(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 November 2006 (30.11.2006)

PCT

(10) International Publication Number
WO 2006/127878 A2

(51) International Patent Classification:
*F16C 35/06* (2006.01) *B60K 17/36* (2006.01)

(21) International Application Number:
PCT/US2006/020202

(22) International Filing Date: 24 May 2006 (24.05.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/684,097 24 May 2005 (24.05.2005) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

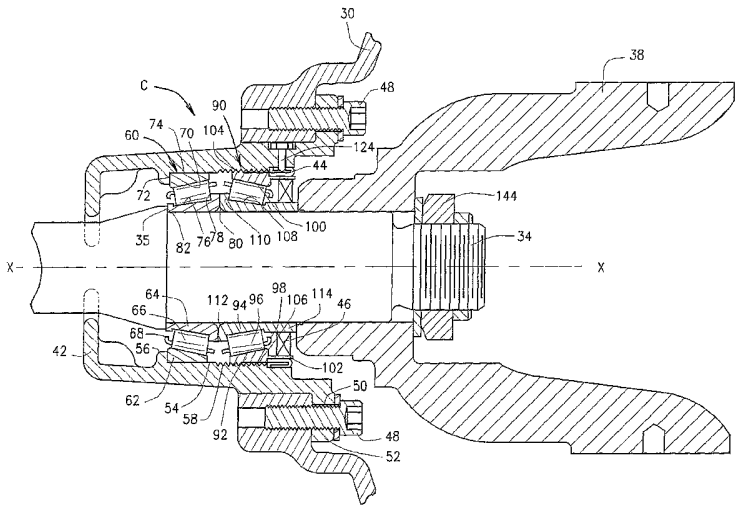
**Declarations under Rule 4.17:**

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

*[Continued on next page]*

(54) **Title:** BEARING ARRANGEMENT FOR THE THROUGH SHAFT IN A TANDEM AXLE DRIVE




(57) **Abstract:** A bearing assembly (C) for a through shaft (34) of a tandem axle assembly (12) having, a bearing housing (42) having an internal seat (54) with a unthreaded portion (74) and a threaded portion (58) for receiving respective front and rear bearings (60 and 90), which are mounted in opposition to support the through shaft (34) and transfer radial and axial loads. An threaded outer race (92) of the rear bearing (90) can be rotated to displace the rear bearing outer race (92) axially to control the setting of the front and rear bearings (60 and 90). The assembly may also include an antirotational locking device (44) attached to the rear bearing outer race (92), and coupled with the bearing housing (42) to prevent rotation of the rear outer race (92).

WO 2006/127878 A2

— *of inventorship (Rule 4.17(iv))*

**Published:**

— *without international search report and to be republished upon receipt of that report*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# BEARING ARRANGEMENT FOR THE THROUGH SHAFT IN A TANDEM AXLE DRIVE

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to United States Provisional Application No. 60/684,097 filed May 24, 2005 entitled THREADED CUP FOR THROUGH-SHAFT BEARING OF A TANDEM AXLE ASSEMBLY and which is incorporated herein by reference.

## BACKGROUND ART

Tandem axle assemblies are widely used on trucks and other heavy, load-carrying vehicles for two main reasons. The first is to distribute a heavy load between two axles so as to avoid excessive weight on a single axle. The second is to provide improved traction for adverse road conditions, such as ice, snow, or mud, or when a high torque is applied to a vehicle drive shaft, as for example because of a heavy load, a steep upgrade, or both.

A tandem axle assembly is usually located near the rear of the vehicle, and comprises two axles, a forward axle and a rear axle, and at least one differential to drive one or both of the axles. A through shaft in the differential is typically supported by a bearing arrangement comprising of a pair of single row tapered roller bearings mounted in opposition, sometimes referred to as direct mounting. This bearing arrangement transfers axial (thrust) loads in both axial directions as well as radial loads.

For each installation, it may be desirable to have the outer races of the two bearings installed with interference fits to provide maximum stability. However, both outer races are typically installed with a loose fit so that the bearings can be moved axially to adjust the setting of the bearings. This is particularly true for the bearings that support the through shaft of a tandem axle assembly. Once the correct setting of

the bearings is attained, the bearings are secured in a fixed axial position to retain the setting.

In some designs, one bearing is installed with the outer race having an interference fit while the other bearing is installed with the outer race having a loose fit. In this arrangement, only the bearing with the loose fit can be moved and secured axially to attain the correct bearing setting.

However, in both designs, the bearings with an outer race having a loose fit can still turn rotationally, which results in wear and premature failure of the outer race and its mating component, such as a housing. Also, installation of current designs can be time consuming, and contain numerous parts. In addition, the outboard mounted seals tend to wear out causing premature leakage.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings which form part of the specification:

Figure 1 is a plan view of a vehicle having a tandem axle assembly;

Figure 2 is a section view of the tandem axle assembly with a first embodiment of a bearing assembly C taken along line A-A of Figure 1;

Figure 3A is an enlarged section view of the first embodiment of the bearing assembly C;

Figure 3B is an enlarged section view of an antirotational device of Figure 3A;

Figure 4 is a perspective view of an adjustment tool;

Figure 5A is an enlarged section view of a second embodiment of the bearing assembly C;

Figure 5B is an enlarged section view of an antirotational device of Figure 5A;

Figure 6A is an enlarged section view of a third embodiment of the bearing assembly C;

Figure 6B is an enlarged section view of an antirotational device of Figure 6A;

Figure 7A is an enlarged section view of a fourth embodiment of the bearing assembly C;

Figure 7B is an enlarged section view of an antirotational device of Figure 7A;

Figure 8A is an enlarged section view of a fifth embodiment of the bearing assembly C;

Figure 8B is an enlarged section view of an antirotational device of Figure 8A;

Figure 9A is an enlarged section view of a sixth embodiment of the bearing assembly C;

Figure 9B is an enlarged section view of an antirotational device of Figure 9A;

Figure 10A is an enlarged section view of a seventh embodiment of the bearing assembly C;

Figure 10B is an enlarged section view of an antirotational device of Figure 10A;

Figure 10C is a perspective view of the antirotational device of Figure 10A;

Figure 11A is an enlarged section view of a eighth embodiment of the bearing assembly C;

Figure 11B is an enlarged section view of an antirotational device of Figure 11A;

Figure 11C is a perspective view of the antirotational device of Figure 11A;

Figure 12A is an enlarged section view of a ninth embodiment of the bearing assembly C;

Figure 12B is an enlarged section view of an antirotational device of Figure 12A;

Figure 12C is a front view of the antirotational device of Figure 12A;

Figure 13A is an enlarged section view of a tenth embodiment of the bearing assembly C;

Figure 13B is an enlarged section view of an antirotational device of Figure 13A;

Figure 13C is a front view of the antirotational device of Figure 13A;

Figure 13D is a front view of the antirotational device of Figure 13A adjusted in a counterclockwise position;

Figure 14A is an enlarged section view of a eleventh embodiment of the bearing assembly C;

Figure 14B is an enlarged section view of an antirotational device of Figure 14A;

Figure 14C is a perspective view of the antirotational device of Figure 14A;

Figure 15A is an enlarged section view of a twelfth embodiment of the bearing assembly C;

Figure 15B is an enlarged section view of an antirotational device of Figure 15A;

Figure 15C is a perspective view of the antirotational device of Figure 15A;

Figure 16A is an enlarged section view of a thirteenth embodiment of the bearing assembly C;

Figure 16B is an enlarged section view of an antirotational device of Figure 16A;

Figure 17A is an enlarged section view of a fourteenth embodiment of the bearing assembly C; and

Figure 17B is an enlarged section view of an antirotational device of Figure 17A.

Corresponding reference numerals indicate corresponding parts throughout the several figures of the drawings.

## BEST MODES FOR CARRYING OUT THE INVENTION

The following detailed description illustrates the invention by way of example and not by way of limitation. The description clearly enables one skilled in the art to make and use the invention, describes several embodiments, adaptations, variations, alternatives, and uses of the invention, including what is presently believed to be the best mode of carrying out the invention.

Figure 1 shows a vehicle 10 having a tandem axle assembly 12. The vehicle includes an engine 14 and transmission 16 operatively connected with a driveshaft 18 for driving the tandem axle assembly 12 via a coupling 20, such as a yoke or universal joint. The driveshaft 18 extends longitudinally from the transmission 16 to operatively connect with the tandem axle assembly 12 via a coupling 21, such as a yoke or universal joint.

The tandem axle assembly 12 is located near the rear of the vehicle 10 and includes two transversely extending axles, a first axle 22 and a second axle 24, which are driven by respective first differential 25 and second differential 26. As shown in Figures 1 and 2, a power divider 27 attached to the forward end of the first differential 25 operatively connects the first differential 25 to the driveshaft 18 via an input shaft 28. The front end of the input shaft 28 couples to the driveshaft 18 in a direct drive relationship with the coupling 21.

As shown in Figure 2, the power divider 27 includes an inter-axial differential (IAD) 31 coupled with the input shaft 28 to split the torque provided by the driveshaft 18 between the first differential 25 and the second differential 26. In addition, the inter-axial differential 31 couples the input shaft 28 to an output shaft 32. The output shaft 32 includes a spline that couples with a through shaft 34 of the first differential 25. Bearing assemblies A and B are mounted within a housing 29 of the power divider 27 and rotatively support the respective input shaft 28 and output shaft 32.

The first differential 25 includes a housing 30 with bearing assembly C mounted within the housing 30 to rotatively support the rear end of the through shaft 34. The through shaft 34 couples in a direct drive relationship to a prop shaft 36 with a suitable coupling 38, such as a yoke or universal joint. The prop shaft 36 couples with the second differential 26 in a direct drive relationship with a suitable coupling 40, such as a yoke or universal joint.

As shown in Figures 3A and 3B, a first embodiment of the bearing assembly C includes a bearing housing 42, a pair of antifriction bearings, front bearing 60 and rear bearing 90, preferably single row tapered roller bearings, coupled with the bearing housing 42 and mounted to the through shaft 34 in opposition in a direct configuration, an antirotational locking device 44 attached to an outer race, or cup 92, of the bearing 90, and a seal 46. The bearings 60 and 90 confine the through shaft 34 axially about axis X, while leaving it free to rotate. In addition, the antirotational locking device 44 prevents the loss of a bearing setting by preventing the cup 92 from backing away, or unthreading, from its originally setup axial position, which will be described in further detail below.

The bearing housing 42, sometimes referred to as a snorkel, is a cup-shaped housing, which secures to the first differential housing 30 by inserting cap screws 48 through holes 50 along a rim 52 of the bearing housing 42. The bore of the bearing housing 42 forms a bearing seat 54, which opens to the interior of the housing 42 and terminates in a shoulder 56. The rear half of the seat 54 contains an internal thread 58, which is of uniform diameter. The thread 58 has truncated crests, but its roots are V-shaped.

Both front and rear bearings 60 and 90 respectively include outer races in the form of front and rear cups 62 and 92, inner races in the form of cones 64 and 94 located within the respective cups 62 and 92, and rolling elements in the form of tapered rollers 66 and 96 arranged in a row between the respective cups 62 and 92 and cones 64 and 94.

The bearings 60 and 90 also include cages 68 and 98 in the row of tapered rollers 66 and 96 to maintain the correct spacing between the rollers 66 and 96. The bearings 60 and 90 have a common axis that coincides with the axis X.

In front bearing 60, the cup 62 has a tapered raceway 70 which is presented inwardly toward the axis X and a back face 72 at the large end of the cup 62. The back face 72 lies perpendicular to the axis X. The cup's 62 outwardly presented surface, that is its OD, is a smooth cylindrical surface 74.

The cone 64 lies within the cup 62 of the bearing 60 and has a tapered raceway 76 which is presented outwardly away from the axis X and toward the cup raceway 70. The large end of the cone 64 has a thrust rib 78 and at the end of the thrust rib 78 a back face 80 which is perpendicular to the axis X. The small end of the cone 64 has a front face 82, which is perpendicular to axis X.

The tapered rollers 66 for the bearing 60 lie in a single row between the raceways 70 and 76 of the cup 62 and cone 64. The rollers 66 contact the raceways 70 and 76 along their tapered side faces, while their large end faces bear against the thrust rib 78 of the cone 64. The rollers 66 are on apex, meaning that the conical envelopes in which their tapered side faces lie have their apices at a common point along the axis X. The apices for the conical envelopes for the raceways 70 and 76 lie at the same point.

The cage 68 holds the rollers 66 around the raceway 76 of the cone 64, so that the cone 64 and rollers 66 are installed as a unit, known as a first cone assembly. To install the bearing unit, the cone 64 for the bearing 60 fits over the through shaft 34, preferably with an interference fit, and the cone's front face 82 bears against a shaft shoulder 35.

In rear bearing 90, the bearing cup 92 has a tapered raceway 100 which is presented inwardly toward the axis X and an extended rib 102 extending axially from the large end of the cup 92. Along the cup's 92

outwardly presented surface, that is its OD, the cup 92 has a thread 104 and a smooth cylindrical surface 106 beyond the thread 104. The thread 104 occupies between 33% and 50% of the length of the cup 92 and extends from the thinner end of the cup 92 toward the opposite end of the cup 92. Thus, it encircles the cup 92 at the thinner end of the tapered raceway 100. The pitch and diameter of the thread 104 correspond to the pitch and diameter of the thread 58 of the seat 54 so that the cup thread 104 will engage the seat thread 58, although with a slight diametric clearance. The diameter of the cylindrical surface 106 exceeds the minor or least diameter for the external threads 104 on the cup 92 and is less than the diameter for the internal thread 58 on the bearing seat 54 at the truncated crests of the thread 58. The diametric clearance between the thread pitch diameters of the cup thread 104 and the bearing seat thread 58 must always be greater than the diametric clearance between the cylindrical surface 106 of the cup 92 and the truncated crests of the housing thread 58.

Preferably, the cups 62 and 92 are formed from steel that is induction hardened along their raceways 70 and 100, but not elsewhere. Alternatively, the cups 62 and 92 could be formed from case carburized steel and the threads 104 hard turned.

The cone 94 lies within the cup 92 of the bearing 90 and has a tapered raceway 108, which is presented outwardly away from the axis X and toward the cup raceway 100. The large end of the cone 94 has a thrust rib 110 and at the end of the thrust rib 110 a back face 112, which is perpendicular to the axis X. Also, the cone 94 has an extended rib 114 extended axially at the small end of the cone 94.

The tapered rollers 96 for the bearing 90 lie in a single row between the respective raceways 100 and 108 of the cup 92 and cone 94. They contact the raceways 100 and 108 along their tapered side faces, while their large end faces bear against the thrust rib 110 of the cone 94. The rollers 96 are on apex, meaning that the conical envelopes in which their tapered side faces lie have their apices at a

common point along the axis X. The apices for the conical envelopes for the raceways 100 and 108 lie at the same point.

The cone 94 for the bearing 90 fits over the shaft 34, preferably with an interference fit. Its back face 112 bears against the back face 80 of bearing 60. The cage 98 holds the rollers 96 around the raceway 108 of the cone 94, so that the cone 94 and rollers 96 are installed as a unit, known as a second cone assembly. The cup 92 for the bearing 90 threads into the bearing seat 54, its external thread 104 engaging the internal thread 58 of the seat 54. The threaded engagement of the bearing 90 with the bearing housing 42 allows for axial adjustment of the bearing 90 along the axis X to achieve a correct bearing setting, which is described in further detail below.

As shown in Figure 3B, the extended rib 102 of the cup 92 has notches 117 arranged at equal circumferential intervals. An adjustment tool 122, shown in Figure 4, can engage the notches 117 to rotate the cup 92, which adjusts the location of the bearing 90 axially along the axis X to achieve the correct bearing setting. The tool 122 takes the form of a disk 128 having tabs 130 along its periphery and a drive socket 132 at its center. It is configured to fit into the extended rib 102 of the cup 92 with its tabs 130 received in the notches 117, so that disk 128 and extended rib 102 engage and rotate in unison. This rotation can be affected by a wrench (not shown) that engages the tool 122 at its drive socket 132. Indeed, the tool 122 engages with the notches 117 in the extended rib 102 and the cup 94 is rotated with the tool 122 to give the bearings 60 and 90 the proper setting. The tool 122 also contains incremental marks 134 on its outer face 136, to aid in providing proper angular rotation to obtain correct bearing adjustment, if needed.

As shown in the first embodiment in Figures 3A and 3B, before the bearing 90 is installed, it is fitted with the antirotational locking device 44, which can be formed as a sheet metal stamping. The antirotational locking device 44 is similar to the antirotational locking device described in U.S. Patent Application 60/585,783, hereby

incorporated by reference. The antirotational locking device 44 is an annular ring 116 having a U-shaped cross-section having an outer lip 118 and an inner lip 120 extending inwardly towards the cup 92. The antirotational locking device 44 is attached to the bearing 90 by welding the inner lip 120 to the outer surface of the extended rib 102 of the cup 92. In other embodiments, the antirotational locking device 44 can assume any of a variety of configurations. Moreover, it can be attached to the cup 92 by a variety of methods, including, adhesives, screws, pins, and the like, at a variety of locations, including the back face, the front face, or the cylindrical surface.

When the bearing 90 is installed, the antirotational locking device 44 is secured against rotation in the housing 42 with a cone point set screw 124 of any type, including slotted, Philips, square, hex socket or any other type head, advanced through a threaded hole 126 of the housing 42, until the cone point set screw 124 penetrates or deforms the outer lip 118 of the antirotational locking device 44. The engagement of the cone point set screw 124 with the housing 42 and with the antirotational locking device 44 welded to the cup 92, connects the cup 92, antirotational locking device 44, screw 124 and housing 42 together, thus preventing rotation of the cup 92 in the housing 42. Therefore, the antirotational locking device 44 serves the important function of securing the cup 92 against rotation, backing away, or unthreading, once it is rotated to the correct bearing setting in the bearing seat 54. In addition, this prevents wear between bearing 90 outside diameter and housing 42 inside diameter in both threaded areas and unthreaded areas of the cup 92 and housing 42.

The cone point set screw 124 can penetrate or deform the outer lip 118 to engage it at any circumferential point. Therefore, the use of a cone point set screw 124 with the outer lip 118 provides for infinite rotational positioning of the cup 92. The width of the outer lip 118 is based on the axial tolerance stackup of all affected components in bearing assembly C, so there will always be enough outer lip 118

available for a cone point set screw 124 to penetrate and engage the outer lip 118.

In an alternate embodiment, the housing 42 does not have a threaded hole 126 for advancing the cone point set screw 124. Rather, the cone point set screw 124 is a self-tapping screw, which is drilled through an unthreaded hole of the housing 42 until it penetrates the outer lip 118 of the antirotational locking device 44.

For installation of the bearing assembly C, the first cone assembly, that is the cone 64 and its rollers 66, is installed over the through shaft 34 so that the front face 82 bears against the shaft shoulder 35. The second cone assembly, that is the cone 94 and its rollers 96, is installed over the through shaft 34 so that the back face 112 of the cone 94 bears against the back face 80 of the cone 64. Once the cone assemblies are fitted to the shaft 34, the cup 62 is fitted inside the housing 42, preferably with an interference fit, so that the back face 72 of the cup 62 bears against the housing shoulder 56. Next, the housing 42 with fitted cup 62 is installed over the shaft 34 so that the cup 62 is fitted around the rollers 66 that are located around the cone 64.

Thereupon, the cup 92 is fitted over the shaft 34 so that the cup external threads 104 engage the housing internal threads 58 and the cup 92 is fitted around the rollers 96 that are located around the cone 94. A thread sealant is placed onto the threads 58 and 104. The rear bearing 90 is adjusted by advancing and retracting the cup 92 in the bearing seat 54 by rotating the cup 92 using the adjustment tool 122 until the correct bearing setting is achieved.

Once the correct bearing setting is achieved, the rear bearing 90 is secured by advancing the cone point set screw 124 through the threaded hole 126 of the housing 42, until the cone point set screw 124 penetrates through or deforms the outer lip 118 of the antirotational locking device 44. It should be noted that this design eliminates the

need for additional parts, such as snap rings and spacers, to achieve the correct bearing setting.

The seal 46 is seated between the outer surface of the extended rib 114 of the cone 94 and the inner surface of the extended rib 102 of the cup 92. By seating the seal 46 within the bearing assembly C, rather than on the coupling 38, a smaller diameter seal is used resulting in a decreased running speed, and the seal 46 is positioned closer to the bearing assembly C, which reduces deflection at the seal lip caused by shaft deflection, thereby extending the life of the seal. In addition, the coupling 38 does not need a machined surface to seat a seal, thereby reducing the cost of producing the coupling.

The coupling 38 is fitted over the through shaft 34 and secured with a nut 144. The through shaft 34 with bearing assembly C and coupling 38 are installed into the first differential housing 30 and secured by inserting cap screws 48 through holes 50 along a rim 52 of the bearing housing 42.

Many variations of the bearing assembly C can be made without departing from the scope of the invention. Several alternate embodiments of the bearing assembly C are shown in Figures 5A-17B. For ease of understanding, components common between the various embodiments are identified with matching reference numbers. Components that are similar but have some variations are identified with matching reference numbers and an appropriate letter suffix. For example, the antirotational locking device of the first embodiment is identified as 44, while a second embodiment with a similar antirotational device is identified as 44A. All similar components in the third embodiment have the letter suffix "B". Similar components in the fourth embodiment will have the letter suffix "C', and so on. Naturally, any new components are identified with unique reference numbers.

As shown in a second embodiment of the bearing assembly C in Figures 5A and 5B (please note that similar components use suffix "A"), the antirotational locking device 44 can be embodied in other forms. In

the second embodiment, the antirotational device 44A is a notched annular ring 138 having a L-shaped cross section with an uninterrupted outer lip 140 extending inwardly towards the cup 92A. The antirotational locking device 44A is attached to the bearing 90A by welding the ring 138 to a back face of the extended rib 102 of the cup 92A. In this way, the antirotational locking device 44A remains with the cup 92A and is configured for engagement by the adjustment tool 122. Similar to the description above, the tool 122 is configured to fit into antirotational locking device 44A with its tabs 130 received in notches 142, so that disk 128 and antirotational locking device 44A are engaged and will rotate in unison to achieve the correct bearing setting. Once the bearing setting is achieved, the bearing 90A is secured by engagement of the cone point set screw 124 into the outer lip 140 of the ring 138, as in previous embodiments.

As shown in Figures 6A and 6B (please note that similar components use suffix "B"), a third embodiment of the bearing assembly C includes a cup carrier 150 that engages a cup 92B. The cup carrier 150 is an annular ring with a threaded outer surface 152 and a smooth inner cylindrical surface 154. The pitch and diameter of the threaded outer surface 152 correspond to the pitch and diameter of a stepped seat thread 58B on the bearing seat 54 so that the cup carrier 150 will engage the stepped seat thread 58B at the truncated crests of the thread 58B, although with a slight diametric clearance. In this embodiment, the outside diameter of the cup 92B is a smooth cylindrical surface 106B, having no threads. The smooth surface 106B of the cup 92B fits within the inner surface 154 of the cup carrier 150, preferably with an interference fit, with a back face 103 of the cup 92B seated against a shoulder 156 of the cup carrier. The seal 46 is seated between the inner surface of an extended rib 158 of the cup carrier 150 and the outer surface of the extended rib 114 of the cone 94.

In the third embodiment, the antirotational device 44B is a notched annular ring 160 having a U-shaped cross section with an

uninterrupted outer lip 162 extending outwardly from the cup carrier 150. The antirotational locking device 44B is attached to the cup carrier 150 by welding the ring 160 to a back face of the extended rib 158. In this way, the antirotational locking device 44B remains with the cup carrier 150 and cup 92B and is configured for engagement by the adjustment tool 122. An inner lip 164 of the ring 160 includes notches 166, which will receive the tabs 130 of the adjustment tool 122. Similar to the embodiments described above, the tool 122 is configured to fit into antirotational locking device 44B with its tabs 130 received in notches 166, so that disk 128 and antirotational locking device 44B are engaged and will rotate in unison to achieve the correct bearing setting. Once the bearing setting is achieved, the bearing 90B is secured by engagement of the cone point set screw 124 into the outer lip 162 of the ring 160, as in previous embodiments.

As shown in a fourth embodiment of the bearing assembly C in Figures 7A and 7B (please note that similar components use suffix "C"), the cup 92C and cone 94C are similar to the first embodiment, except neither has an extended rib 117 and 114 for seating the seal 46C. Consequently, the seal 46C is seated between the outer surface of the coupling 38 and the inner surface of the bearing housing 42C. A cone spacer 168 is seated around the through shaft 34 and between the front face 113C of the cone 94C and the coupling 38.

In the fourth embodiment, the antirotational device 44C is the same as in Figures 6A and 6B having a notched annular ring 160 having a U-shaped cross section with an uninterrupted outer lip 162 extending outwardly from the cup 92C. However, in this embodiment the antirotational locking device 44C is attached to the cup 92C by welding the ring 160 to a back face 103 of the cup 92C. In this way, the antirotational locking device 44C remains with the cup 92C and is configured for engagement by the adjustment tool 122. An inner lip 164 of the ring 160 includes notches 166, which will receive the tabs 130 of the adjustment tool 122. Similar to the embodiments described above,

the tool 122 is configured to fit into antirotational locking device 44C with its tabs 130 received in notches 166, so that disk 128 and antirotational locking device 44C are engaged and will rotate in unison to achieve the correct bearing setting. Once the bearing setting is achieved, the bearing 90C is secured by engagement of the cone point set screw 124 into the outer lip 162 of the ring 160, as in previous embodiments.

As shown in Figures 8A and 8B, a fifth embodiment of the bearing assembly C (please note that similar components use suffix "D") is similar to the fourth embodiment in Figures 7A and 7B, except for the cup 92D. In the fifth embodiment, a thread 104D and a smooth cylindrical surface 106D of the cup 92D are located on the opposite end of the cup 92D, thereby, extending from the thicker end of the cup 92D to the opposite end and occupying between 33%-50% of the length of the cup 92D.

The antirotational locking device 44D is attached to the cup 92D by welding the ring 160 to a back face 103 of the cup 92D. Once the bearing setting is achieved, the bearing 90D is secured by engagement of the cone point set screw 124 into the outer lip 162 of the ring 160, as in previous embodiments.

As shown in Figures 9A and 9B, a sixth embodiment of the bearing assembly C (please note that similar components use suffix "E"), is similar to the fifth embodiment in Figures 8A and 8B except for the bearing seat thread 58E. In the sixth embodiment, the bearing housing 42E has a stepped internal thread 58E along the rear portion of the seat 54E. The thread 58E is approximately the same length as the thread 104E of the cup 92E so that the smooth cylindrical surface 106E of the cup 92E rides along the bearing seat 54E of the bearing housing 42E. There is a gap 146 between the end of the threads 104E on the cup 92E and the start of the bearing seat 54E.

The antirotational locking device 44E is attached to the cup 92E by welding the ring 160 to a back face 103 of the cup 92E. Once the bearing setting is achieved, the bearing 90E is secured by engagement

of the cone point set screw 124 into the outer lip 162 of the ring 160, as in previous embodiments.

As shown in Figures 10A-10C (please note that similar components use suffix "F"), a seventh embodiment of the bearing assembly C is similar to the fifth embodiment Figures 8A and 8B, except for a different antirotational device 44F. Similarly, the cup 92F and cone 94F do not have an extended rib 117 and 114 for seating the seal 46F. The seal 46F is seated between the outer surface of the coupling 38 and the inner surface of the bearing housing 42. A cone spacer 168 is seated around the through shaft 34 and between the front face 113F of the cone 94F and the coupling 38.

In the seventh embodiment, the antirotational device 44F is an annular ring 170 having a U-shaped cross section with an outer lip 172 and an inner lip 174 extending outwardly from the cup 92F. The antirotational locking device 44F is attached to the cup 92F by welding the ring 170 to a back face 103 of the cup 92F. In this way, the antirotational locking device 44F remains with the cup 92F and is configured for engagement by the adjustment tool 122. An inner lip 174 includes notches 176, which will receive the tabs 130 of the adjustment tool 122. Similar to the embodiments described above, the tool 122 is configured to fit into antirotational locking device 44F with its tabs 130 received in notches 176, so that disk 128 and antirotational locking device 44F are engaged and will rotate in unison to achieve the correct bearing setting. The outer lip 172 includes outwardly bent tabs 178 that point in the direction opposite for advancement of the bearing 90F. In Figure 10C, the bent tabs 178 point counterclockwise. All the bent tabs 178 point the same direction so that the antirotational device 44F and attached cup 92F can only rotate in one direction.

When the bearing 90F is installed, the antirotational locking device 44F is secured against rotation in the housing 42 with the set screw 179. The set screw 179 advances through the threaded hole 126 until the tip is positioned between the bent tabs 178, but the set screw

179 does not penetrate the outer lip 172. In this position, the antirotational locking device 44F can rotate clockwise to adjust the bearing setting. As the antirotational locking device 44F rotates clockwise, the set screw 179 presses down on each bent tab 178, which allows the set screw 179 to pass over the bent tab 178. After the set screw 179 passes over the bent tab 178, the bent tab 178 springs back to its original position, which prevents the antirotational locking device 44F from turning counter-clockwise. In this way, the antirotational locking device 44F can only rotate in one direction. To achieve the correct bearing setting, the installer simply rotates the antirotational locking device 44F clockwise until the correct setting is achieved. No further steps are needed because, the bent tabs 178 prevent the antirotational device 44F from backing out. If the installer wants to rotate the antirotational locking device 44F counter-clockwise, the installer must remove the set screw 179.

The accuracy of bearing setting adjustment is related to the number of bent tabs 178. Therefore, increasing the number of bent tabs 178 along the outer lip 172 will result in greater accuracy in adjustment. Those skilled in the art will recognize that any number of bent tabs 178 can be used.

As shown in Figures 11A-11C (please note that similar components use suffix "G"), an eighth embodiment of the bearing assembly C is similar to the fifth embodiment in Figures 8A and 8B, except for a different antirotational device 44G. In this embodiment, the antirotational device 44G is a flat disc 180 having a penannular slot 182 and a tab 184 extending from the inside diameter. The flat disc 180 can be formed as a sheet metal stamping. The antirotational device 44G attaches to the cup 92G by inserting the tab 184 into an annular slot 186 in the cup thread 104G. An adjustment tool having a tab (not shown) engages the slot 186 to advance or retract the bearing 90G and achieve the proper bearing setting. Once the bearing setting is achieved, the antirotational device 44G is secured by inserting a fastener 188 through

the penannular slot 182 and into one of the threaded holes 190 in the housing 42G. Like previous embodiments, this arrangement allows for infinite axial positioning of the cup 92G.

As shown in Figures 12A-12C (please note that similar components use suffix "H"), a ninth embodiment of the bearing assembly C is similar to the eighth embodiment in Figures 11A-11C, except for a different antirotational locking device 44H. In this embodiment, the antirotational device 44H is a flat disc 180 having a penannular slot 182 and a stepped inner face 192. The flat disc 180 can be formed as a sheet metal stamping. The antirotational locking device 44H is attached to the cup 92H by a suitable means, such as welding, the stepped inner face 192 to a back face 103 of the cup 92H. In this way, the antirotational locking device 44H remains with the cup 92H and is configured for engagement by the adjustment tool 122. The stepped inner face 192 has notches 194 arranged at equal circumferential intervals, which will receive the tabs 130 of the adjustment tool 122. Similar to the embodiments described above, the tool 122 is configured to fit into antirotational locking device 44H with its tabs 130 received in notches 194, so that disk 128 and antirotational locking device 44H are engaged and will rotate in unison to achieve the correct bearing setting. Once the bearing setting is achieved, the antirotational device 44H is secured by inserting a fastener 188 through the penannular slot 182 and into one of the threaded holes 190 in the housing 42H.

As shown in Figures 13A-13D (please note that similar components use suffix "J"), a tenth embodiment of the bearing assembly C is similar to the embodiment in Figures 8A and 8B, except for the antirotational locking device 44J. In the tenth embodiment, the antirotational device 44J is a flat rectangular first plate 212 with straight edges 214. The first plate 212 has a circular bore 216 that includes notches 218 arranged at equal circumferential intervals, which will receive the tabs 130 of the adjustment tool 122. The antirotational

device 44J is attached to the bearing 90J by welding an inner face 220 of the antirotational device 44J to the back face 103 of the cup 92J. In this way, the antirotational locking device 44J remains with the cup 92J and is configured for engagement by the adjustment tool 122. Similar to the embodiments described above, the tool 122 is configured to fit into antirotational locking device 44J with its tabs 130 received in notches 218, so that disk 128 and antirotational locking device 44J are engaged and will rotate in unison to achieve the correct bearing setting.

A flat rectangular second plate 222 is attached to the housing 42J with an appropriate fastener 224 so that a bottom edge 226 of the second plate 222 mates with the edge 214 of the first plate 212. A slot 228 allows the second plate 222 to rotate/adjust to the corresponding position of the first plate 212. Once the bearing setting is achieved, the bearing 90J is secured by tightening the fastener 224. Once secured, the bar 222 prevents the first plate 212 from any further rotation.

Note that the widths of the first plate 212 and second plate 222 are sized appropriately to allow rotational movement inside the housing 42J. The bottom edge of the second plate 222 is longer than the edge 214 of the first plate 212 to accommodate the adjustment of both parts. In addition, the second plate 222 should have a thickness to accommodate the axial movement of the cup 92J and first plate 212 as the bearing setting is adjusted. Also note that the dimensions of the first plate 212 and second plate 222 in Figures 13C and 13D are not shown to scale, but are shown for ease of understanding.

As shown in Figures 14A-14C (please note that similar components use suffix "K"), an eleventh embodiment of the bearing assembly C is similar to the second embodiment in Figures 5A and 5B, except for the antirotational device 44K. The antirotational locking device 44K is an annular ring 200 having a U-shaped cross-section having an outer lip 202 and an inner lip 204 extending inwardly towards the cone 94K. The antirotational locking device 44K is attached to the bearing 90K by welding the inner lip 204 to the outer surface of the

extended rib 102K of the cup 92K. The outer lip 202 includes notches 206, which will receive the tabs 130 of the adjustment tool 122. Similar to the embodiments described above, the tool 122 is configured to fit into antirotational locking device 44K with its tabs 130 received in notches 206, so that disk 128 and antirotational locking device 44K are engaged and will rotate in unison to achieve the correct bearing setting. Once the bearing setting is achieved, the bearing 90K is secured by engagement of the cone point set screw 124 into the annular ring 200, as in previous embodiments.

The antirotational device 44K includes a shaft sensor 208 attached to the outer lip 202 with an appropriate fastener 210. The shaft sensor 208 is positioned to point inwardly at the seal 46K, which contains an embedded tone wheel 209. In operation, the shaft sensor 208 sends a signal that is used to measure the speed of the through shaft 34. Although, Figures 14A-14C show the shaft sensor 208 next to the cone point set screw 124 for clearer illustration, in operation, the shaft sensor 208 is preferably attached to the outer lip 202 180° away from the cone point set screw 124.

As shown in Figures 15A-15C (please note that similar components use suffix "L"), a twelfth embodiment of the bearing assembly C is similar to the eleventh embodiment in Figures 14A-14C, except for the cup 94L and the antirotational device 44L. The cone 94L has a shortened extended rib 114L with a cone spacer 168L seated around the through shaft 34 and between the front face 113L of the cone 94L and the coupling 38.

The antirotational device 44L is similar to Figures 14A-14C except for the position of the shaft sensor 208L and the tone wheel 209L. In this embodiment, the shaft sensor 208L is positioned to point towards the tone wheel 209L attached to the cone spacer 168L. In operation, the shaft sensor 208L sends a signal that is used to measure the speed of the through shaft 34. Although, Figures 15A-15C show the shaft sensor 208L next to the cone point set screw 124 for clearer

illustration, in operation, the shaft sensor 208L is preferably attached to the outer lip 202 180° away from the cone point set screw 124.

As shown in Figures 16A and 16B (please note that similar components use suffix "M"), a thirteenth embodiment of the bearing assembly C is similar to the fifth embodiment in Figures 8A and 8B, except for the addition of the shaft sensor 208M. In this embodiment, the shaft sensor 208M is attached to housing 42M with an appropriate fastener 210M. This allows the shaft sensor 208M to be wireless. The shaft sensor 208M is positioned to point towards a tone wheel 209M, which is embedded in the seal 46M. In operation, the shaft sensor 208M sends a signal that is used to measure the speed of the through shaft 34.

As shown in Figures 17A and 17B (please note that similar components use suffix "N"), a fourteenth embodiment of the bearing assembly C is similar to the thirteenth embodiment in Figures 16A and 16B, except for the position of the shaft sensor 208N and tone wheel 209N. In this embodiment, the shaft sensor 208N is positioned to point towards a tone wheel 209N, which is attached to the coupling 38. In operation, the shaft sensor 208N sends a signal that is used to measure the speed of the through shaft 34.

Other variations of the bearing assembly C are available as well. For example, the threads 58 and 104 in the bearing seat 54 and on the cup 92, respectively, are helices, and other forms of helices can be used, such as ball screws. Also, other bearings with inclined raceways – for example, angular contact ball bearing – can be substituted for the tapered roller bearings 60 and 90.

Changes can be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

CLAIMS:

What is claimed is:

1. A bearing assembly for a through shaft of a tandem axle assembly, comprising:

a bearing housing having an internal seat with a unthreaded portion and a threaded portion;

a front antifriction bearing supporting the through shaft in the bearing housing about a primary axis, the front bearing being configured to transfer a radial load and an axial load, the front bearing including an front inner raceway carried by the through shaft and presented outwardly away from the axis, a front outer race engaged with the non-threaded portion of the seat and having a front outer raceway presented inwardly toward the inner raceway, and front rolling elements located between the front inner raceway and front outer raceway;

a rear antifriction bearing supporting the through shaft in the bearing housing about a primary axis, the rear bearing being mounted in opposition to the front bearing, the rear bearing being configured to transfer a radial load and an axial load, the rear bearing including an rear inner raceway carried by the through shaft and presented outwardly away from the axis, a rear outer race engaged with the threaded portion of the seat and having a rear outer raceway presented inwardly toward the rear inner raceway, and rear rolling elements located between the rear inner raceway and rear outer raceway;

whereby rotation of the rear bearing outer race will displace the rear bearing outer race axially and control the setting of the front and rear bearings.

2. The bearing assembly of claim 1, further comprising:

a first differential having a differential housing, the bearing housing being secured to the differential housing; and

a power divider having a divider housing, the power divider operatively connecting the first differential to a drive shaft.

3. The bearing assembly of claim 2, the power divider further comprising:

an input shaft coupled to the drive shaft and supported by an input shaft bearing assembly within the divider housing;

an output shaft aligned with the input shaft and supported by an output shaft bearing assembly within the divider housing; and

the through shaft being coupled to the output shaft for rotation with the output shaft at the same velocity as the output shaft.

a second axle operatively engages with the first differential;

4. The bearing assembly of claim 3, the power divider further comprising:

an interaxle differential located within the divider housing and coupling the input shaft to the output shaft so that the input and output shafts can rotate about the axis at different angular velocities.

5. The bearing assembly of claim 1, wherein the front bearing outer race includes a smooth surface that engages the unthreaded portion of the seat with an interference fit.

6. The bearing assembly of claim 1, wherein the rear bearing outer race includes an external thread that engages the threaded portion of the seat.

7. The bearing assembly of claim 1, wherein the rear bearing inner race includes an extended rib for seating a seal.

8. The bearing assembly of claim 1, further comprising:

a spacer seated about the through shaft, the spacer being positioned between the inner race and a coupling.

9. The bearing assembly of claim 1, further comprising:

an antirotational locking device attached to the rear bearing outer race, the locking device being coupled with the bearing housing to prevent rotation of the rear outer race.

10. The bearing assembly of claim 9, wherein the antirotational locking device comprises:

an annular ring having an outer lip and an inner lip, the inner lip being attached to an extended rib of the rear bearing outer race; and

a fastener being capable of advancing through a hole of the bearing housing and engaging the outer lip to prevent the rotation of the rear bearing outer race.

11. The bearing assembly of claim 9, wherein the antirotational locking device comprises:

an annular ring attached to an extended rib of the rear bearing outer race, the annular ring having an outer lip and an inner lip extending inwardly toward the rear bearing outer race; and

a fastener being capable of advancing through a hole of the bearing housing and engaging the outer lip to prevent the rotation of the rear bearing outer race.

12. The bearing assembly of claim 1, wherein the rear outer race comprises:

a carrier having a threaded outer surface that engages the threaded portion of the seat, the carrier having an inner surface;

a cup engaged with the carrier inner surface and including the rear outer raceway presented inwardly toward the inner raceway;

wherein the antirotational locking device, comprises;

an annular ring attached to the carrier, the ring having an outer lip extending outwardly from the carrier; and

a fastener being capable of advancing through a hole of the bearing housing and engaging the outer lip to prevent the rotation of the rear bearing outer race.

13. The bearing assembly of claim 9, wherein the antirotational locking device comprises:

an annular ring attached to the rear outer race, the ring having an outer lip extending outwardly from the rear outer race; and

a fastener being capable of advancing through a hole of the bearing housing and engaging the outer lip to prevent the rotation of the rear bearing outer race.

14. The bearing assembly of claim 1, the bearing housing further comprising:

a gap between the threaded portion and the unthreaded portion, wherein the threaded portion is stepped to have a diameter greater than the diameter of the unthreaded portion.

15. The bearing assembly of claim 9, wherein the antirotational locking device comprises:

an annular ring attached to the rear bearing outer race, the ring having an outer lip and an inner lip, the outer lip having at least two tabs bent outwardly in the direction opposite for advancement of the rear bearing; and

a fastener being capable of advancing through a hole of the bearing housing and positioning between the tabs to prevent the rotation of the rear bearing outer race.

16. The bearing assembly of claim 9, wherein the antirotational locking device comprises:

a flat disc having a penannular slot and a tab extending inwardly toward the axis, the tab being capable of engaging an annular slot in the rear bearing outer race; and

a fastener being capable of advancing through the penannular slot of the bearing housing and engaging a threaded hole in the bearing housing to prevent the rotation of the rear bearing outer race.

17. The bearing assembly of claim 9, wherein the antirotational locking device comprises:

a flat disc having a penannular slot and stepped inner face extending inwardly toward the axis, the inner face being attached to the rear bearing outer race; and

a fastener being capable of advancing through the penannular slot of the bearing housing and engaging a threaded hole in the bearing housing to prevent the rotation of the rear bearing outer race.

18. The bearing assembly of claim 9, wherein the antirotational locking device comprises:

a first rectangular plate having a first edge and a slot;

a second rectangular plate having a second edge capable of mating with the first edge, the second rectangular plate being attached to the rear bearing outer race; and

a fastener being capable of advancing through the slot of the first rectangular plate and engaging a threaded hole in the bearing housing to prevent the rotation of the rear bearing outer race.

19. The bearing assembly of claim 9, further comprising:

a seal seated between an extended rib of the rear bearing outer race and an extended rib of the rear bearing inner race;

a tone wheel attached to the seal, the tone wheel being presented outwardly away from the rear bearing;

wherein the antirotational locking device comprises an annular ring having an inner lip attached to the extended rib of the rear bearing outer race and an outer lip extending inwardly toward the axis, the locking device including a sensor attached to the outer lip and positioned to point at the tone wheel;

a fastener being capable of advancing through a hole of the bearing housing and engaging the locking device to prevent the rotation of the rear bearing outer race.

20. The bearing assembly of claim 9, further comprising:

a spacer seated around the through shaft, the spacer being positioned between an extended rib of the rear bearing inner race and a coupling;

a tone wheel attached to the spacer, the tone wheel being presented outwardly away from the axis;

wherein the antirotational locking device comprises an annular ring having an inner lip attached to the extended rib of the rear bearing outer race and an outer lip extending inwardly toward the axis, the locking device including a sensor attached to the outer lip and positioned to point at the tone wheel; and

a fastener being capable of advancing through a threaded hole of the bearing housing and engaging the locking device to prevent the rotation of the rear bearing outer race.

21. The bearing assembly of claim 1, further comprising:

a coupling engaged with the through shaft;

a seal seated between the bearing housing and a coupling;

a tone wheel attached to the seal, the tone wheel being presented inwardly toward the rear bearing;

a sensor attached to bearing housing, the sensor being positioned to point at the tone wheel;

an antirotational locking device attached to the rear bearing outer race, the locking device being coupled with the bearing housing to prevent rotation of the rear outer race; and

a fastener being capable of advancing through a hole of the bearing housing and engaging the antirotational locking device to prevent the rotation of the rear bearing outer race.

22. The bearing assembly of claim 1, further comprising:

a coupling engaged with the through shaft;

a tone wheel attached to the coupling, the tone wheel being presented outwardly away from the axis;

a sensor attached to bearing housing, the sensor being positioned to point at the tone wheel;

an antirotational locking device attached to the rear bearing outer race, the locking device being coupled with the bearing housing to prevent rotation of the rear outer race; and

a fastener being capable of advancing through a hole of the bearing housing and engaging the antirotational locking device to prevent the rotation of the rear bearing outer race.

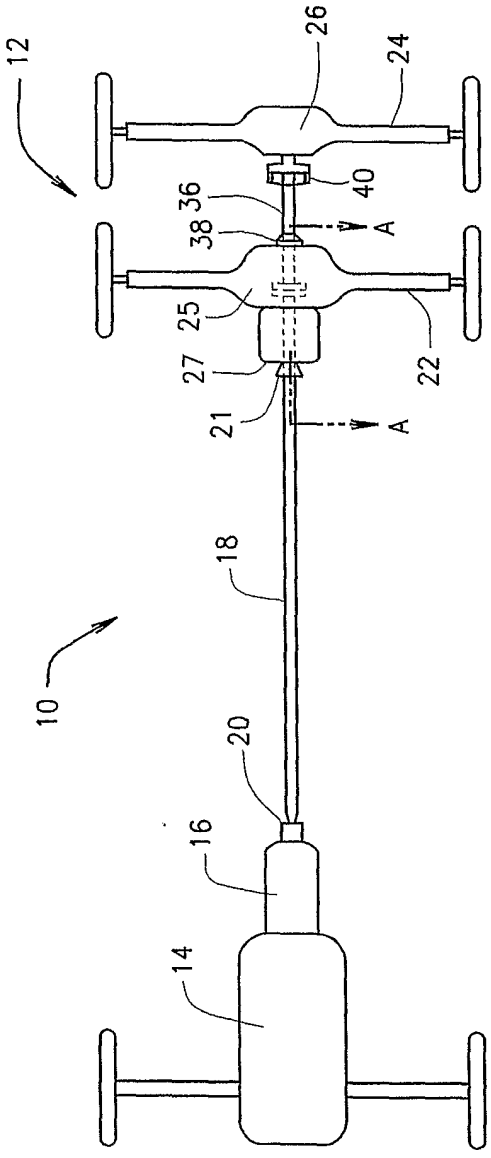



FIG. 1

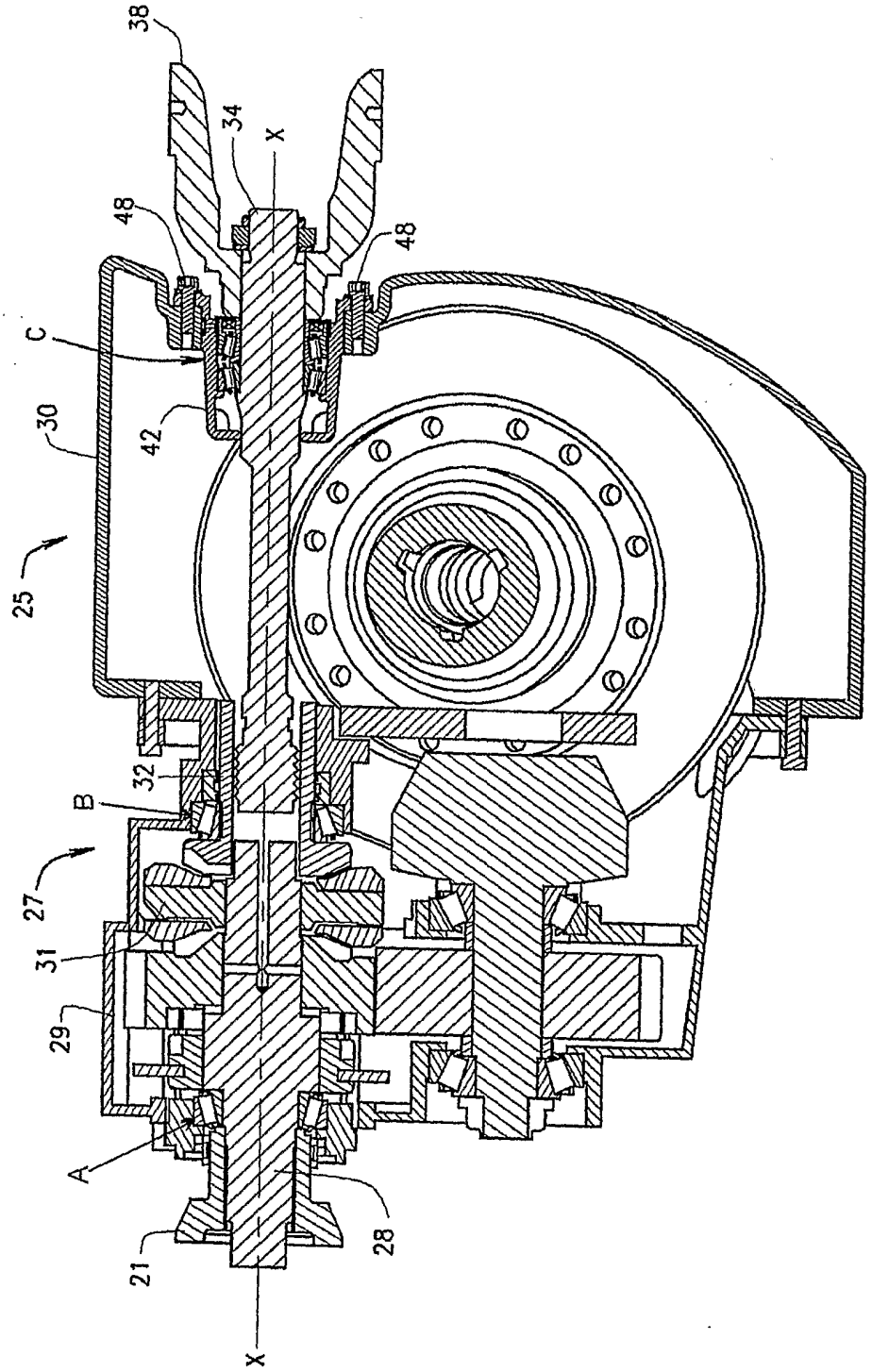



FIG. 2

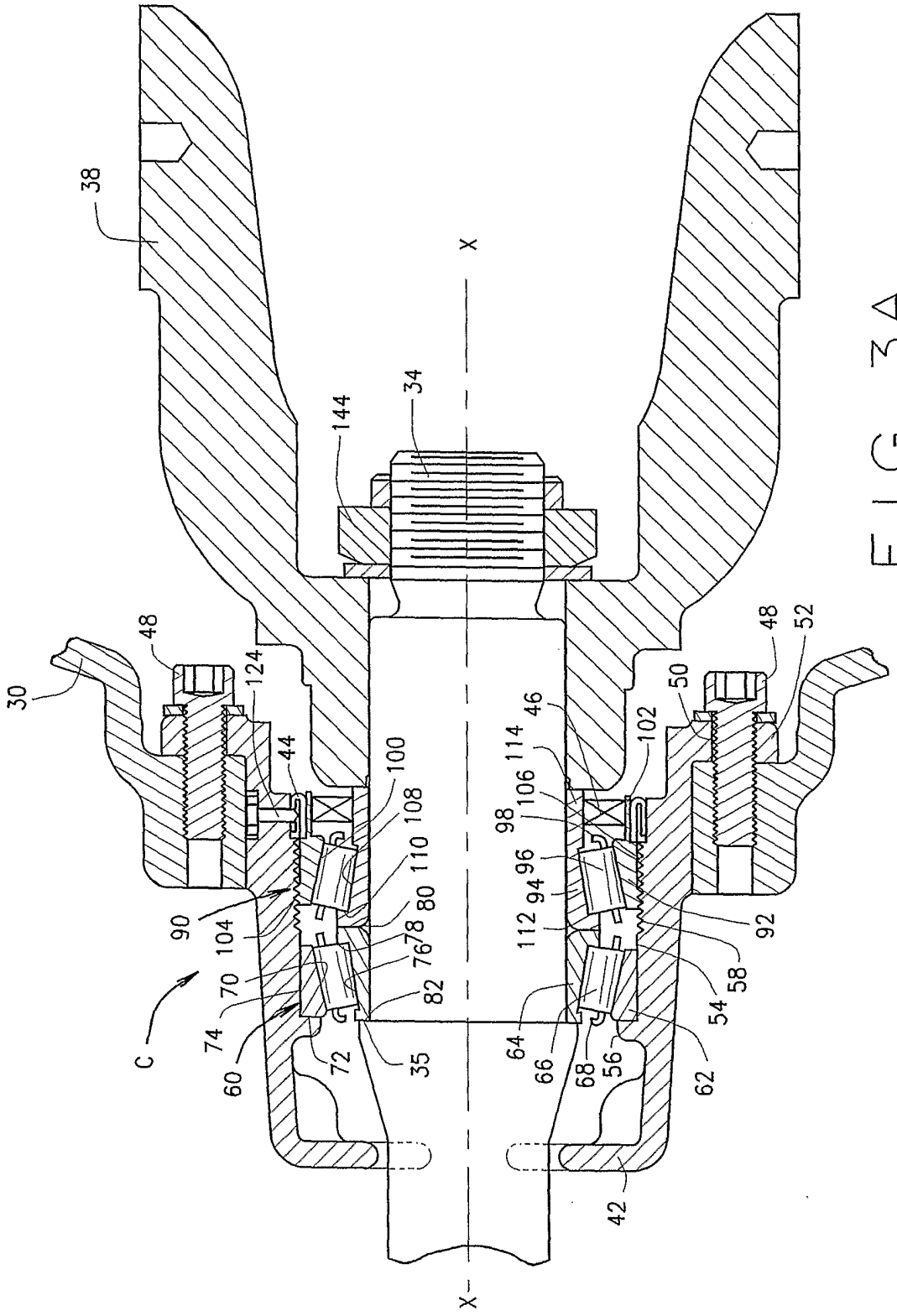

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X

FIG. 3A

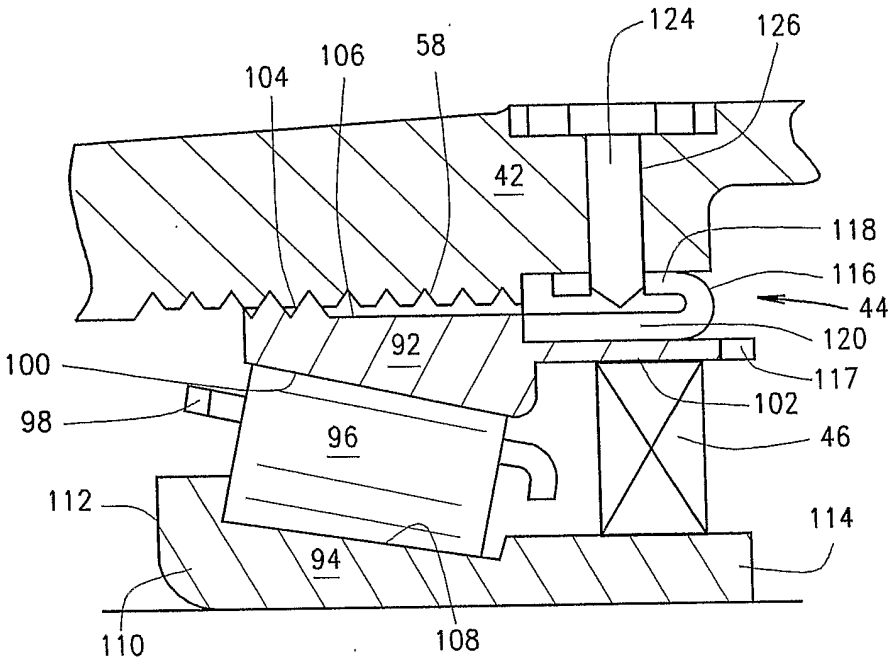

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126
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118
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120
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108

FIG. 3B

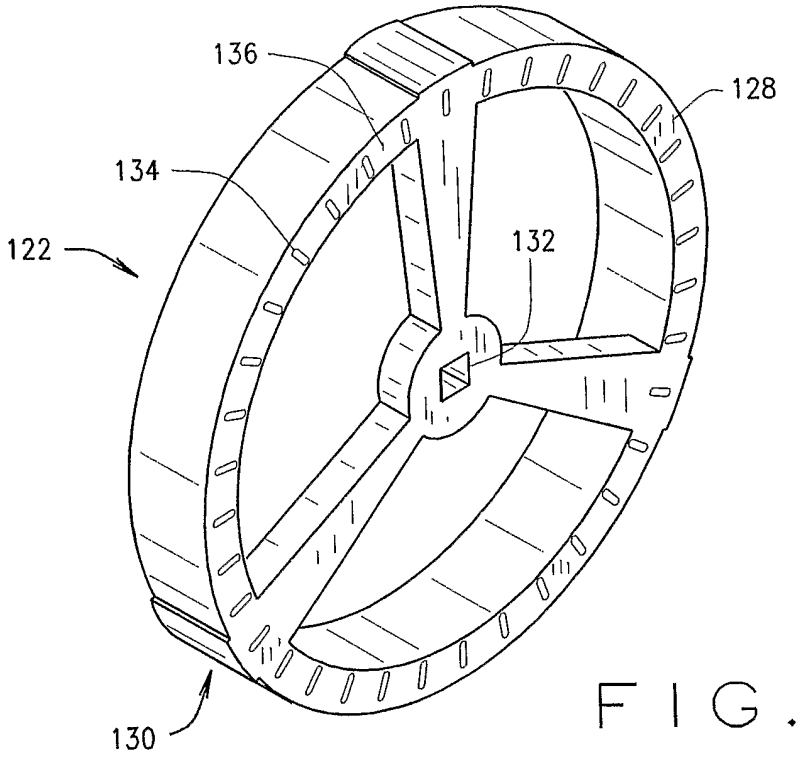

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122
132
130

FIG. 4

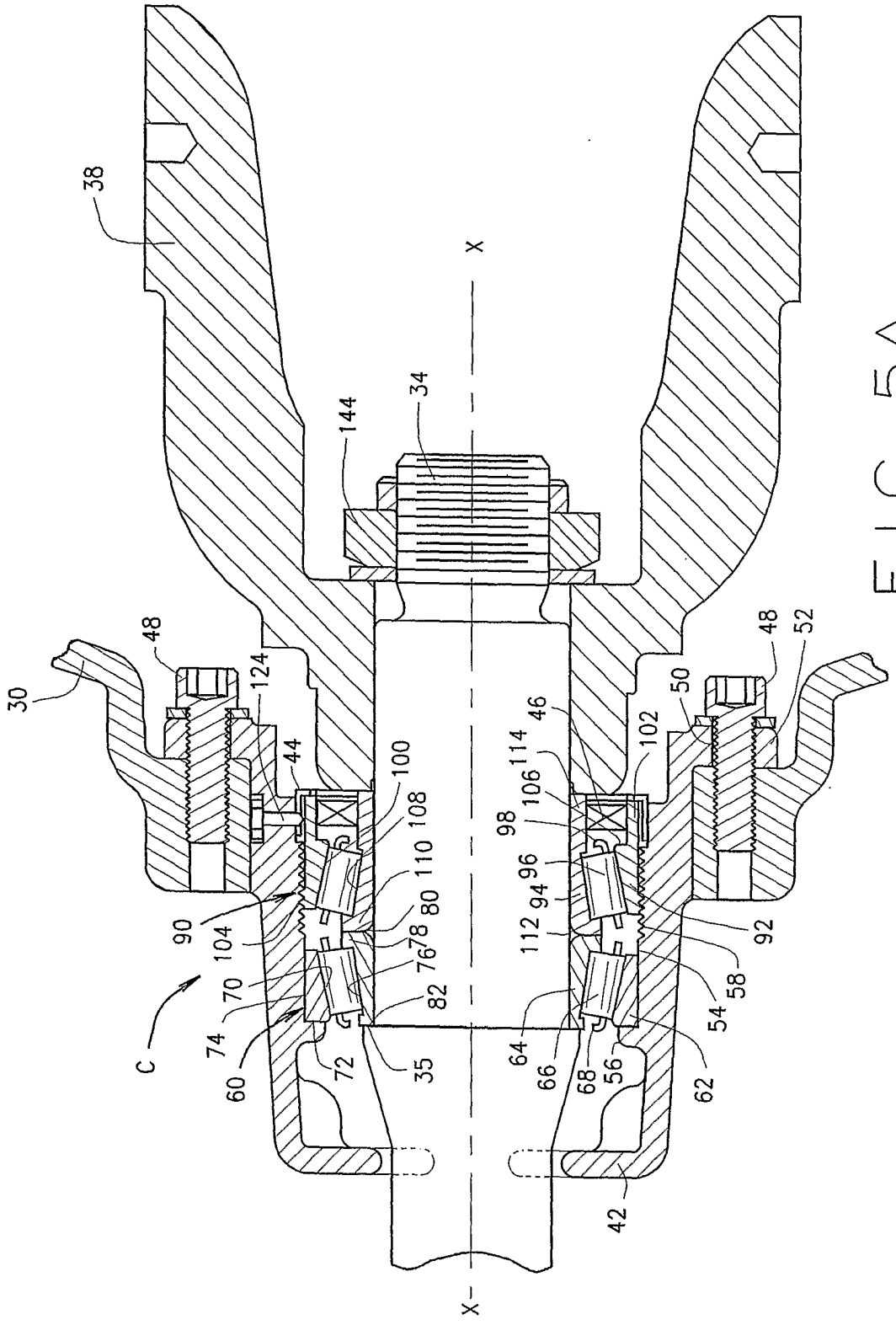

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X

FIG. 5A

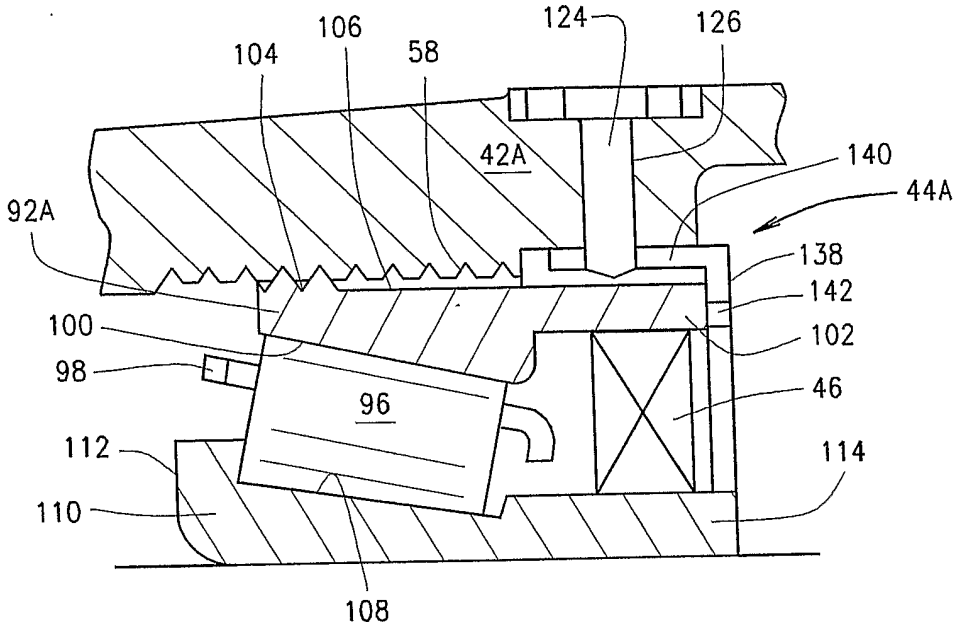

124
126
106
104
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42A
140
44A
92A
138
142
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102
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96
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112
114
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108

FIG. 5B

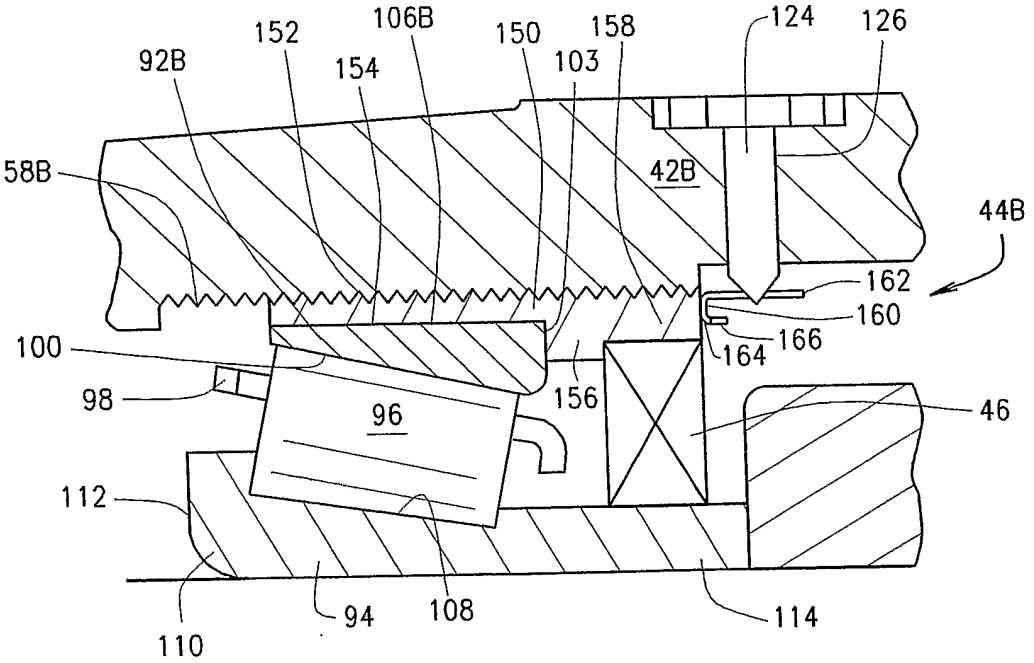

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106B
150
158
124
126
92B
154
103
58B
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46
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94
108
114
110

FIG. 6B

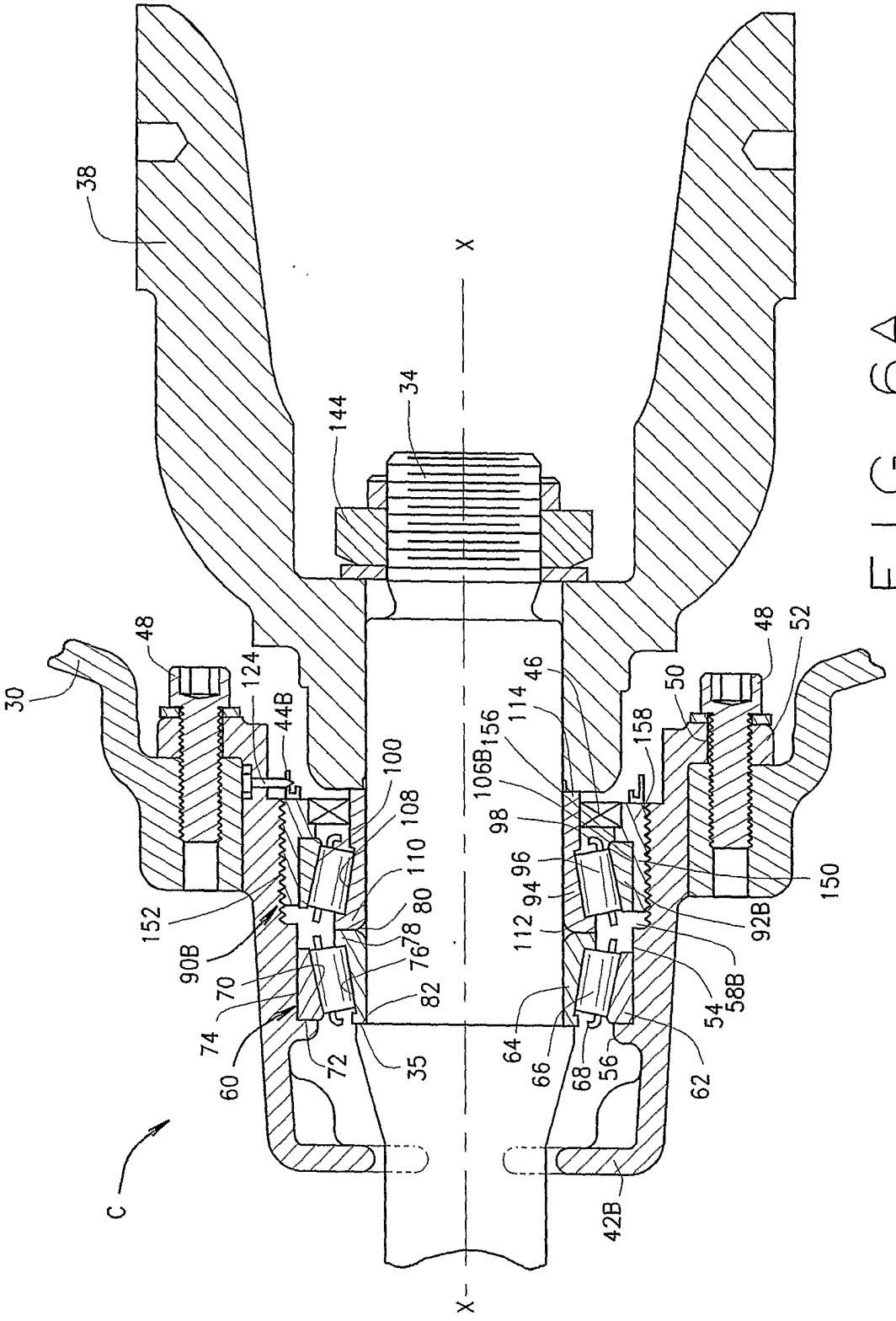

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124
44B
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72
35
C
X
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114
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106B
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92B
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42B

FIG. 6A

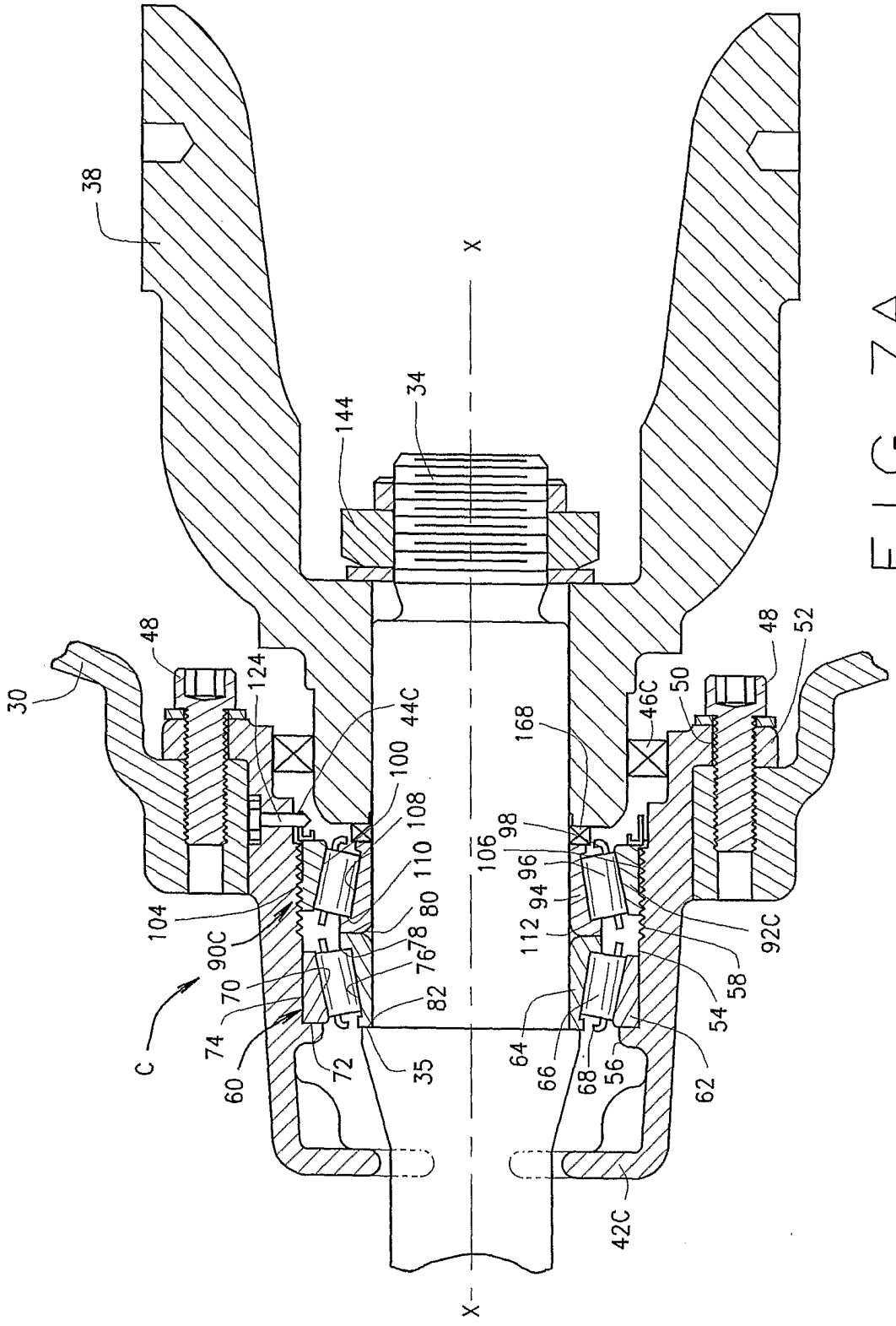

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144
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48
124
44C
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80
78
76
82
104
90C
70
74
60
72
35
C
106
98
96
94
112
168
46C
50
48
52
92C
58
54
64
66
68
56
62
42C
X

FIG. 7A

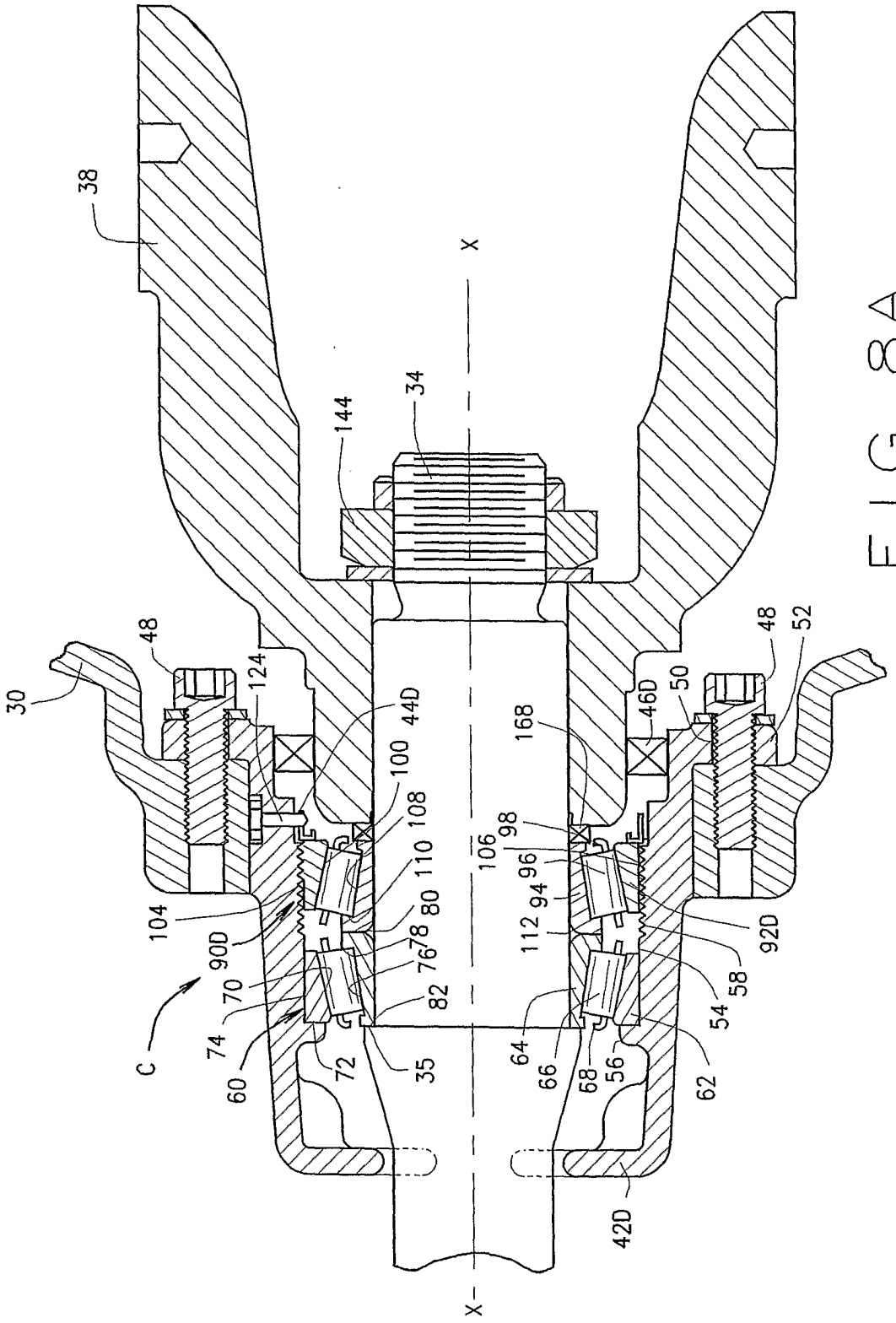

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124
44D
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92D
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X

FIG. 8A

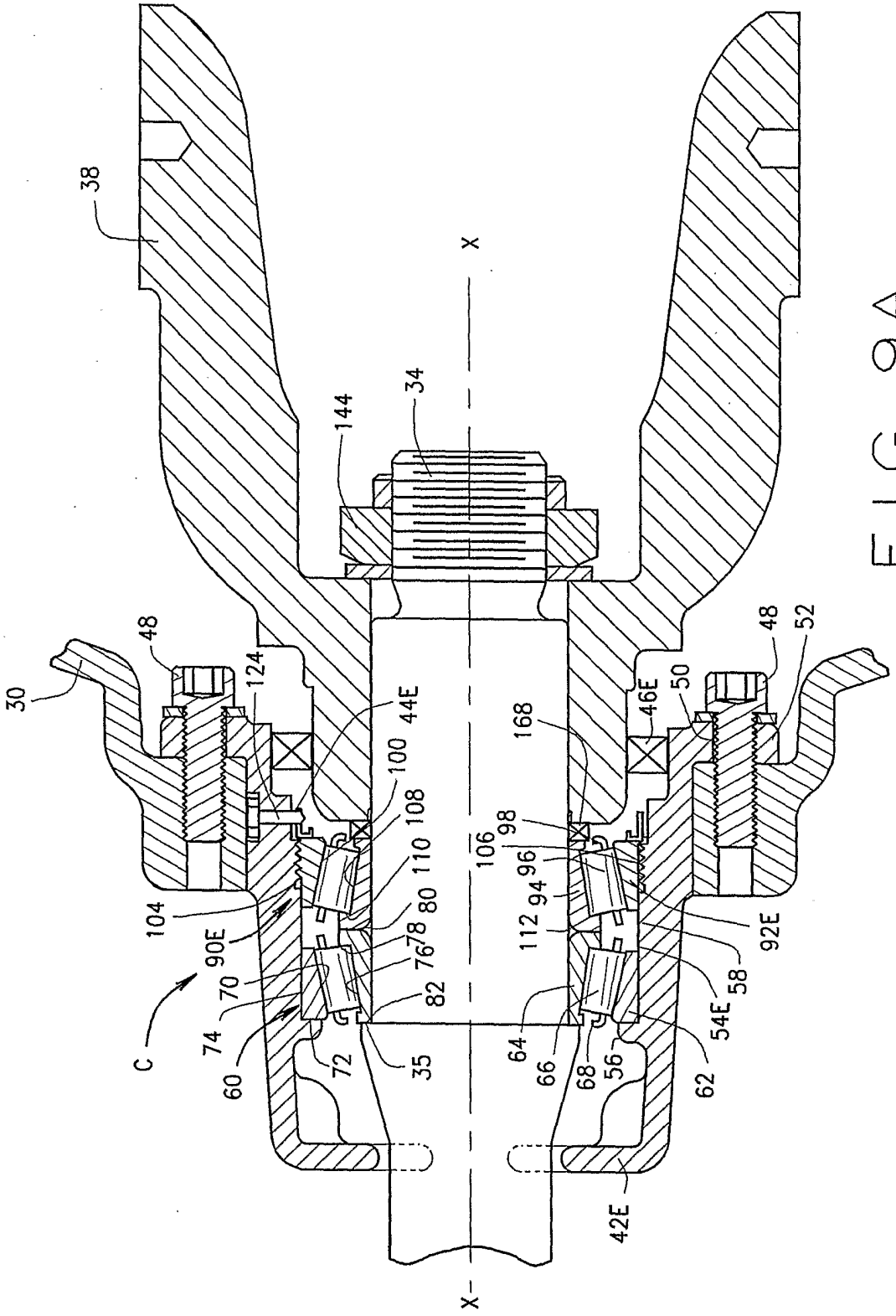

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42E
X

FIG. 9A

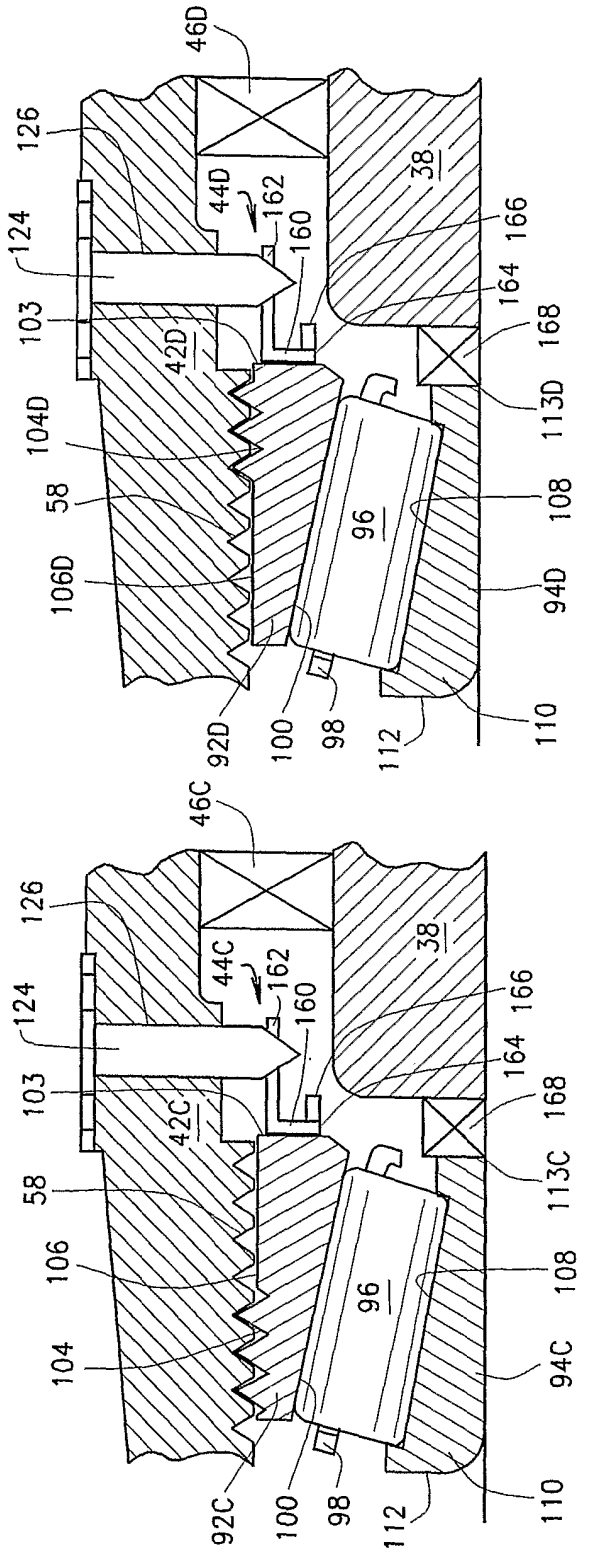



FIG. 8B




FIG. 7B

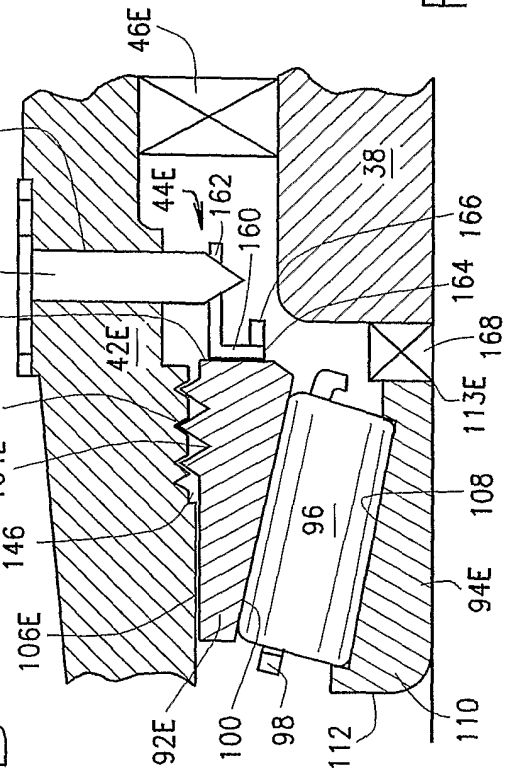



FIG. 9B

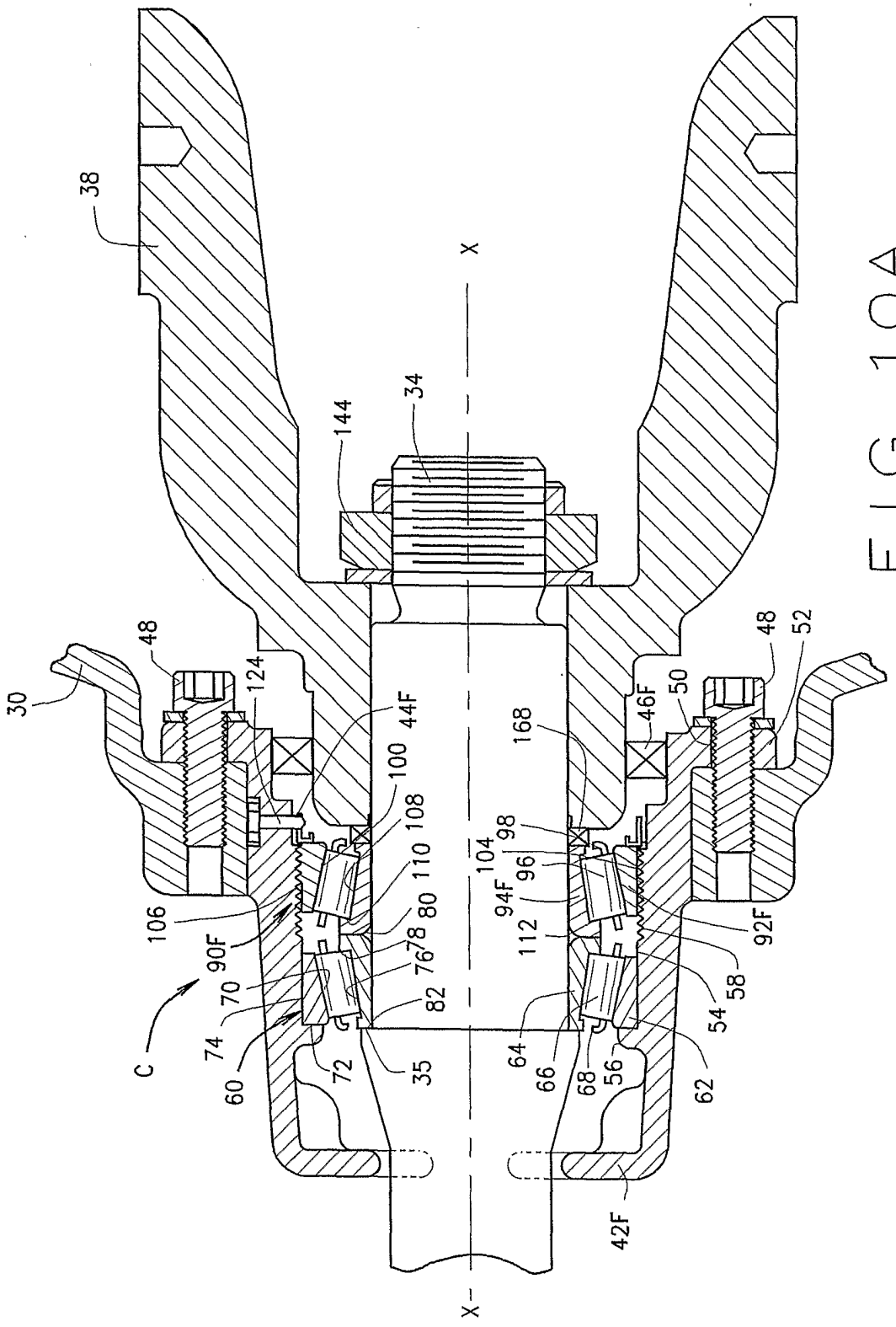

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90F
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C
168
46F
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42F
X

FIG. 10A

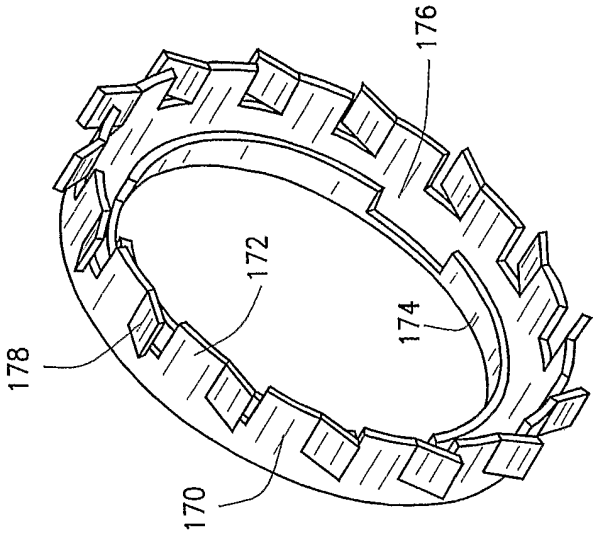



FIG. 10C

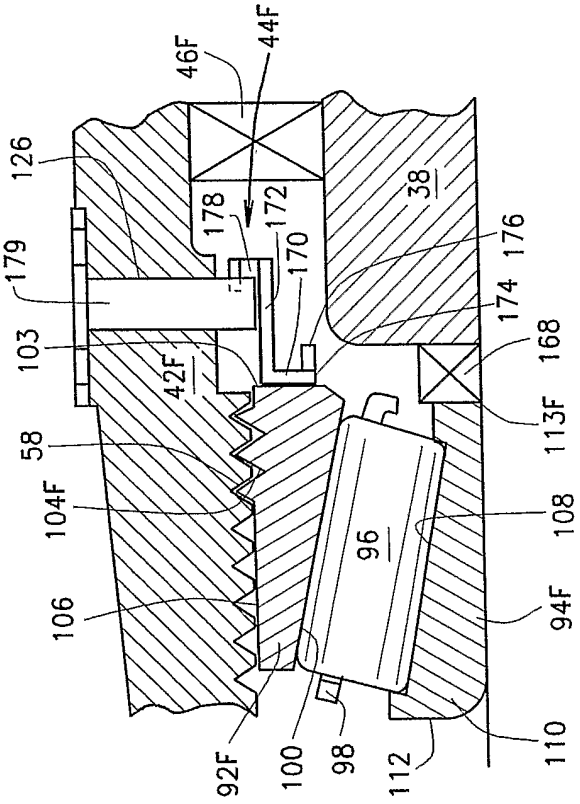



FIG. 10B

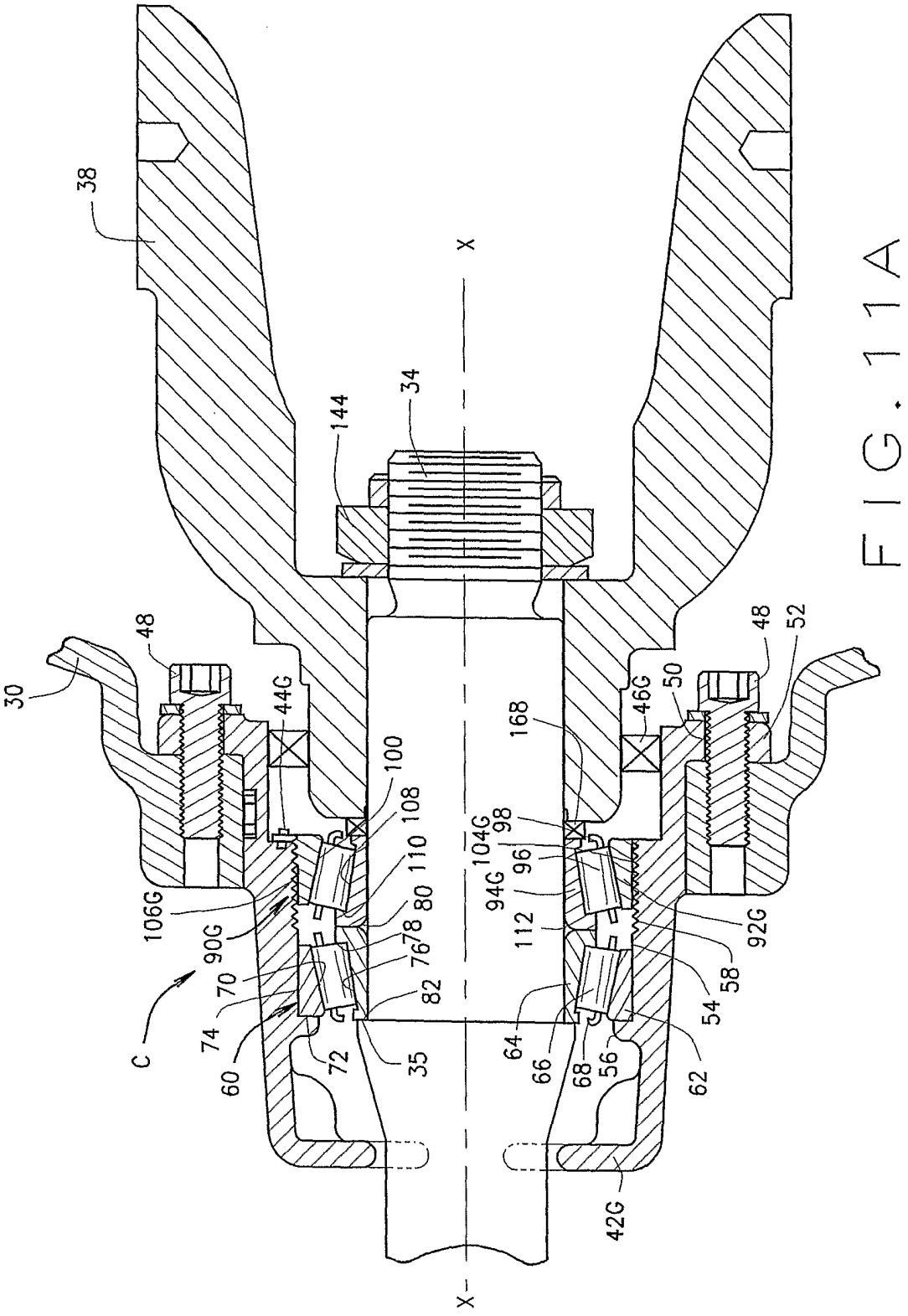

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44G
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106G
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54
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92G
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42G
X

FIG. 11A

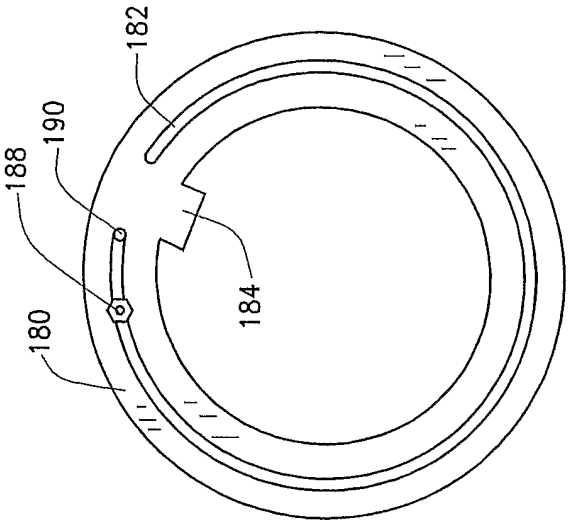



FIG. 11C

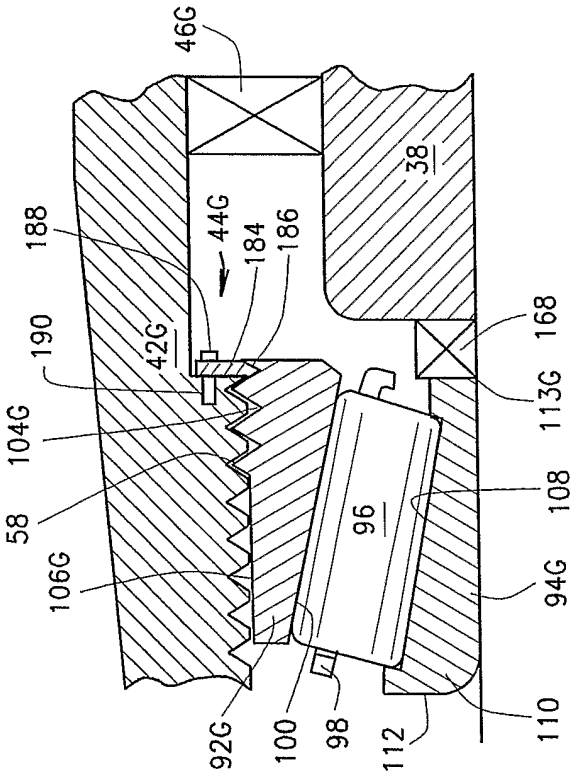



FIG. 11B

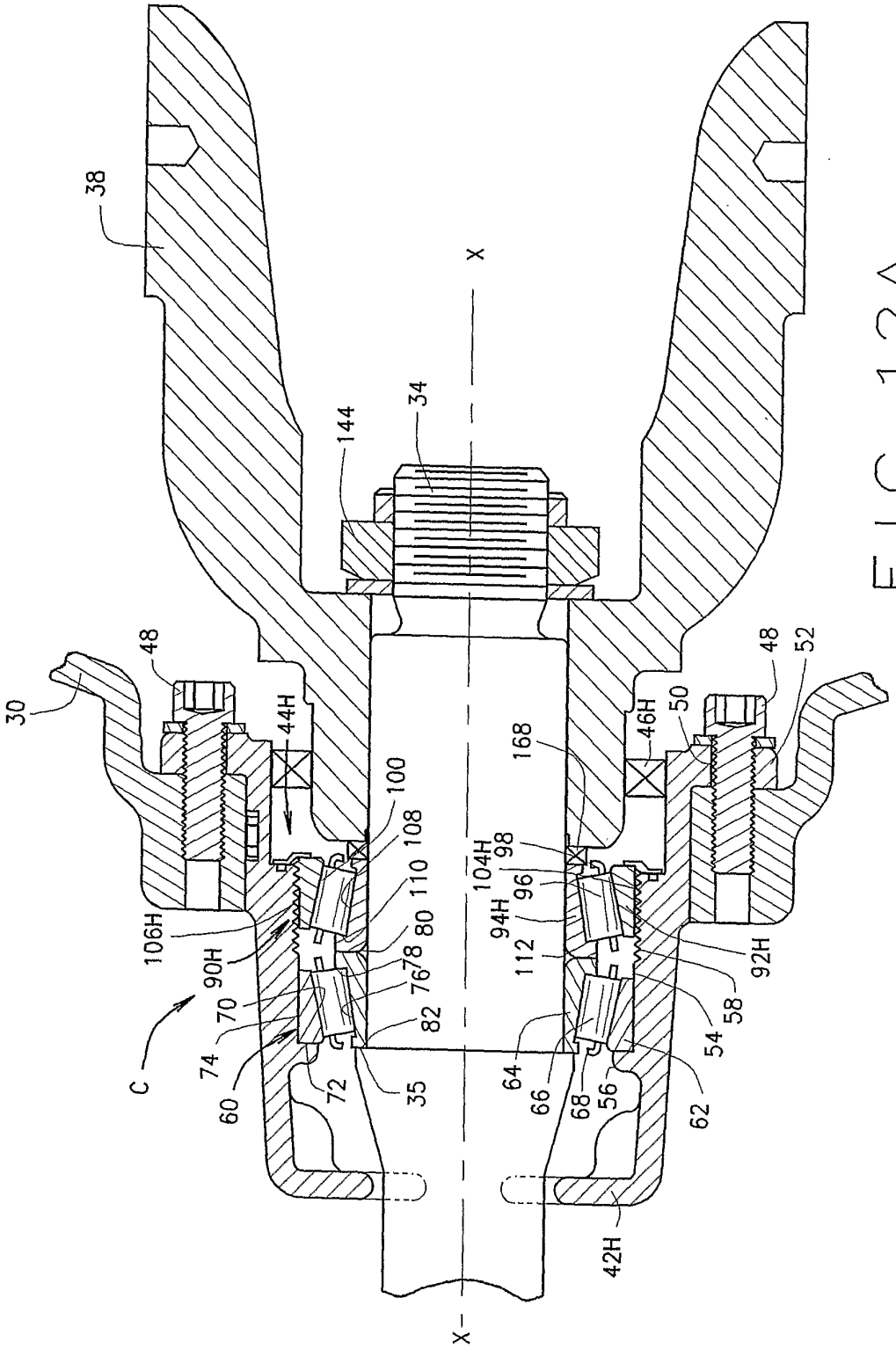

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106H
90H
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46H
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104H
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94H
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92H
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68
56
62
42H
X

FIG. 12A

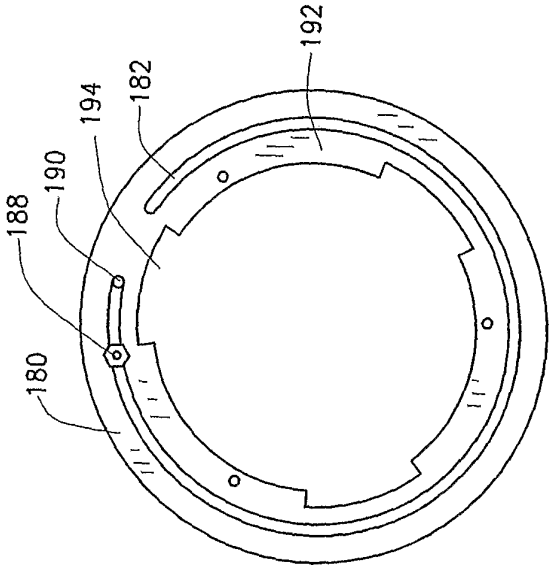



FIG. 12C

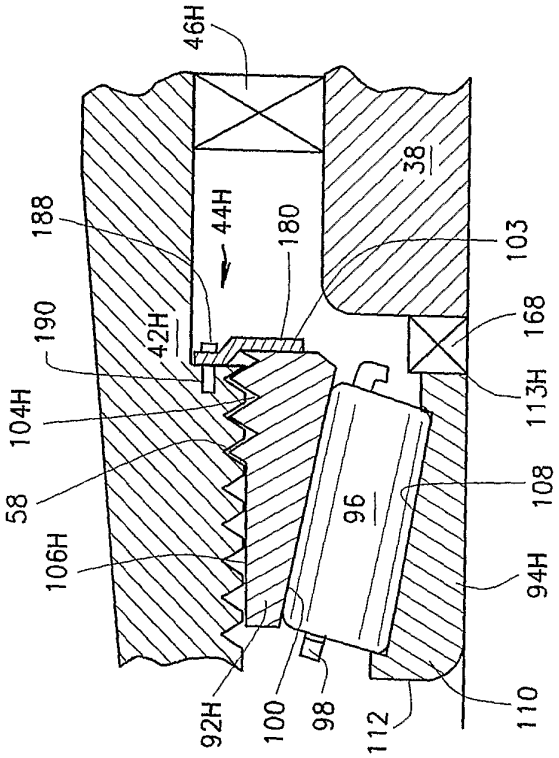



FIG. 12B

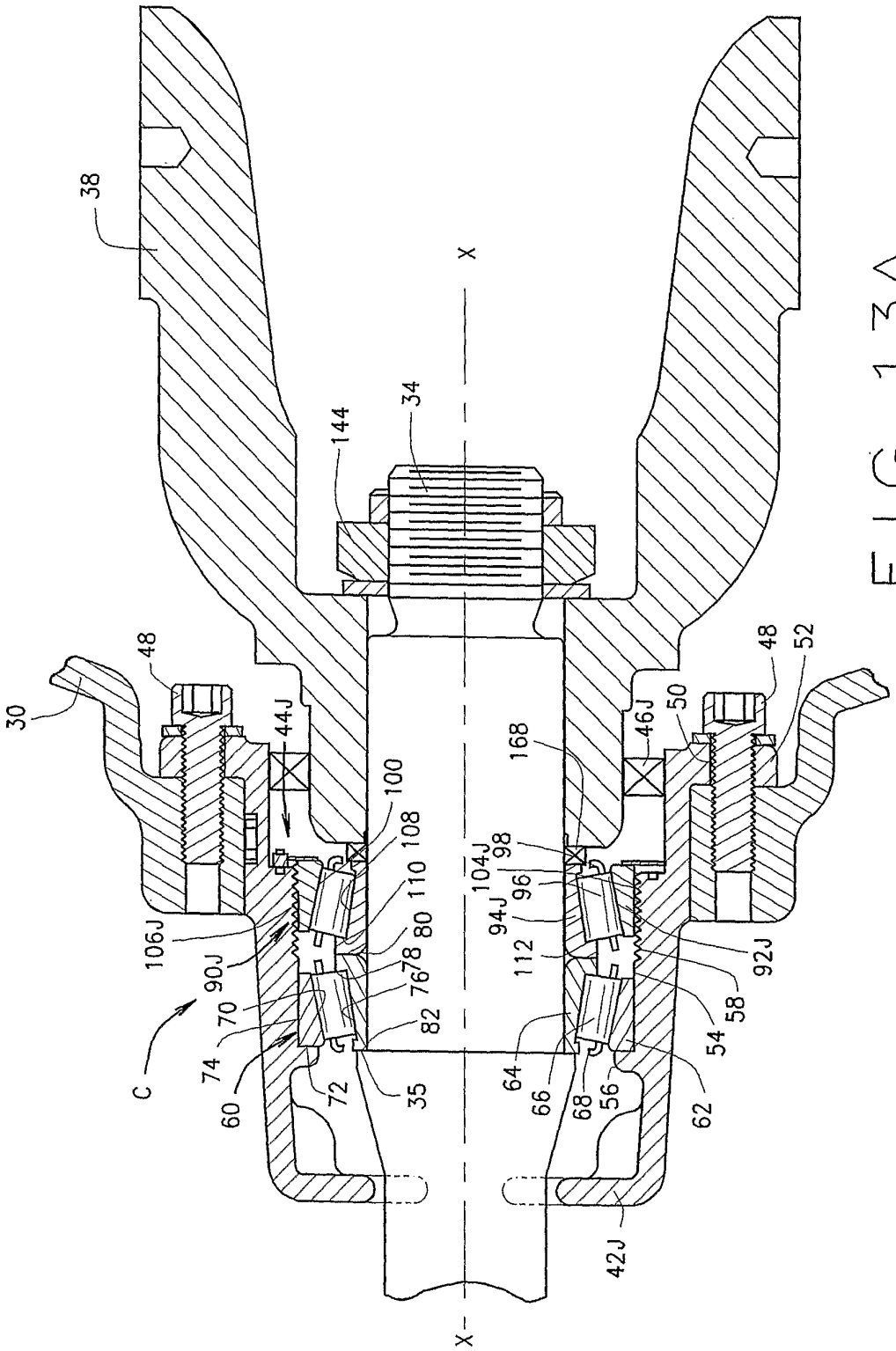

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106J
90J
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46J
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104J
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94J
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92J
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66
68
56
62
42J
X

FIG. 13A

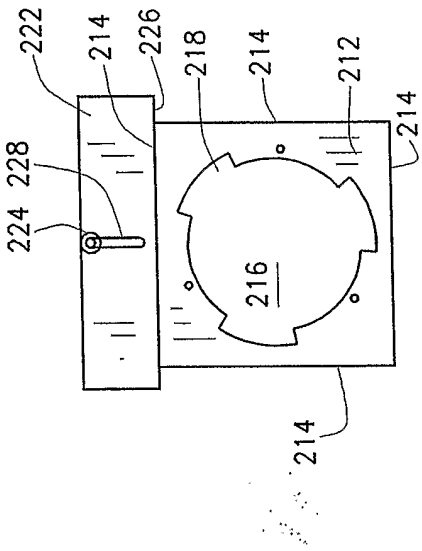



FIG. 13C

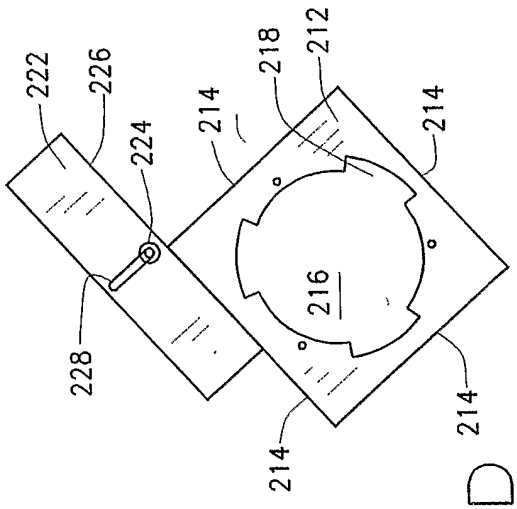



FIG. 13D

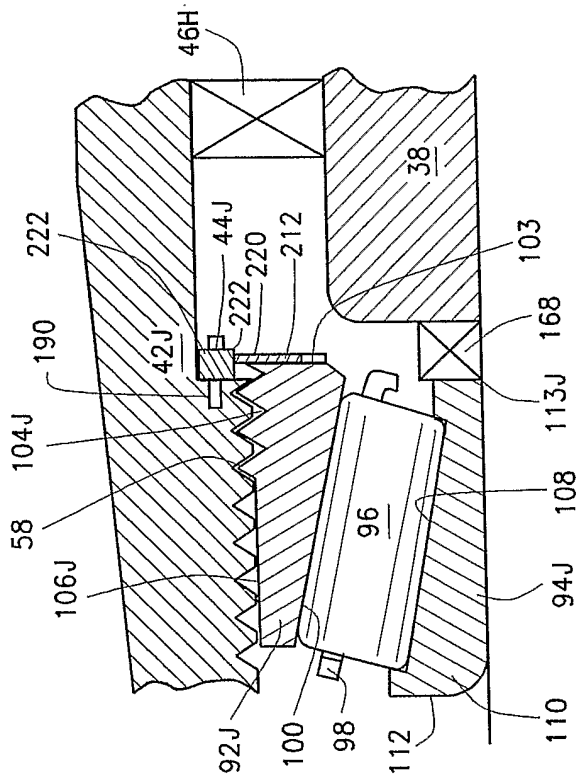



FIG. 13B

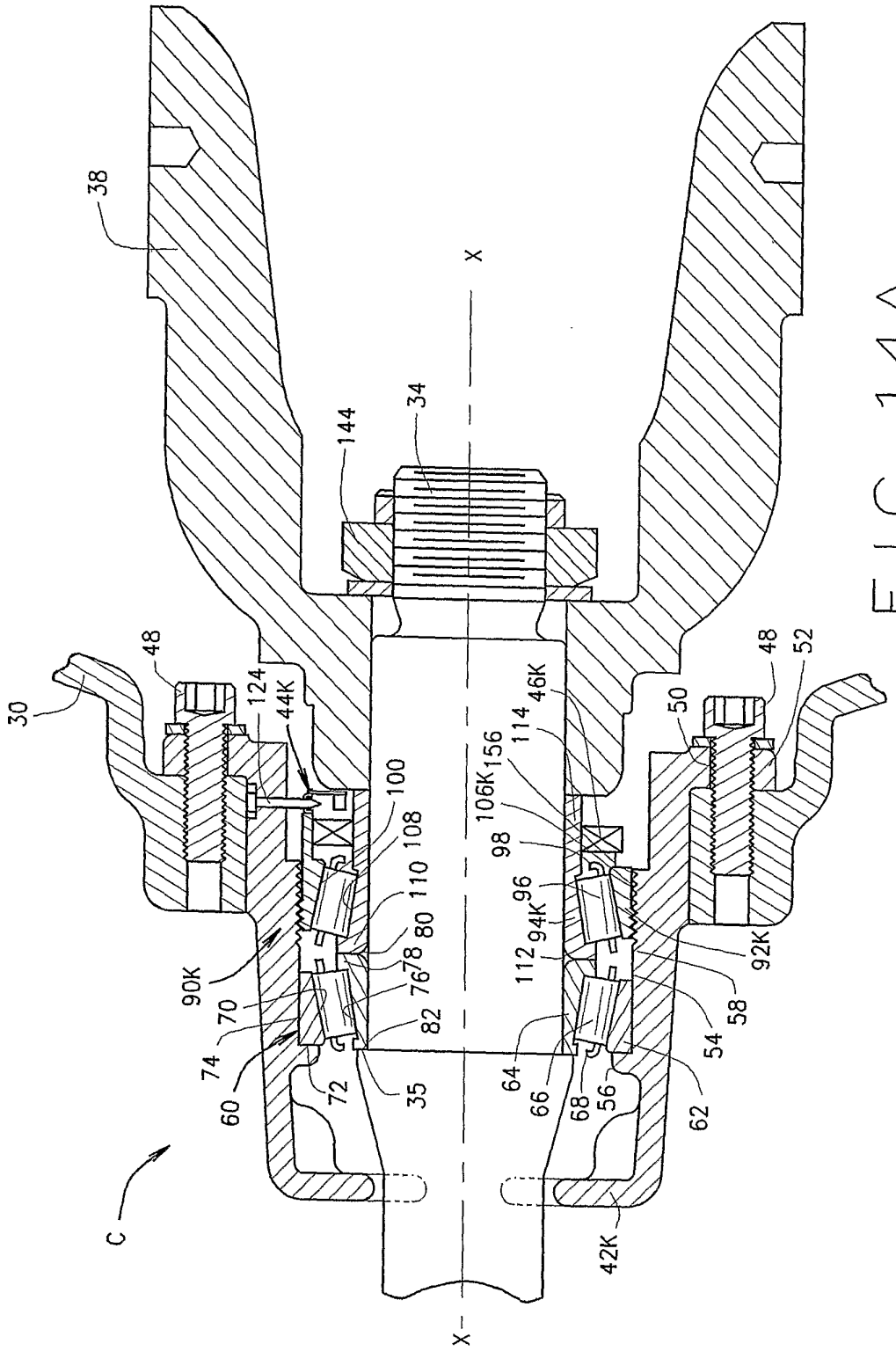

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44K
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90K
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92K
94K
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112
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C
42K
X

FIG. 14A

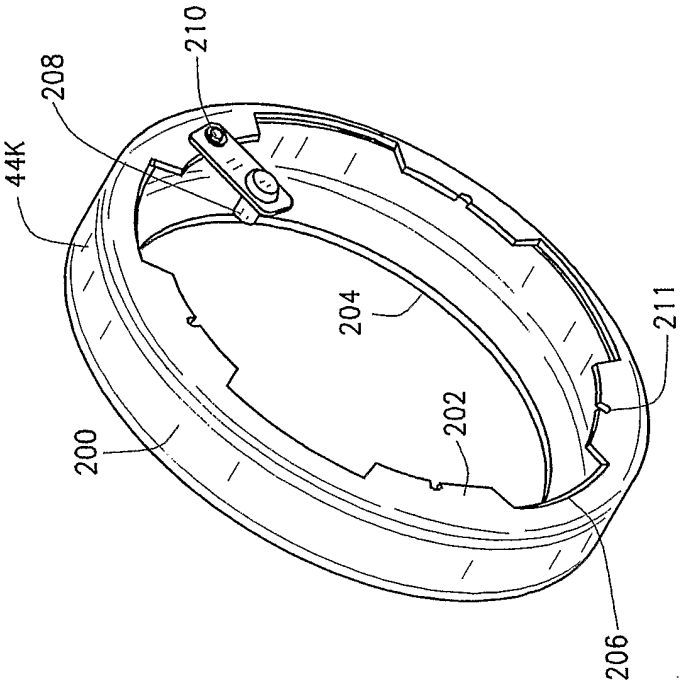



FIG. 14C

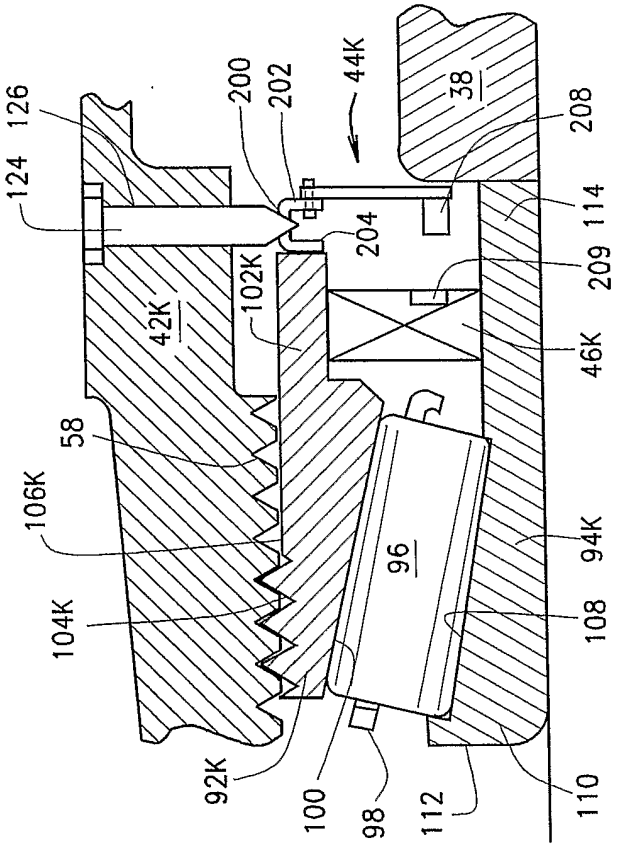



FIG. 14B

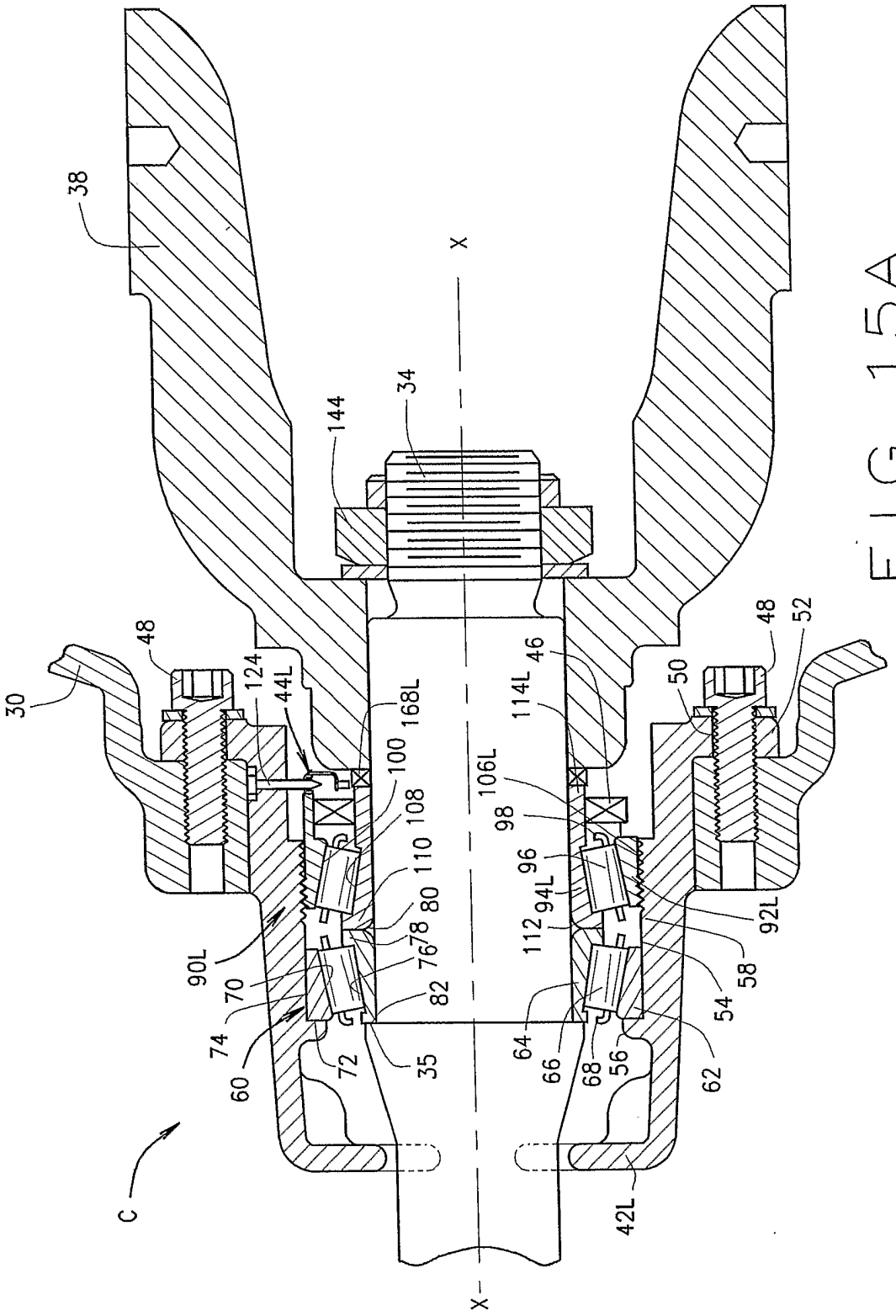

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42L
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X

FIG. 15A

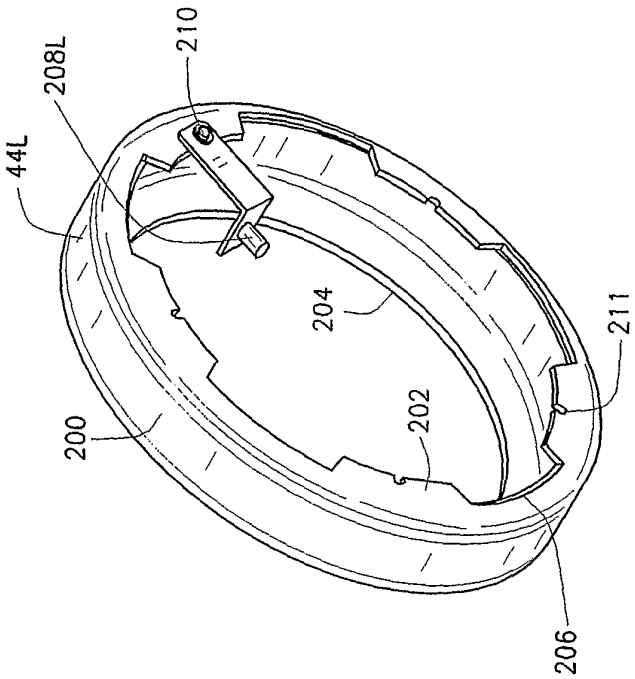



FIG. 15C

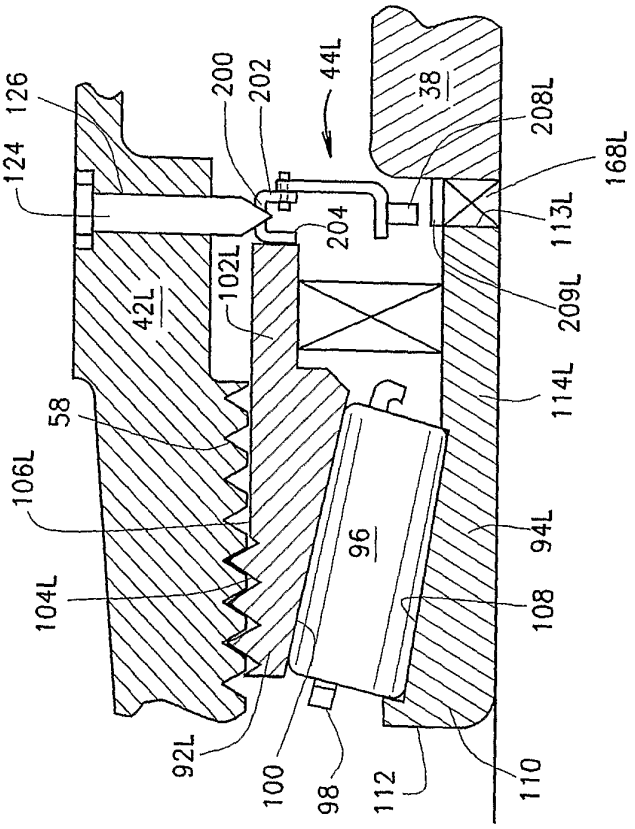



FIG. 15B

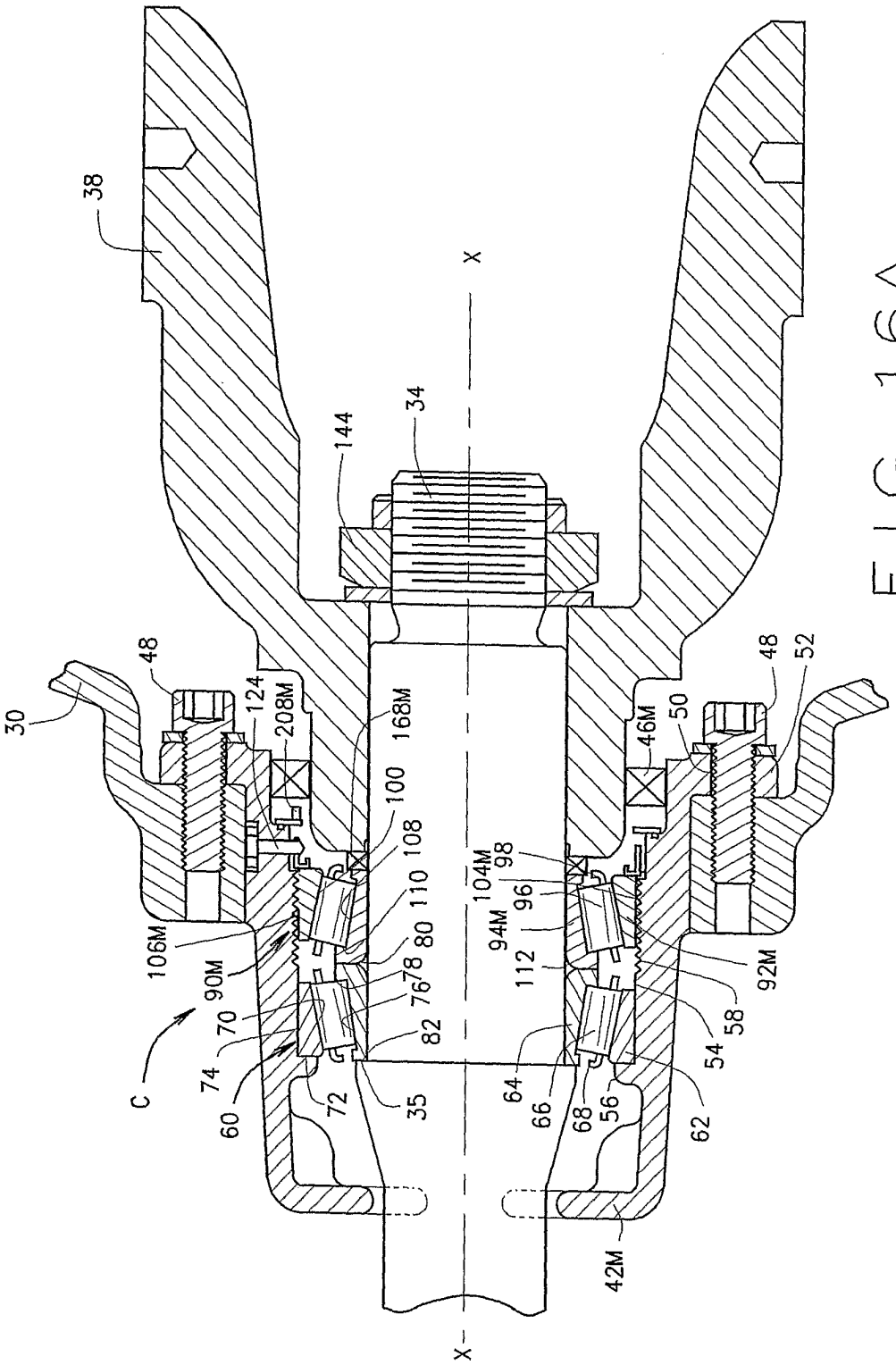

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106M
90M
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72
35
C
104M
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94M
112
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92M
46M
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42M
X

FIG. 16A

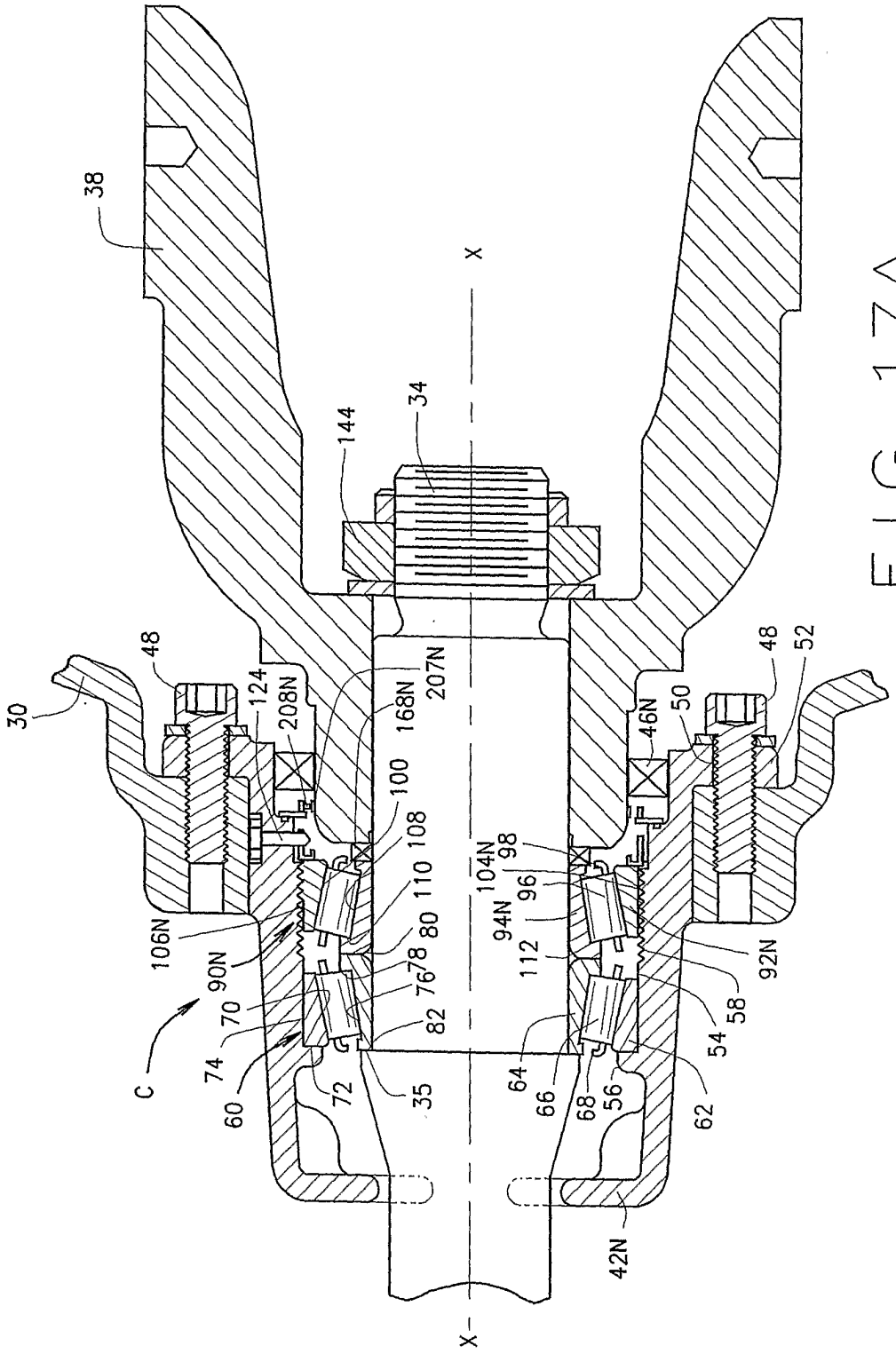

38
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42N
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FIG. 17A

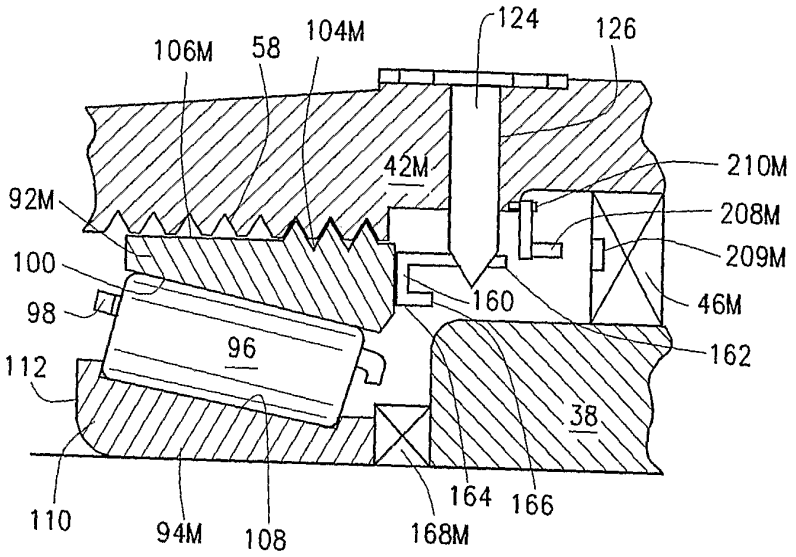



FIG. 16B

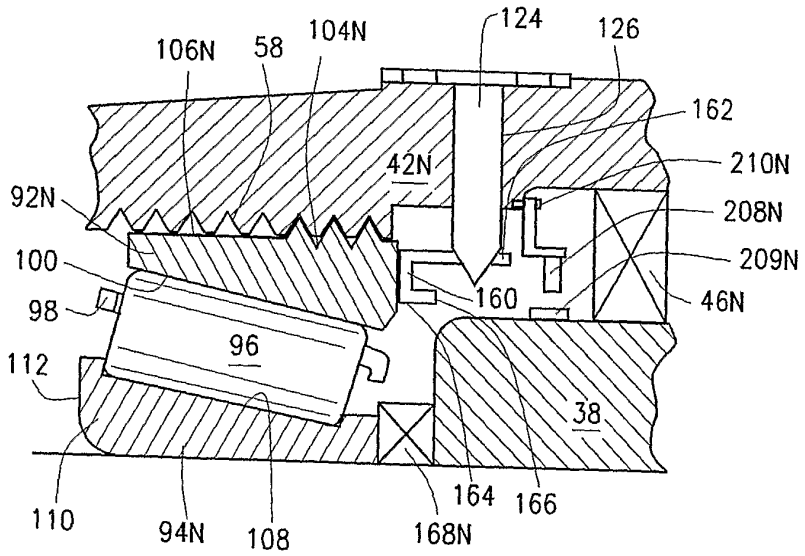



FIG. 17B