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(54) Title: CRADLE BEARING ASSEMBLY WITH TOOTHED GEAR TO SYNCHRONIZE MOVEMENT OF THE BEARING PARTS

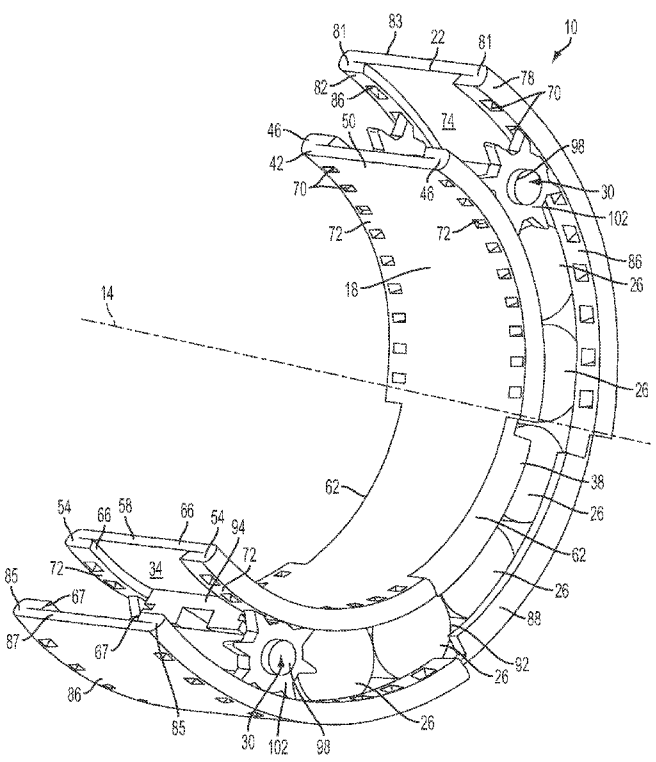

FIG. 1

(57) Abstract: A bearing assembly (10) includes a first bearing race (18) having a first bearing raceway and a first track (72) positioned axially outside the first bearing raceway (34). The bearing assembly (10) also includes a second bearing race (22) having a second bearing raceway (74) axially aligned with the first bearing raceway (34) and a second track (72) positioned axially outside the second bearing raceway (74) and axially aligned with the first track (72). The bearing assembly (10) also includes a plurality of rolling elements (26) positioned between the first bearing race (34) and the second bearing race (74) in contact with the first and second bearing raceways (34, 74), and a gear (30) engaging the first and second tracks (72) to synchronize the movement of the rolling elements (26) and the first and second bearing races (18, 22).

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CRADLE BEARING ASSEMBLY WITH TOOTHED GEAR TO SYNCHRONIZE MOVEMENT OF THE BEARING PARTS

FIELD OF THE INVENTION

[0001] The present invention relates to a cradle bearing, and more particularly to a cradle bearing with synchronized races.

BACKGROUND OF THE INVENTION

[0002] Radial roller bearing assemblies typically comprise a plurality of rollers positioned between inner and outer races. A full complement of rollers may be positioned between the races or the rollers may be maintained by a bearing cage positioned between the races. The rollers serve to control friction between the two races. As one of the races moves relative to the other race, the rollers are free to roll between the races, thereby allowing the races to move independent of one another.

[0003] In some applications, such as cradle bearings, bearings may utilize a gear mesh to synchronize the motion of the inner and outer raceways. Typically, such bearings have the timing gears and/or racks within the roller path. For example, PCT published applications WO 2005/068859 and WO 2007/044464 describe and illustrate such cradle bearing assemblies. The contents of these applications are hereby incorporated herein by reference.

SUMMARY OF THE INVENTION

[0004] Cradle bearing designs with timing gears and/or racks within the roller path do not allow for the rolling elements and timing gear components to travel at the optimum relative velocities when the raceways are rotated with respect to one another and can decrease the maximum forces withstandable at larger bearing angles.

[0005] The present invention relates generally to a bearing assembly including a first bearing race having a first bearing raceway and a first track positioned axially outside the first bearing raceway. The bearing assembly also includes a second bearing race having a second bearing raceway axially aligned with the first bearing raceway and a second track positioned axially

outside the second bearing raceway and axially aligned with the first track. The bearing assembly also includes a plurality of rolling elements positioned between the first bearing race and the second bearing race in contact with the first and second bearing raceways, and a gear engaging the first and second tracks to synchronize the movement of the first and second bearing races.

[0006] In one embodiment, the bearing assembly may comprise a bearing assembly including a first bearing race having a first bearing raceway and a first track, a second bearing race having a second bearing raceway axially aligned with the first bearing raceway and a second track axially aligned with the first track. A plurality of rolling elements is positioned between the first bearing race and the second bearing race in contact with the first and second bearing raceways, the rolling elements each having an outer diameter. The bearing assembly also includes a gear assembly contacting the plurality of rollers and having a gear intermeshing between the track of the first bearing race and the track of the second bearing race to synchronize movement of the first bearing race and the second bearing race. The gear includes a pitch diameter substantially equal to the outer diameter of at least one of the rolling elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a perspective view of a bearing assembly embodying the present invention.

[0008] FIG. 2 is an exploded view the bearing assembly of FIG. 1.

[0009] FIG. 3 is a partial end view of the bearing assembly of FIG. 1.

[0010] FIG. 4 is a partial side view of the bearing assembly of FIG. 1.

[0011] FIG. 5 is a section view taken along line 5-5 of FIG. 3.

[0012] FIG. 6 is a schematic view of the bearing assembly of FIG.1.

[0013] FIG. 7 is a perspective view of an embodiment of the gear-axle assembly.

[0014] FIG. 7a is a section view taken along line 7a-7a of Fig. 7.

[0015] FIG. 8 is a perspective view of an embodiment of the gear-axle assembly.

[0016] FIG. 8a is a section view taken along line 8a-8a of Fig. 8.

[0017] FIG. 9 is a perspective view of an alternative embodiment of the first bearing race.

[0018] FIG. 10 is a perspective view of an alternative embodiment of the second bearing race.

[0019] FIG. 11 is a section view illustrating the first bearing race coupled to the second bearing race.

[0020] FIG. 12 is another section view of the first bearing race coupled to the second bearing race.

[0021] FIG. 13 is a partial end view of another embodiment of the bearing assembly.

[0022] FIG. 14 is a partial end view of the bearing assembly of Fig. 13 with the gear assembly removed for clarity.

[0023] FIG. 15 is a perspective view of an alternate embodiment of the gear carrier.

[0024] Before any embodiments of the invention are explained in detail, it is to be understood that the invention 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 invention 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.

DETAILED DESCRIPTION

[0025] FIGS. 1-6 illustrate a cradle bearing assembly 10 to limit friction between two relatively moving elements. The bearing assembly 10 includes a central axis 14, a first bearing race 18, a second bearing race 22 spaced radially outward of and moveable with respect to the first bearing race 18, a plurality of rolling elements 26 positioned between the first and second

bearing races 18, 22, and a pair of gear assemblies 30 contacting the outermost rolling elements of the plurality of rolling elements to maintain the elements therebetween. In the present construction, each race 18, 22 extends over an arc of approximately 180° as the cradle bearing assembly 10 is configured for use in an oscillating application, such as in a hydraulic pump and the like. However, the races 18, 22 are not limited to such, but instead can be provided at any desired arc such as 90° and 270°. Alternatively, the races 18, 22 may also be flat, as opposed to arcuate as shown.

[0026] Best illustrated in Fig. 2, the first bearing race 18 includes a first retaining wall 38, a second retaining wall 42 substantially parallel to and spaced a distance from the first retaining wall 38, and a first raceway 34 extending between the first and second retaining walls 38, 42 and through which external loads are transmitted to the rolling elements 26. In the illustrated construction, the first raceway 34 extends axially substantially the width 44 of the rolling elements 26 and substantially the entire arcuate length of the first bearing race 18 to maximize the amount of external force that can be transmitted through the first raceway 34 at large rotation angles A, defined as the relative angle between the first bearing race 18 and the second bearing race 22 (see Fig. 6). Further, in the illustrated embodiment, the first raceway 34 is free from recesses and/or protrusions to minimize roller/race contact stress and/or excessive wear on the rolling elements 26, each of which would ultimately reduce the reliability of the bearing assembly 10.

[0027] In some alternate constructions, the first bearing race 18 may include a pair of stops (not shown) adjacent a first and a second end 50, 58, respectively, of the raceway 34 to limit the extent the rolling elements 26 can travel along the first bearing raceway 34, as well as to limit the maximum rotation angle A (e.g., between ± 24 degrees). In yet another construction, the first bearing race 18 may include a plurality of locating tabs and/or locating recesses (not shown) extending from the exterior of the race 18 to better position and/or secure the bearing assembly 10 within a device (not shown).

[0028] The first and second retaining walls 38, 42 of the first bearing race 18 are substantially similar, extending radially outwardly from the first bearing race 18 to limit the axial movement of the rolling elements 26 and to maintain the rolling elements 26 on the first raceway

34. For brevity, only the first retaining wall 38 will be described in detail herein. The first retaining wall 38 includes a first portion 46 proximate the first end 50 of the first bearing race 18, a second portion 54 proximate the second end 58 of the first bearing race 18, and a third portion 62 extending between the first portion 46 and the second portion 54. The first and second portions 46, 54 each extend radially and axially outwardly from the first raceway 34 to produce an inner surface 66 defining an axial edge of the first raceway 34. The first and second portions 46, 54 also define a plurality of pockets 70 evenly spaced along the arcuate length of the first and second portions 46, 54 to produce a respective track 72.

[0029] Each track 72 is positioned axially outside the first raceway 34 to eliminate any gear teeth and/or recesses in the first raceway 34. By doing so, the tracks 72 are not required to transmit any of the external loads exerted upon the bearing assembly 10 regardless of the rotation angle A. In contrast, existing cradle bearing assemblies contain internal gear tracks (e.g., recesses and/or protrusions positioned within the raceway) causing the track itself to support at least a portion of the load exerted onto the bearing assembly at large rotation angles. Internal gear tracks may also interfere with the movement of the rolling elements along the raceways. As such, previous bearing assemblies typically have higher raceway contact stress in the areas adjacent to the internal gear tracts. These contact stress values are highest when the bearing is operating at larger angles of rotation (e.g., greater than 30 degrees). In an alternate construction, each track 72 may include a plurality of gear teeth (not shown) in place of the pockets 70.

[0030] Best illustrated in Fig. 5, each pocket 70 is shaped to receive a tooth 122 of a respective gear 102 (described below) and includes a pair of walls 73 to contact the tooth profile. In the illustrated embodiment, the walls 73 taper as they extend radially inwardly, however in alternate constructions, the walls 73 may produce any one of an involute profile and a curvilinear profile to best suite the particular type of gear tooth being used. In yet another embodiment, the pocket 70 may include a substantially constant shape to simplify the manufacturing process.

[0031] The third portion 62 of the retaining wall 38 extends between the first portion 46 and the second portion 54 extending radially outwardly from the first raceway 34 to axially limit the motion of the rolling elements 26 relative to the raceway 32. In the illustrated embodiment, the third portion 62 extends radially beyond and is separate from the first and second portions 46,

54. However, in alternate constructions, the third portion 62 may be integral the first and second portions 46, 54. In alternate constructions, the third portion 62 may include a plurality of pockets 70, similar to the first and second portions 46, 54.

[0032] Best illustrated in Fig. 2, the second bearing race 22 is substantially similar to the first bearing race 18. The second bearing race 22 includes a third retaining wall 78 and a fourth retaining wall 82 substantially parallel to and spaced a distance from the third retaining wall 78. The second bearing race also includes a second raceway 74 axially aligned with the first raceway 34 and extending between the third and a fourth retaining walls 78, 82 to transmit external loads to the rolling elements 26. In the illustrated embodiment, the second raceway 74 extends axially substantially the width 44 of the rolling elements 26 and substantially the entire arcuate length of the second bearing race 22 to allow external forces to be transmitted through the second raceway 74 regardless of the rotation angle A. Further, in the illustrated embodiment, the second raceway 74 is free from recesses and/or protrusions to minimize the number of high stress areas located on the raceway 74. In some constructions, the second bearing race 22 may include a pair of stops (not shown) adjacent a first and a second end 83, 87, respectively, of the second raceway 74 to limit the extent the rolling elements 26 can traverse along the second raceway 74. In yet another construction, the second bearing race 22 may include a plurality of locating tabs and/or locating recesses (not shown) extending from the exterior of the race 22 to better position and/or secure the bearing assembly 10 within a device (not shown).

[0033] The third and fourth retaining walls 78, 82 of the second bearing race 22 are substantially similar extending radially inwardly from the second bearing race 22 and being axially aligned with the first and second retaining walls 38, 42, respectively, to limit the axial movement of the rolling elements 26 and to maintain the rolling elements 26 within the second raceway 74. For brevity, only the third retaining wall 78 will be described in detail herein. The third retaining wall 78 includes a first portion 81 proximate the first end 83 of the second bearing race 22, a second portion 85 proximate the second end 87 of the second bearing race 22, and a third portion 88 extending between the first portion 81 and the second portion 85. The first and second portions 81, 85 of the third retaining wall 78 extend radially inwardly and axially outwardly from the second raceway 74 to produce an inner surface 67 defining an axial edge of the second raceway 74. The first and second portions 81, 85 also include a plurality of pockets

70 (described above) spaced evenly along the circumferential length of the first and second portions 81, 85 to produce a respective track 86, each track 86 being axially aligned with a corresponding track 72 of the first bearing race 18.

[0034] The third portion 88 of the third retaining wall 78 extends between the first portion 81 and the second portion 85 and extends radially inwardly to limit the axial motion of the rolling elements 26 on the second raceway 74. In the illustrated embodiment, the third portion 88 extends radially beyond and is separate from the first and second portions 81, 85. However, in alternate constructions, the third portion 88 may be integral with the first and second portions 81, 85. In yet another alternate construction, the third portion may include a plurality of pockets 70, similar to the first and second portions 81, 85.

[0035] Although the retaining walls 38, 42, 78, 82 are illustrated with three portions, the retaining walls 38, 42, 78, 82 may include additional portions with or without pockets 70 as necessary. Furthermore, supplemental tracks (not shown) corresponding to additional gear assemblies 30 may be included as necessary.

[0036] In the illustrated embodiment, the first and second bearing races 18, 22 are formed by generally stamping a piece of sheet material (e.g., metal) into the desired shape. However, the bearing races 18, 22 may also be forged, cast, machined, and the like to produce the desired shape. Furthermore, in the illustrated embodiment, the first and second portions 46, 54, 81, 85 of the retaining walls 38, 42, 78, 82 are formed as tabs extending axially from the bearing races 18, 22 and folded back upon themselves to produce the inner surfaces 66, 67. As such, the first and second portions 46, 54, 81, 85 are generally twice the thickness of the raceways 34, 74 and allow the gears 102 to have a pitch diameter 126 substantially corresponding to the outer diameter 92 of the rolling elements 26 (described below). In addition, the third portion 62 is formed from a tab extending axially from the bearing race 18 folded generally 90 degrees from the raceway 34 to form a radially outwardly extending wall. The third portion 88 is formed from a tab extending axially from the bearing race 22 folded generally 90 degrees from the raceway 74 to form a radially inwardly extending wall. In some alternate constructions, the first, second, and third portions may also be formed by casting, stamping, and

the like. In yet another construction, the first, second, and third portions may be formed separately and coupled to the races 18, 22.

[0037] The pockets 70 of the tracks 72, 86 are generally formed by punching, stamping, or the like through the first and second portions 46, 54, 81, 85 of the races 18, 22. The pockets 70 may be formed either before the tabs are folded back upon themselves or after, dependent upon the desired contour of the walls 73. Furthermore, the pockets 70 may not extend through the entire thickness of the first and second portions 46, 54, 81, 85, and instead may extend only through a single layer of the sheet material.

[0038] Illustrated in Figs. 2 and 4, each rolling element 26 defines a first outer diameter 92 and an axial length 44. The rolling elements 26 are positioned between the races 18, 22 and move (e.g., roll) circumferentially along both the first and second raceways 34, 74 to transmit external loads between the first bearing race 18 and the second bearing race 22. In the present embodiment, the rolling elements 26 are placed adjacent one another without a cage positioned therebetween, however in alternate constructions, a cage or the like may be used. In the illustrated embodiment each rolling element 26 has a similar outer diameter 92, however in some constructions, one or more of the rolling elements may have a different outer diameter for vibration dampening. In the illustrated construction, the rolling elements 26 are substantially cylindrical in shape, however, the rolling elements 26 may be any one of spherical, needle, tapered and the like.

[0039] Illustrated in Figs. 1 and 2, the gear assemblies 30 are positioned between and synchronize the relative movement of the inner bearing race 18 and the outer bearing race 22. Each gear assembly 30 includes a gear carrier 94, a gear shaft 98 rotatably coupled to the gear carrier 94, and a pair of gears 102 supported by the gear shaft 98. The gear assemblies 30 contact the rolling elements 26 to bias the elements 26 along the raceways 34, 74. In the illustrated embodiment, a gear assembly 30 is positioned adjacent the outermost rolling elements 26 of the bearing assembly 10, however in alternate constructions, supplemental gear assemblies 30 may be placed throughout the group of rolling elements 26.

[0040] The gear carrier 94 is positioned between the first and second bearing races 18, 22 and is configured to contact the rolling elements 26 while sliding generally circumferentially

along the first and second raceways 34, 74. The gear carrier 94 includes a contacting surface 106 configured to contact the rolling elements 26, a radially inward wall 110 contacting the first raceway 34, a radially outward wall 114 contacting the second raceway 74, and a gear shaft retaining recess 118 to rotatably receive the gear shaft 98 (e.g., by snap fit).

[0041] The radially inward and outward walls 110, 114 include an arcuate surface having a radius substantially corresponding to and slidable along the first and second raceways 34, 74, respectively. In alternate constructions, the radially inward and radially outward walls 110, 114 may also include a plurality of rolling elements (not shown) to reduce friction between the gear carrier 94 and the raceways 34, 74.

[0042] The contacting surface 106 of the gear carrier 94 includes an arcuate surface having a radius generally corresponding to the radius of the rolling elements 26. In alternate constructions, the contacting surface 106 may include a compound surface (not shown) corresponding to the shape of a spherical rolling element (not shown).

[0043] The gears 102 of the gear assemblies 30 are supported by the gear shaft 98 and rotate with respect to the gear carrier 94. Each gear 102 spans between a track 72 in the first bearing race 18 and the axially aligned track 86 in the second bearing race 22 (see Fig. 4). In the illustrated construction, each gear 102 includes a plurality of teeth 122 configured to be received by the pockets 70 of each track 72, 86. The gears 102 intermesh between the tracks 72, 86 of the first and second bearing races 18, 22 to coordinate the relative positions of the first bearing race 18, the second bearing race 22, the gear assemblies 30, and the rolling elements 26. In the illustrated construction, each gear 102 is coupled to an end of the gear shaft 98 by a through hole (see Fig. 2), a blind hole (see Fig. 8 and 8a), or the like; however in alternate constructions, the gear shaft 98 and its corresponding gears 102 may be formed as a single piece (see Fig. 7 and 7a).

[0044] It is contemplated that multiple stacked gears (not shown) can be provided, for example on multiple spindles, between the tracks 72, 86 to control relative movement direction and gear ratios. In the illustrated embodiment, each gear tooth 122 has an involute profile, however in alternate constructions, each gear tooth 122 may include straight cut teeth, square cut teeth, triangular cut teeth, and the like. Furthermore, in the illustrated construction, each gear

includes a pitch diameter 126 (see Fig. 5) substantially corresponding to the outer diameter 92 of at least one of the rolling elements 26 to synchronize the rolling elements 26 and races 18, 22 at relative velocities configured to minimize roller sliding and reduce heat generation and lubrication film breakdown.

[0045] In an alternate construction of the bearing assembly 10' illustrated in Figs. 9-12, the third portion 62' of the first bearing race 18' may extend a sufficient radial distance to overlap and engage a corresponding third portion 88' of the second bearing race 22'. In such an embodiment, the third portion 62' may include a retaining mechanism 130' to rotatably couple the first bearing race 18' to the second bearing race 22', thereby unitizing the bearing assembly 10'. More specifically, in some constructions, the retaining mechanism may include a plurality of stamped protrusions 134' (see Fig. 9) spaced a circumferential distance from one another at a common radial distance from the central axis 14', each stamped protrusion 134' corresponding to an arcuate groove 138' placed in the corresponding third portion of the opposing bearing race. Alternately, as shown in Fig. 12, the retaining mechanism 130' may include a continuous ridge 142' mating with a groove 146' defined by the corresponding third portion of the opposing bearing race.

[0046] In another alternate construction of the bearing assembly 10'', illustrated in Figs. 13-15, the gear carrier 94'' may also include a plurality of retaining flanges 150'' extending from the gear carrier 94'' (see Fig. 15) to rotatably couple the first bearing race 18' to the second bearing race 22''. In the alternate construction, the inner surfaces 66'' 67'' of the races 18'', 22'' are formed at an angle B with respect to their corresponding raceway 34'', 74'' of less than 90 degrees to create a retention area 154''. The retaining flanges 150'' of the gear carrier 94'' are configured to be received by and slidable along a corresponding retention area 154'' to restrict relative radial motion between the gear carrier 94'' and the respective bearing race, thereby unitizing the bearing assembly 10", while permitting relative movement along the raceway.

[0047] During operation, the first bearing race 18 oscillates about the central axis 14 with respect to the second bearing race 22. As the first bearing race rotates in a first direction (e.g., rotation angle A is increasing), each gear 102 advances along tracks 72, 86, biasing the gear

assemblies 30 along the first and second raceways 34, 74. The gear assemblies 30 in turn bias the rolling elements 26 along the first and second raceways 34, 74 at a rate configured to minimize roller sliding along the raceways 34, 74.

[0048] Various features of the invention are set forth in the following claims.

CLAIMS

What is claimed is:

1. A bearing assembly comprising:

a first bearing race having a first bearing raceway and a first track positioned axially outside the first bearing raceway;

a second bearing race having a second bearing raceway axially aligned with the first bearing raceway and a second track positioned axially outside the second bearing raceway and axially aligned with the first track;

a plurality of rolling elements positioned between the first bearing race and the second bearing race in contact with the first and second bearing raceways; and

a gear engaging the first and second tracks to synchronize the movement of the first and second bearing races.

2. The bearing assembly of claim 1, wherein a rolling element of the plurality of rolling elements includes an outer diameter, and wherein the gear includes a pitch diameter substantially equal to the outer diameter.

3. The bearing assembly of claim 1, wherein each gear includes a plurality of teeth and each tooth includes a substantially involute tooth profile.

4. The bearing assembly of claim 1, wherein each gear includes a plurality of teeth and each tooth includes a substantially linear tooth profile.

5. The bearing assembly of claim 1, wherein each track includes a plurality of pockets.

6. The bearing assembly of claim 5, wherein each pocket includes a pair of tooth engaging walls, and wherein the tooth engaging walls include a substantially involute profile.

7. The bearing assembly of claim 5, wherein each pocket includes a pair of tooth engaging walls, and wherein the tooth engaging walls include a substantially tapered, linear profile.

8. The bearing assembly of claim 1, wherein the first bearing raceway extends axially substantially the width of the rolling elements and extends substantially the entire arcuate length of the first bearing race.

9. The bearing assembly of claim 1, further comprising a first retaining wall adjacent one edge of the first bearing raceway, and a second retaining wall adjacent a second edge of the first bearing raceway opposite the first retaining wall.

10. The bearing assembly of claim 9, wherein the first retaining wall and the second retaining wall each define a track.

11. The bearing assembly of claim 9, wherein the first and second retaining walls are formed at least in part from tabs folded upon themselves.

12. The bearing assembly of claim 9, further comprising a third retaining wall adjacent one edge of the second bearing raceway, and a fourth retaining wall adjacent a second edge of the second bearing raceway opposite the third retaining wall.

13. The bearing assembly of claim 12, wherein the third retaining wall and the fourth retaining wall each define a track.

14. The bearing assembly of claim 1, further comprising a retaining wall to retain the rollers on the raceways.

15. A bearing assembly comprising:

a first bearing race having a first bearing raceway and a first track;

a second bearing race having a second bearing raceway axially aligned with the first bearing raceway and a second track axially aligned with the first track;

a plurality of rolling elements positioned between the first bearing race and the second bearing race in contact with the first and second bearing raceways, the rolling elements each having an outer diameter; and

a gear assembly contacting the plurality of rollers and having a gear intermeshing between the track of the first bearing race and the track of the second bearing race to synchronize movement of the first bearing race and the second bearing race, wherein the gear includes a pitch diameter substantially equal to the outer diameter of at least one of the rolling elements.

16. The bearing assembly of claim 15, wherein the first track is positioned axially outside the first bearing raceway.

17. The bearing assembly of claim 16, wherein the track is formed at least in part from a tab folded upon itself.

18. The bearing assembly of claim 15, wherein the gear includes a plurality of teeth, each having a substantially involute profile.

19. The bearing assembly of claim 15, wherein each track includes a plurality of pockets.

20. The bearing assembly of claim 19, wherein each pocket includes a pair of gear contacting walls, and wherein each wall includes a substantially linear, tapered profile.

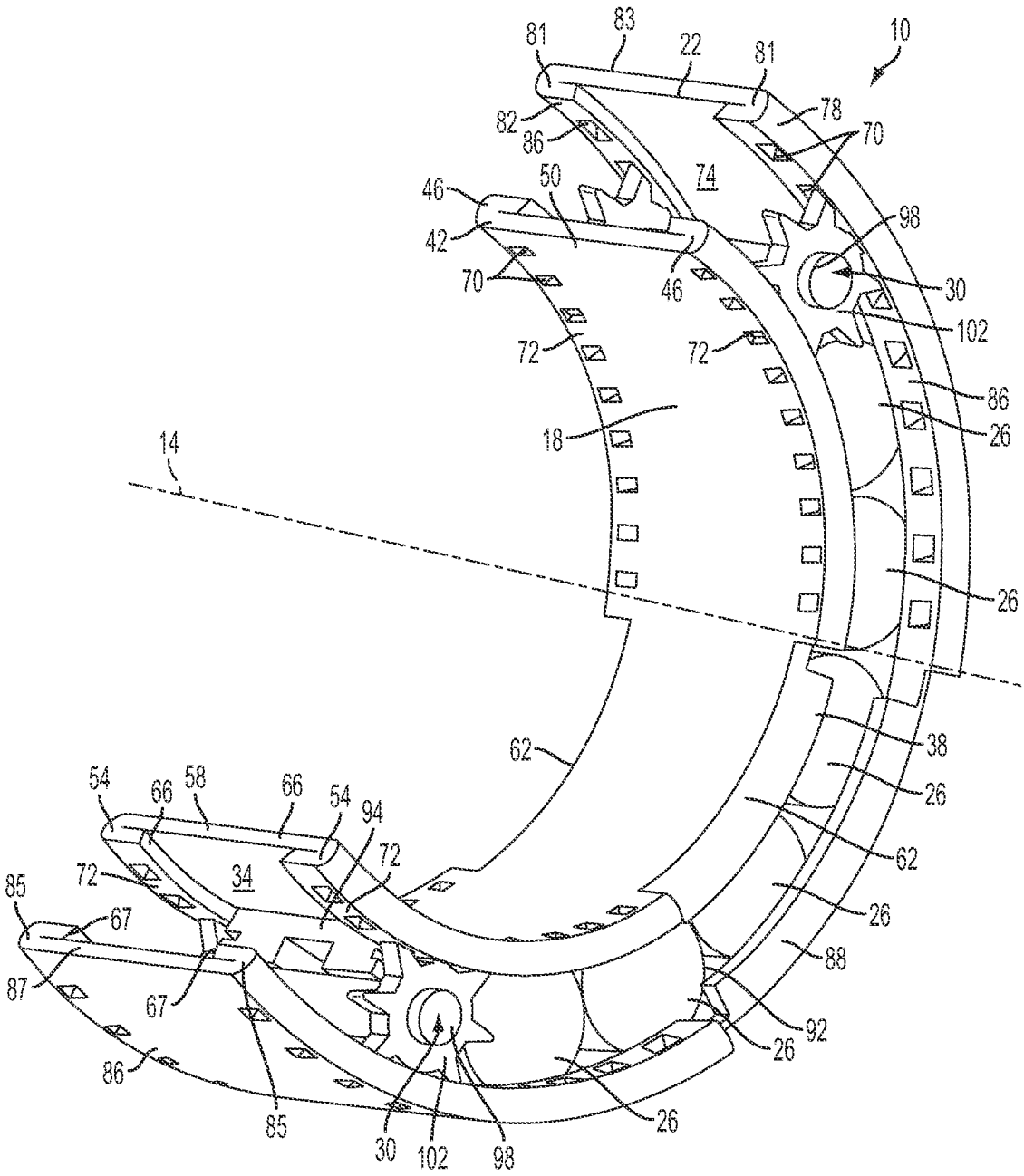
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FIG. 1

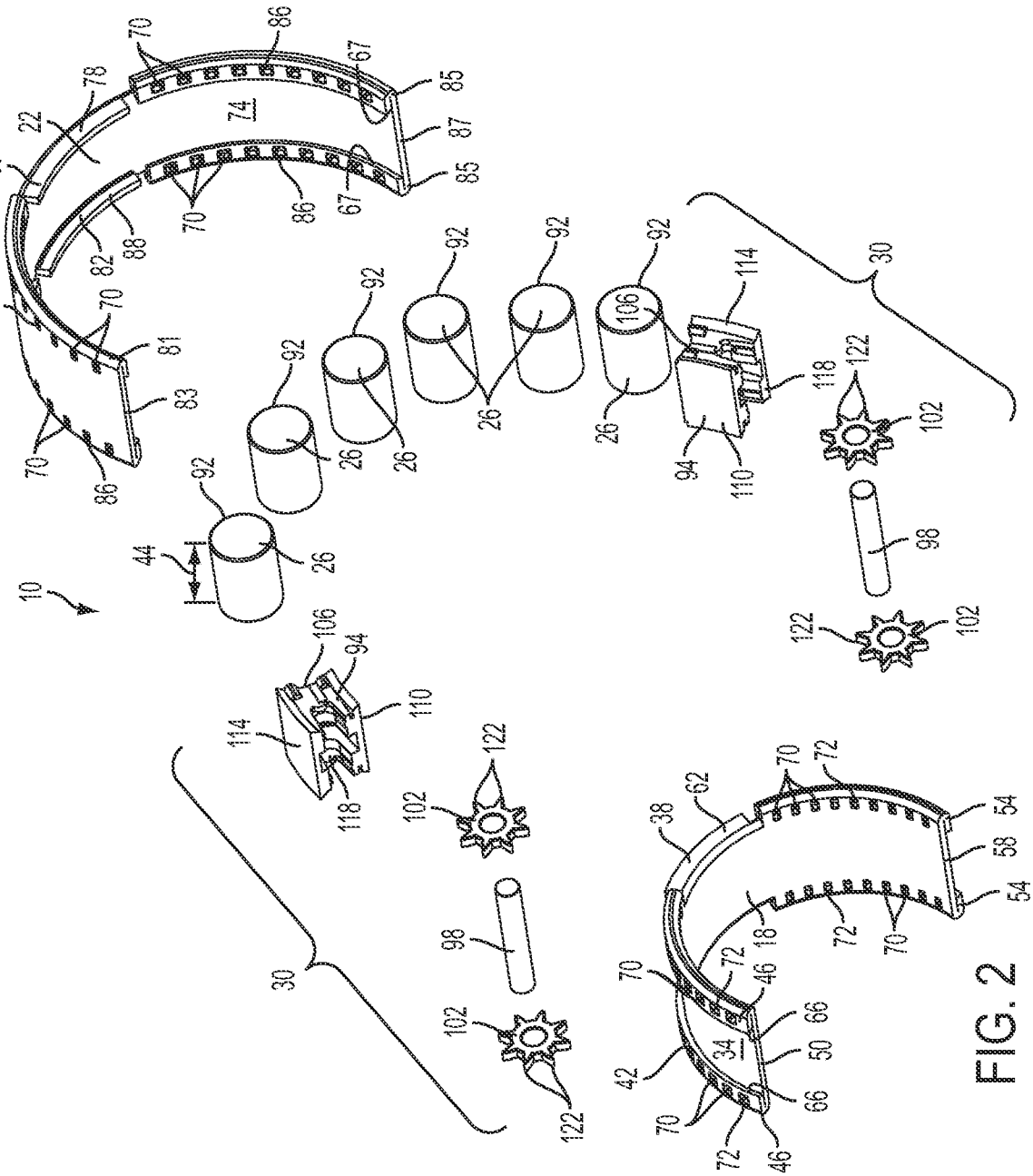
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FIG. 2

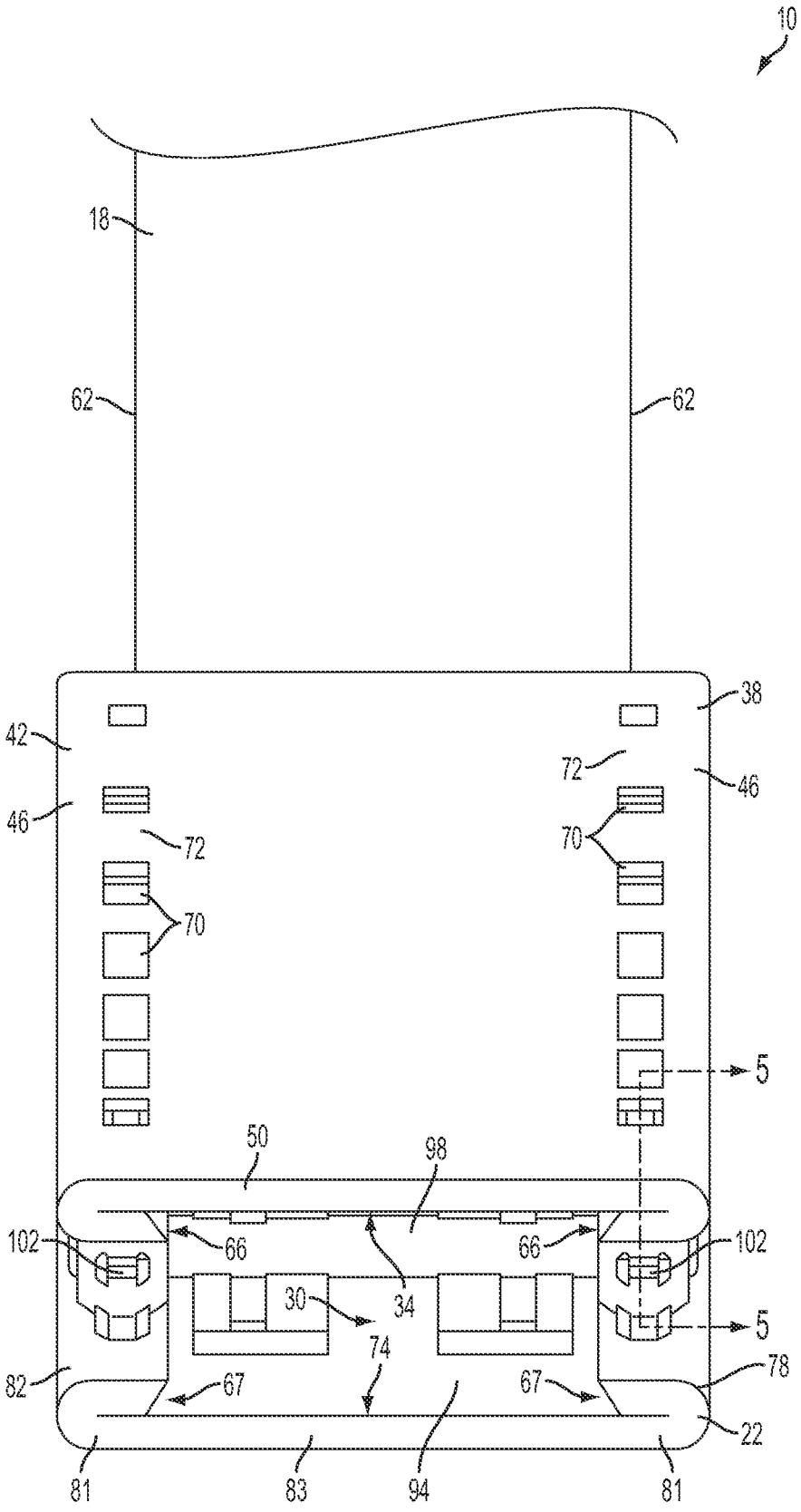
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FIG. 3

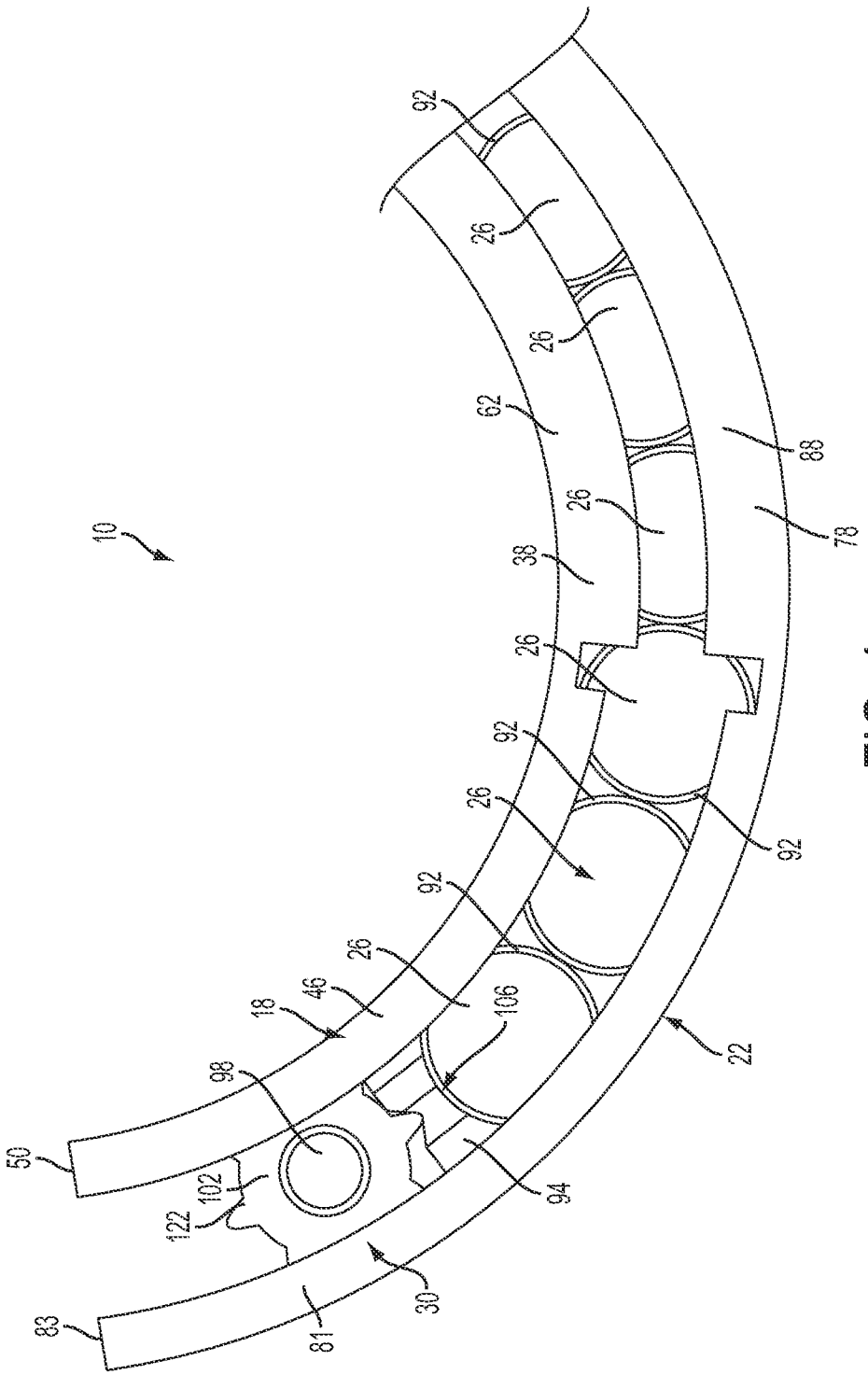
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FIG. 4

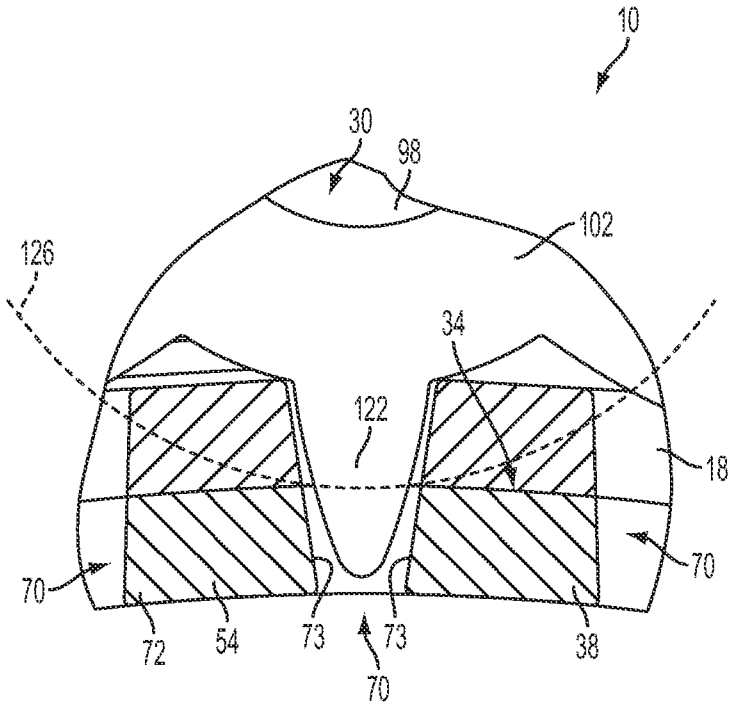

FIG. 5

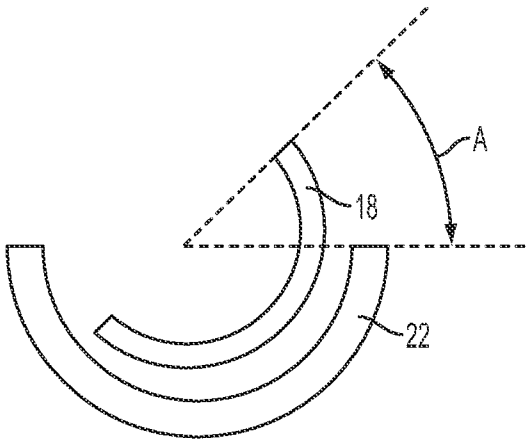

FIG. 6

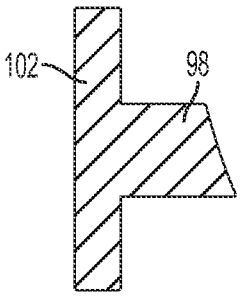

FIG. 7a

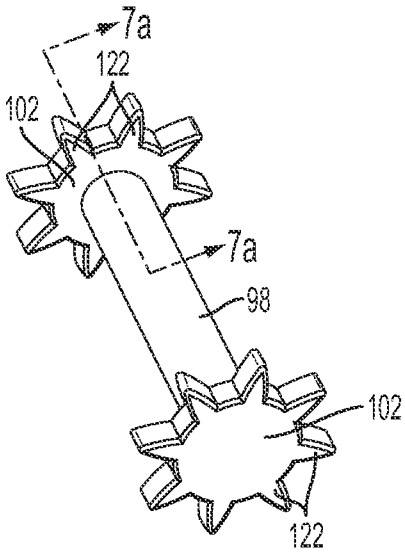

FIG. 7

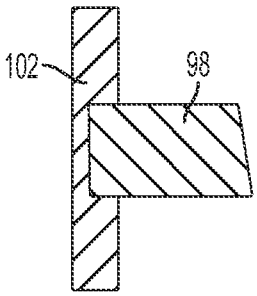

FIG. 8a

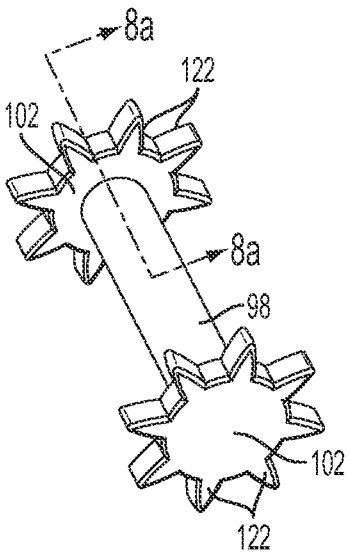

FIG. 8

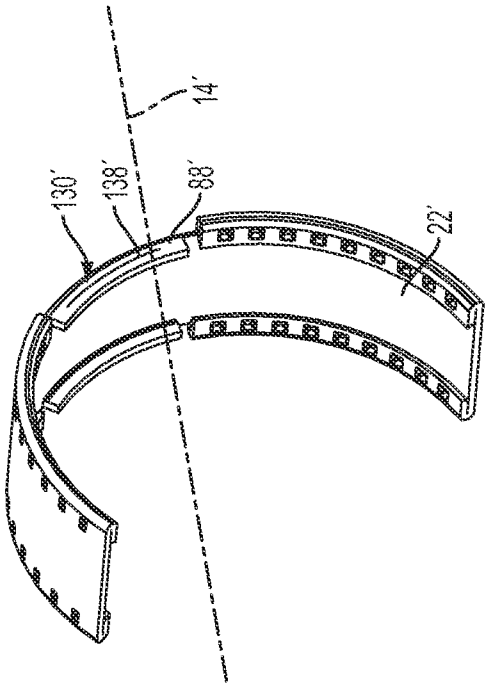

FIG. 10

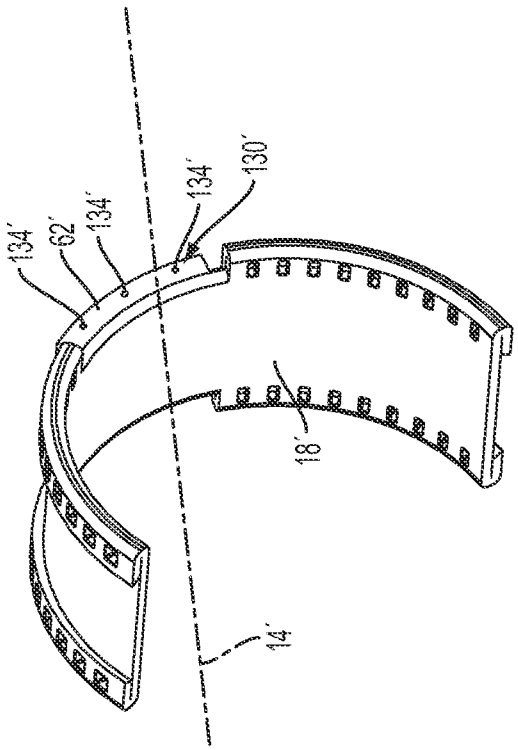

FIG. 9

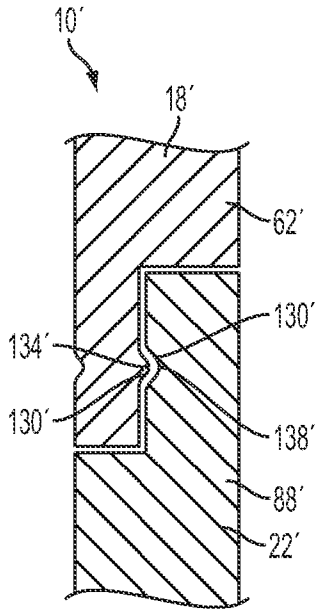

FIG. 11

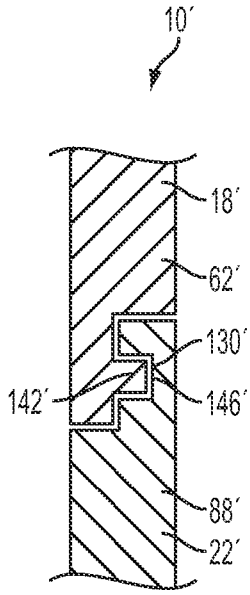

FIG. 12

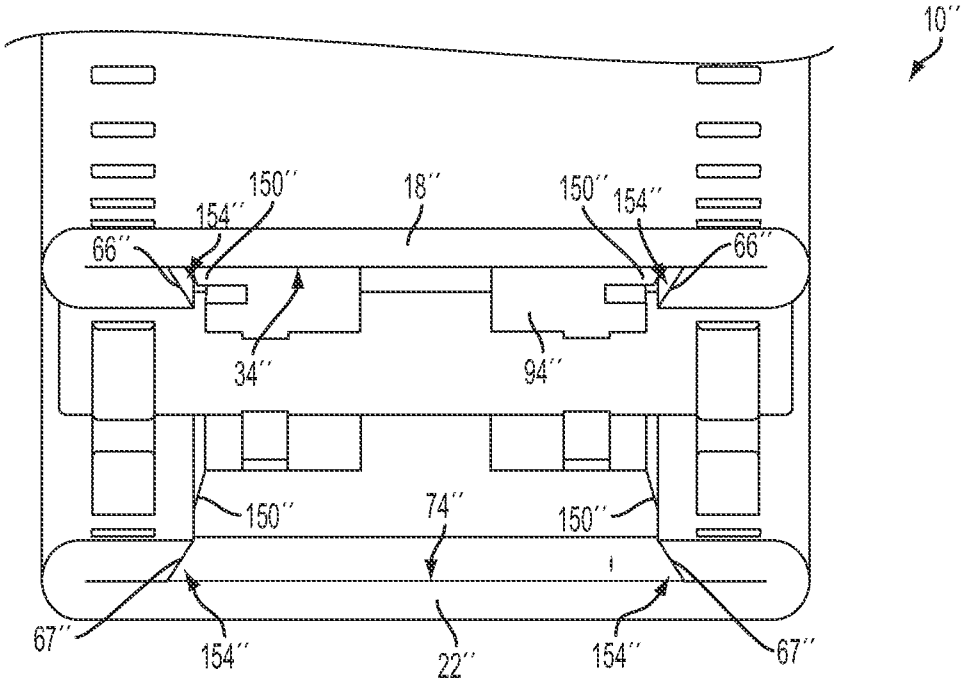
10''
150''
18''
150''
154''
154''
66''
66''
34''
94''
150''
74''
150''
67''
154''
22''
154''
67''

FIG. 13

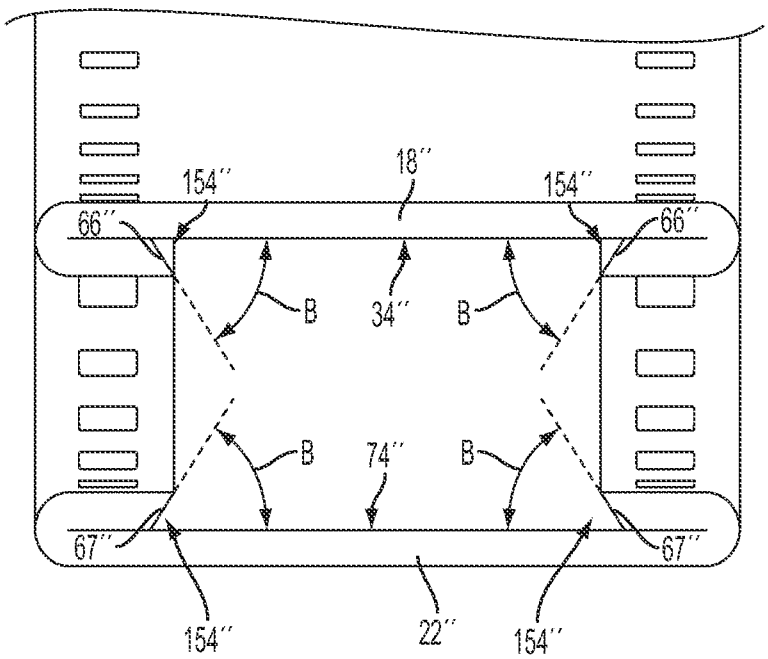
18''
154''
154''
66''
66''
B
34''
B
B
74''
B
67''
67''
154''
22''
154''

FIG. 14

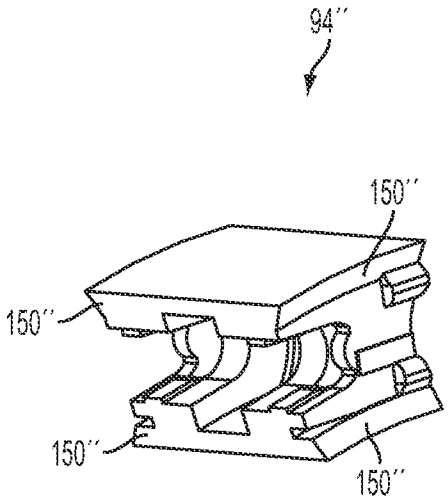

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/024139

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16C19/50 F16C33/30
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 F01B F04B

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	US 2009/126561 A1 (BECKER KLAUS [DE] ET AL) 21 May 2009 (2009-05-21) paragraph [0030] - paragraph [0033]; figures 1-7	1,2,5, 8-10, 12-16,19
X	US 121 040 A (BEERS, J.D.) 21 November 1871 (1871-11-21) the whole document	1,2, 8-10, 12-16
X	US 5452 A (HARRIS, JR., J.) 22 February 1848 (1848-02-22) the whole document	1-3,5,6, 8,15,16, 18,19

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2012	07/11/2012

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

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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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X	DE 10 2010 007465 A1 (BOSCH GMBH ROBERT [DE]) 11 August 2011 (2011-08-11) the whole document	1,2,5, 8-10, 14-16,19

X	WO 2005/068859 A1 (TIMKEN US CORP [US]; HAYWARD JOHN S [US]; BOBER THOMAS R [US]; MCLARET) 28 July 2005 (2005-07-28) cited in the application	1,2, 8-10, 12-16
A	paragraph [0019] - paragraph [0024]; figures 3-5	5,19

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X	US 570 040 A (MUELLER, F.A.) 27 October 1896 (1896-10-27) the whole document	1,2,8, 15,16

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International application No
PCT/US2012/024139

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