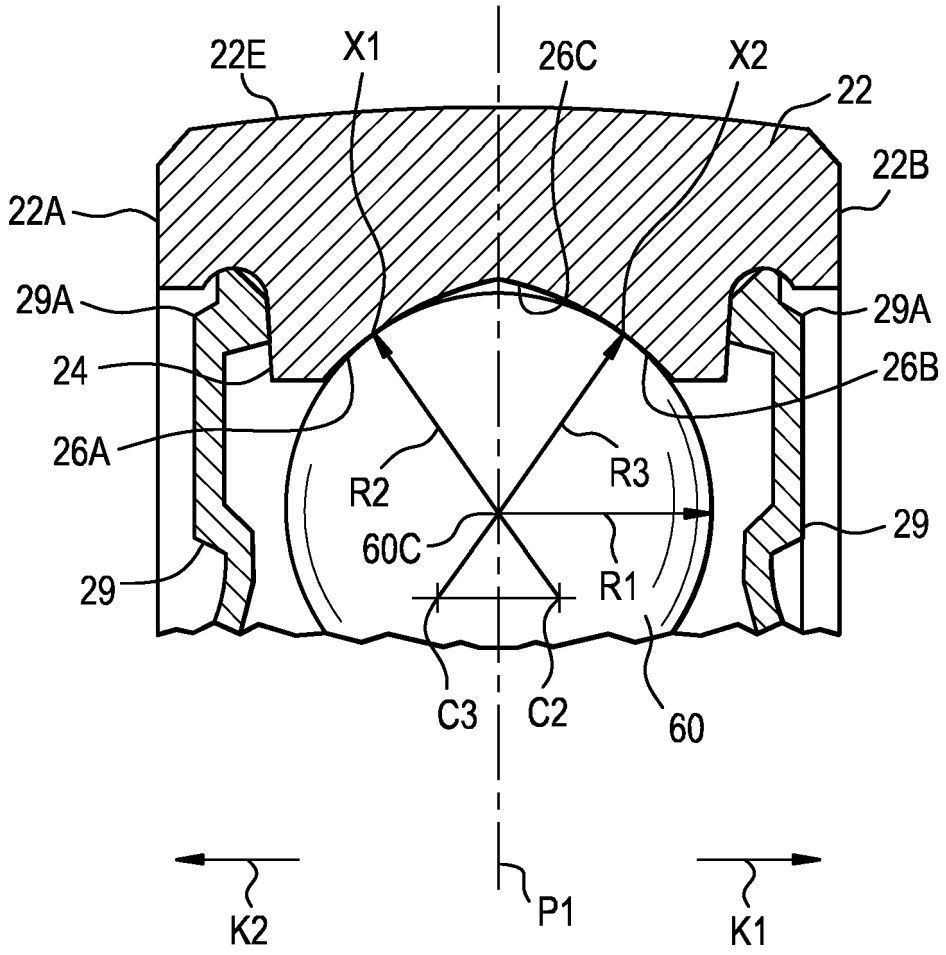

22E
X1
26C
X2
22
22B
22A
29A
29A
24
26B
26A
R2
R3
29
60C
R1
29
C3
C2
60
P1
K2
K1

FIG. 4

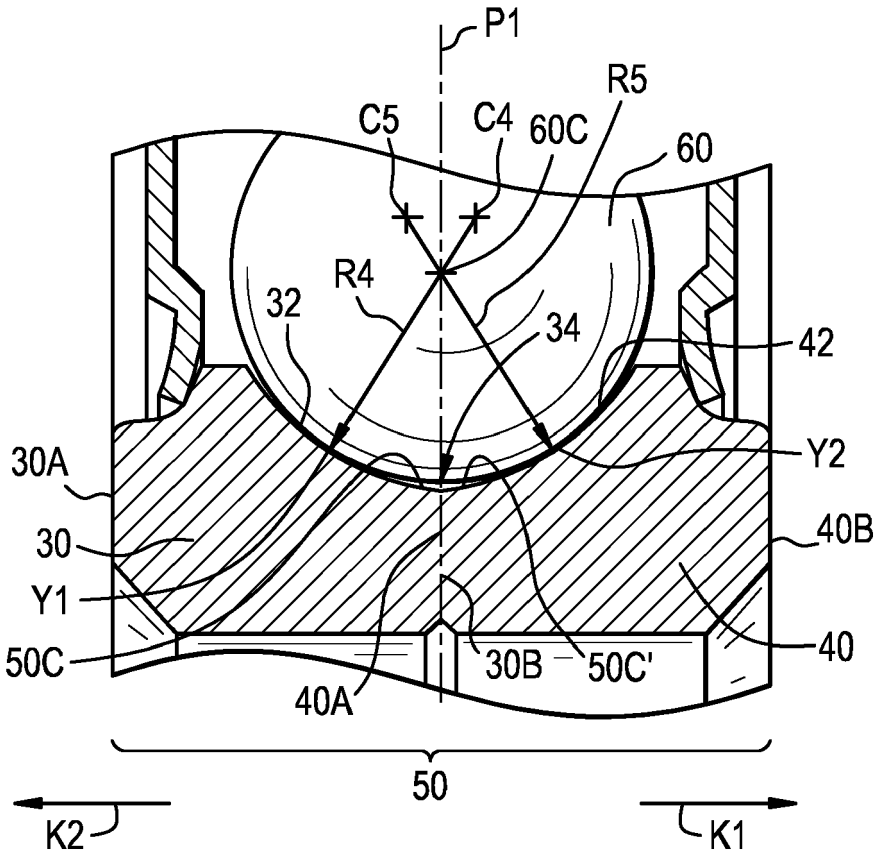
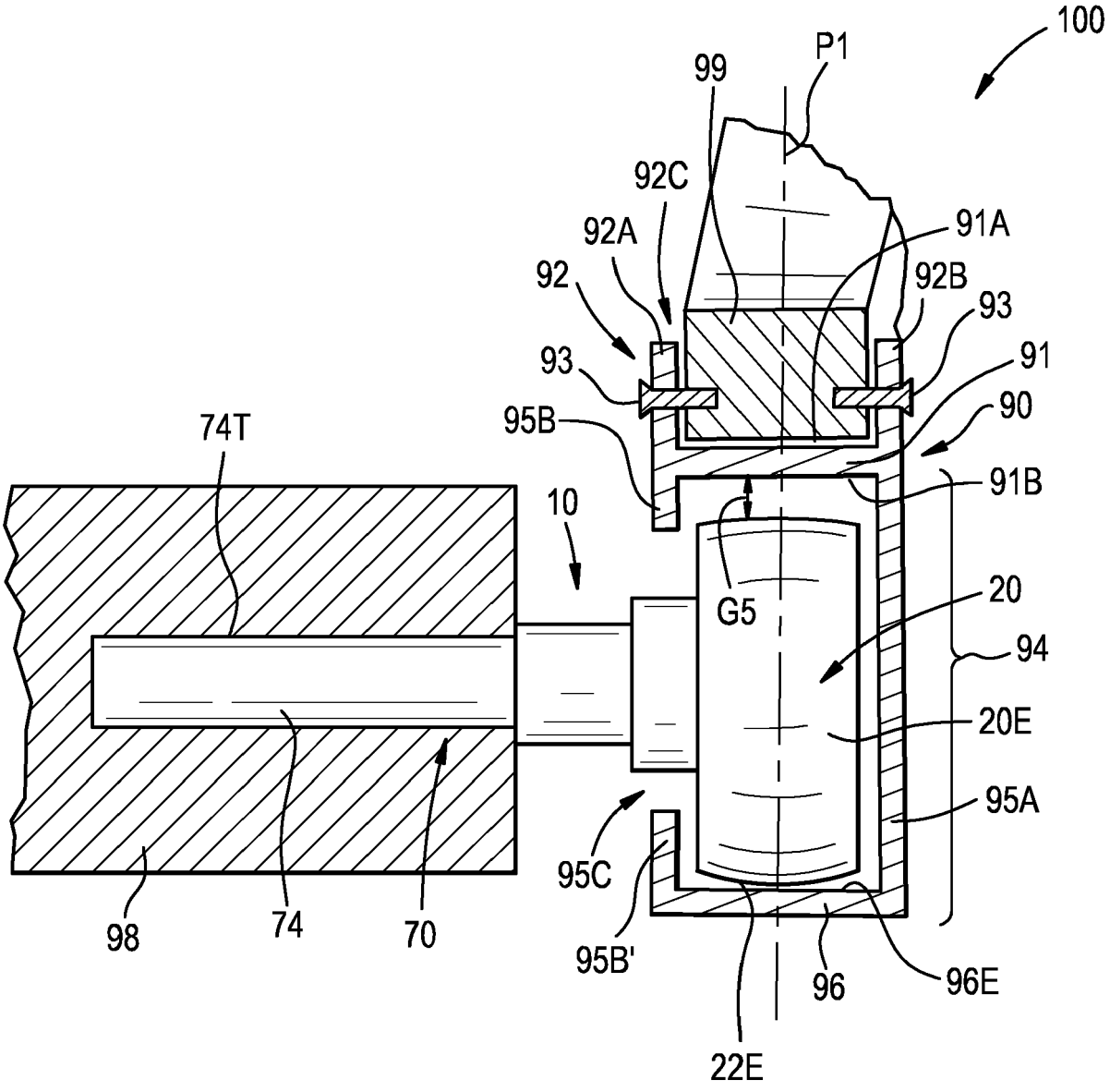

P1
R5
C5
C4
60C
60
R4
32
34
42
30A
Y2
30
40B
Y1
50C
30B
50C'
40
40A
50
K2
K1

FIG. 5


100
P1
99
92C
92A
92
91A
92B
93
93
91
95B
90
74T
91B
10
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95A
95C
95B'
98
74
70
96
96E
22E

FIG. 6

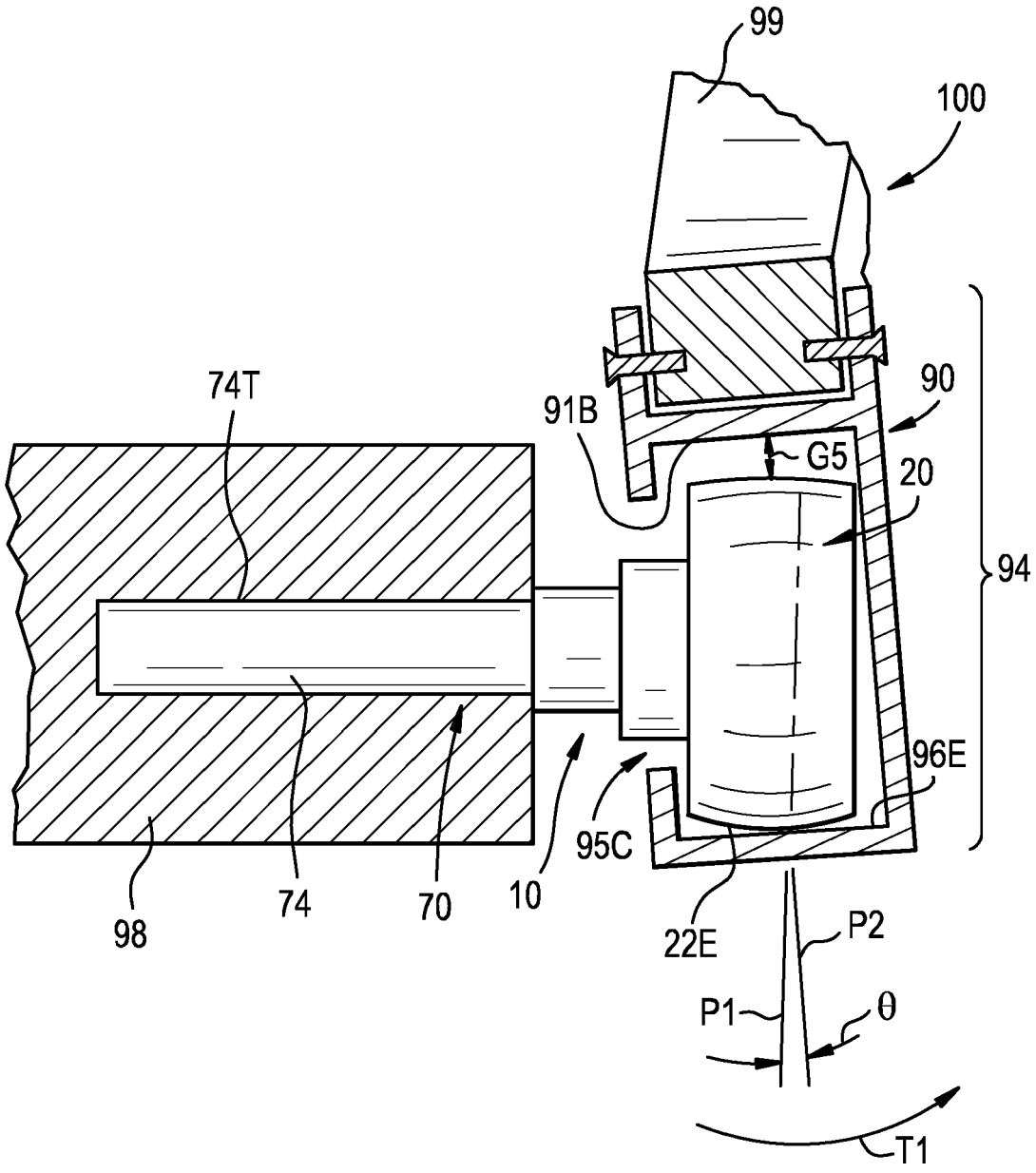


FIG. 7

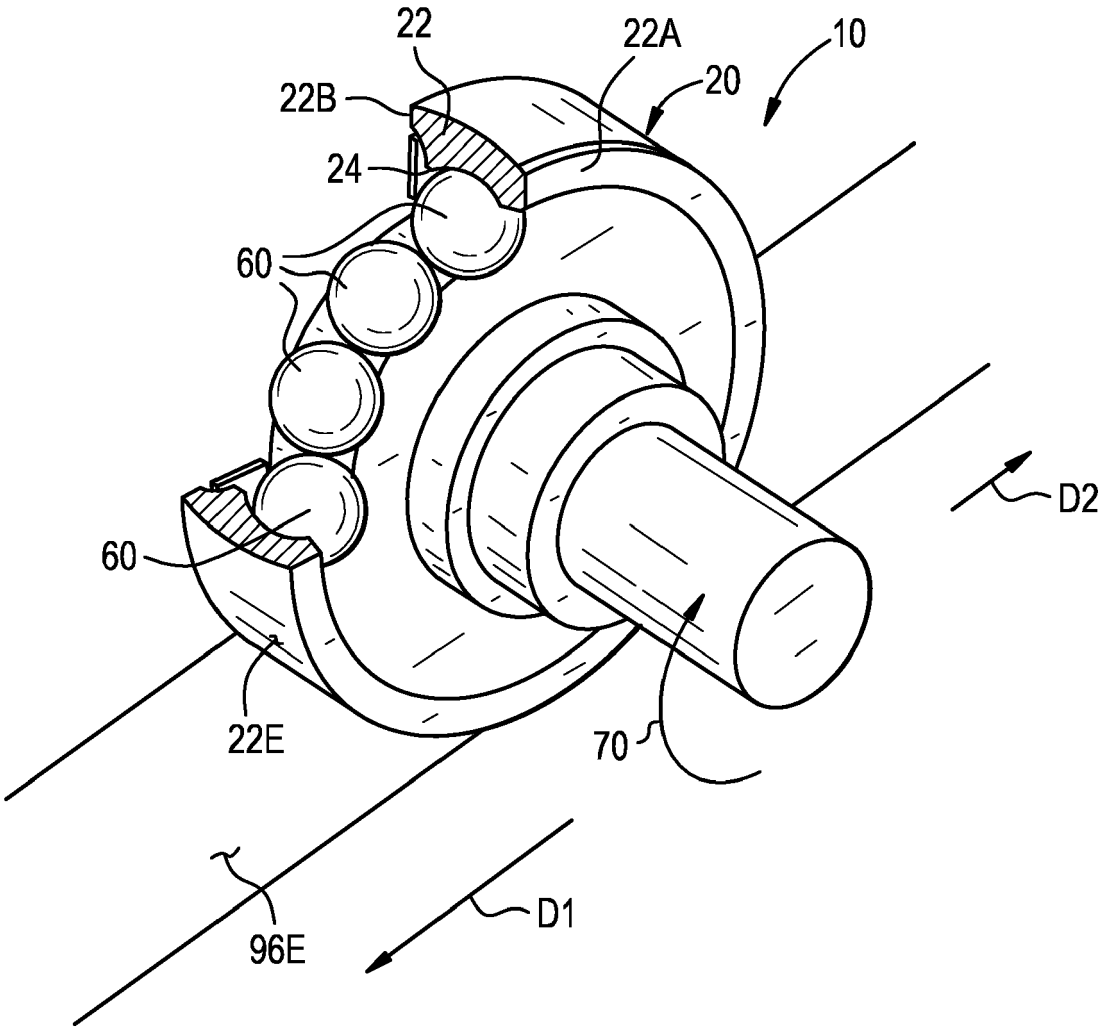
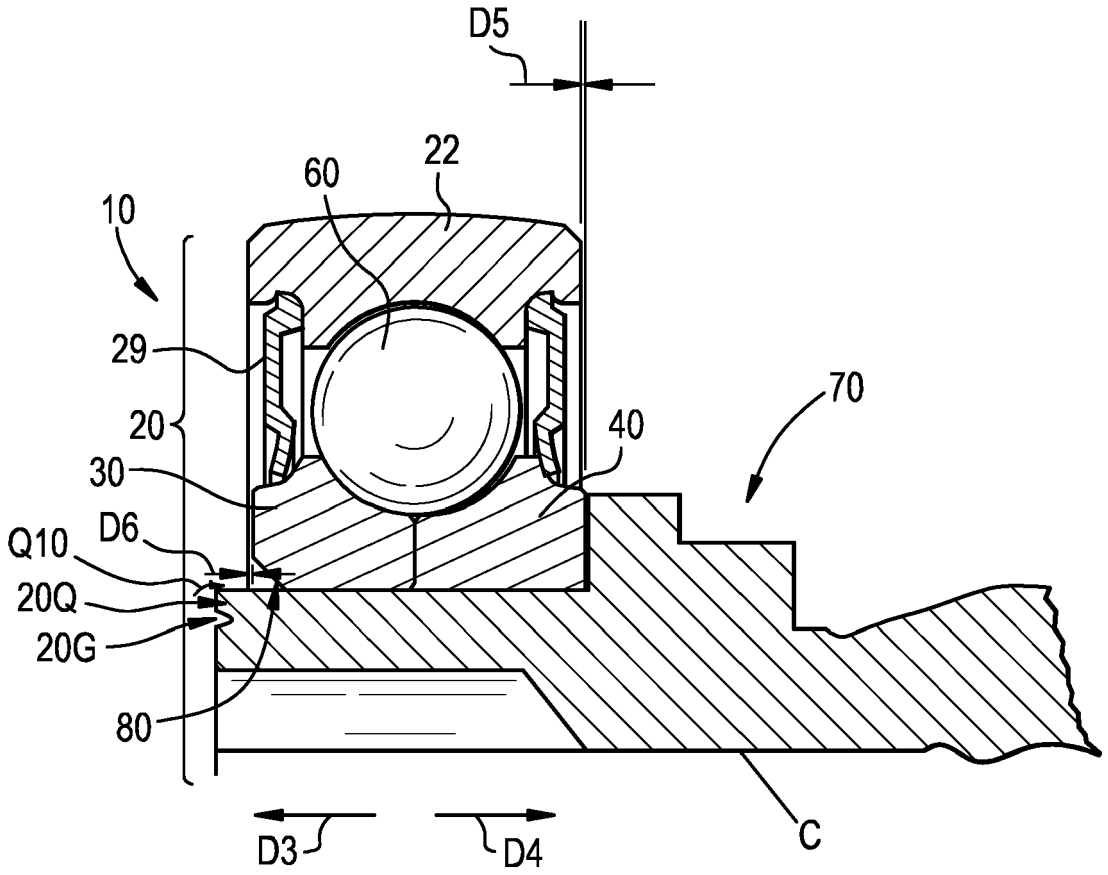


FIG. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 18 17 6503

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2 076 239 A (LEMMON ALEXIS W) 6 April 1937 (1937-04-06)	1,2,4,6, 8,9,11, 13	INV. F16C13/00 F16H53/06
Y	* figure 7 * * column 4, line 7 - line 10 * * column 4, line 53 - line 54 * -----	3,5,7, 10,12,14	F16C33/60 F16C33/78 F16C19/06 F16C33/58
Y	US 3 586 396 A (BARR VICTOR L ET AL) 22 June 1971 (1971-06-22) * figure 5 * * column 3, line 31 - line 38 * -----	5,7,12, 14,15	
Y	US 1 782 622 A (KILIAN FREDERICK K) 25 November 1930 (1930-11-25) * figure 2 * * page 1, line 51 - line 55 * -----	3,10	
Y	US 3 588 206 A (FROST RUBEN E) 28 June 1971 (1971-06-28) * figure 3 * * column 3, line 41 - line 48 * -----	3,5,10, 12,15	

TECHNICAL FIELDS SEARCHED (IPC)
F16C F16H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 September 2018	Frechard, Fabrice

CATEGORY OF CITED DOCUMENTS

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18-09-2018

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US 3588206 A	28-06-1971	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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